# ENGINEERING DEVELOPMENT IN THE PETROLEUM INDUSTRY.\*

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THE Institute of Petroleum Technologists was incorporated in 1914, and in that year I entered the petroleum industry. It is appropriate, therefore, for me to commence my address from that date, and in retrospect and by reminiscence interest the younger members and revive and refresh the memories of the older members of the Institute. Perhaps in the broader scope of the Institute it may even be of some educational value.

The application and ready absorption of up-to-date engineering practice in all its forms have been an important factor in the establishment of the petroleum industry in the position which it now occupies. I propose to deal with this survey as a form of cavalcade, directing attention to milestones on the road of progress, and to take the various branches of the Institute's activities in their natural sequence.

#### Geology.

The geologist in 1914 had only his skill, knowledge, experience, and courage to help him to locate an elusive material which, being in most cases fluid, is capable of migration. It was not until 1920 or even later that he received additional assistance by the adaptation of scientific and electrical discoveries. To-day, in addition to geophysical methods, such as the seismograph and torsion balance and magnetometer, the exploration geologist has the advantage of a geo-electric method of soil analysis. The torsion balance was originally a purely scientific instrument, and in 1924 the inventor was very disturbed because, as he said, his scientific instrument had been degraded to commercial use.

The geo-electric method of soil analysis has only recently become available, and it calls for more than a passing mention. Some time ago, I believe, the Russians discovered that what were thought to be impervious rocks and clays were really in geological time open to the transference of gases, and permitted the leakage of gases to the upper strata. The geoelectric method of soil analysis enables a rapid and accurate investigation to be made, particularly where gases are present in extremely small quantities, mixed with other gases and vapours. In such cases a chemical analysis, even if possible, is slow and tedious, and requires large quantities of the material to be available. This method is based on the principle that the ion-mobility of a gas is directly proportional to the molecular weight of the gas, and by electrical means a gaseous mixture can be divided into the constituent gases in accordance with their molecular weights. Ions are produced in the mixture. The ions of the different constituent gases are grouped by virtue of their different ion-mobilities. The groups of the ions are selectively collected on different electrodes, and the charge imparted to the electrode is measured. This is a measure of the quantity of gas present having that particular ion-mobility.

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Whilst in theory this may sound somewhat abstruse, in practice it is very simple. The sample is placed in a rectangular chamber, and an electric field is produced between electrodes on opposite sides of the chamber. The gases are ionized. The field is then changed over to the opposite side of the chamber. This results in the gases being immediately identifiable and arranged in their correct order. It will be realized that this method has applications in many directions.

The geologist can therefore, with his knowledge of the structure gained from his experience and previous methods and from his soil analysis, site his drilling location not only with considerable accuracy, but with greater certainty than ever before that oil will be located.

The exploitation geologist has an important subsidiary equipment in the electric coring or well-survey apparatus, the gamma-ray, and an electrical inclinometer which gives a graphic record of deviation correctly orientated.

Electrical well surveying is an adaptation to this purpose of well-known electrical laws. Primarily, and in its simplest form, the apparatus measures electrical resistivity. For example, a sand impregnated with salt water has a lower resistivity than one impregnated with oil. The whole depth of the well is so surveyed by lowering an electric cable and electrodes into the hole, which is uncased and full of fresh-water mud while the survey is being made. A graphic diagram is thus produced of the whole depth of the well. Refinements and improvements consist in additional measurements simultaneously to correct the "masking" effect of the fresh-water mud. As the fresh-water mud plasters the side of the hole in drilling, it may have, from an electrical point of view, an insulating effect over, for instance, the surface of a salt-water sand. The additional curve which is produced, so to speak, climbs behind the mud and gives a correct interpretation of the various strata behind it. Hand operation is now replaced by photographic automatic recording, which enables the survey to be made at a relatively high speed and eliminates human errors.

The diagrams produced must be interpreted by the geologist with a knowledge of the particular field, and he has to take into consideration a number of factors. The electrode arrangement may require variation, as the same arrangement is not necessarily suitable for all fields. No reliable way has yet been discovered of calculating production rates from the diagrams. Theoretically resistivities should decrease with depth and, in general, this is borne out by experience. Also, heavy oil and pitch sands show very high resistivities.

A problem yet unsolved is how to differentiate between gas and oil on the diagram. It is not uncommon for a sand to be perforated in the exploitation of oil and only gas be produced. These diagrams are only empirical, and require correlation, and occasionally diagrams are obtained which cannot be interpreted. In such cases an actual sample of the rock is necessary, but it is too late to obtain this by coring.

To meet this requirement there has been developed a system of shooting into the side of the hole at the desired points hollow cylinders attached to a barrel by wires. On the barrel being moved up into the hole, the wires attaching the cylinders to the barrel pull the cylinder out with a sample inside it. This device works quite satisfactorily in practice. The main basis for interpreting these diagrams is that increased resistivity denotes oil. Since resistivity is a resultant, it follows that in hard rocks like quartzitic sandstones, with inherent high resistivity, it is more difficult to distinguish oil characteristics than it is in non-resistive sands or sandstones. A great deal of research will be required before any exact interpretation of electric logs will be possible.

This apparatus is frequently called an electric coring device, because to a great extent it eliminates the taking of mechanical cores. Mechanical coring always slowed up drilling speed, and for that reason mechanical cores were not taken as often as they might have been or as often as the geologist wished, and there have been many cases of wells drilled before electric logging was introduced where oil-sands were "cased off."

The gamma-ray or radioactivity logging is capable of distinguishing between sands and shales through the steel casing. It is based on the principle that measurable quantities of radioactive materials are found in all kinds of igneous, metamorphic, and sedimentary rocks. In general, pure quartz sandstones and pure limestones show very low amounts of radioactivity. Ordinary shales show high radioactivity. The instrument consists of an ionization chamber filled with a mixture of inert gases under pressure, and fitted with insulated electrodes connected externally to an electrical circuit, and an amplifier of special design. Under ordinary conditions the gas in the ionization chamber is non-conductive, and no current flows between the electrodes. When the ionization chamber is lowered into a well, gamma-rays partly ionize the gas, and it becomes conductive. A measurable current then flows. It is proportional to the amount of ionization, which in turn is proportional to the amount of radioactive material in the surrounding rocks.

When a gamma-ray survey is made, a diagram extremely like the electrical survey diagram is obtained. From this it is easy to see where the cased-off sands in a well are. At present, to ascertain whether they contain oil or water is a matter for actual trial.

Steel has an insulating effect on gamma-rays. On this account, the position where an extra string of casing is entered or left by the instrument is very clearly shown on the diagram.

Gamma-ray logging affords a remarkable instance of the application of somewhat abstruse scientific principles to everyday use in oilfields. Its use has been made possible by research, together with the production of recording instruments of extraordinary sensitivity. This is the subject of a paper read before the Trinidad Branch and published recently in our *Journal*.

Little information can be given here with regard to the electrical inclinometer, except that it is also a simple application of electrical and physical laws. All deviations from the vertical are correctly orientated and recorded on a graph or graphs similar to an electrical survey.

In addition, the exploitation geologist has available an electric recording thermometer whereby he can record the rise in temperature when his cement sets, so that he knows that it has set, and he has also an electric gun to perforate the casing for production.

I should utter a word of warning here, in case any budding enthusiast contemplates buying a few of these instruments and starting out to become

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an expert at once. These instruments in the hands of experienced geologists are valuable supplementary equipment, but they have little value otherwise. They are of particular interest here, as most of them have been developed by members of this Institute.

#### Drilling.

Drilling in 1914 was largely carried out by percussion or cable-tool drilling. The rotary method, which is the logical engineering method of boring a hole in the ground wherever practicable, although first used in 1901, was still not in common use in 1914, and was, indeed, almost frowned upon by the exponents of the percussion system. Now the position is changed, although there are still oilfields which, on account of the formation, do not permit of the use of a rotary, and in some cases a combination of the two methods is used.

Steam was the universal motive power, generated in the now wellknown and so-called portable boiler of the locomotive type.

It is desirable at this point to digress for a moment. It is strange, but nevertheless a fact, that the producers of fuel often failed to realize the necessity for their own fuel economy, and this failing still persists in some directions. At the present time a great public campaign for fuel economy is being carried on throughout this country, and it is interesting to recall an earlier and a private campaign which probably reached its peak in 1908-12. At that time a number of what might be called "efficiency disciples" travelled through the industrial districts of this country, and whenever they saw, either by invitation or by gate-crashing, exhaust steam escaping from some colliery or steel works they developed their economy campaign with the slogan : "Every 40 lb. of exhaust steam represents 1 h.p." This exhaust steam, after collection in an accumulator, is passed into a steam turbine, which is an appropriate and flexible unit for the conversion of such exhaust steam into electrical energy.

Units as large as 3000 kilowatts have been installed in this country, a great portion of their steam energy being obtained from the exhaust from winding engines, etc. Thus the economy in steam consumption and fuel at a large colliery was very considerable. I hasten to add that those conditions of waste no longer exist.

What an opportunity is presented to the engineer who has been engaged in such work as detailed above, to find himself confronted with an oilfield on which there are dozens of small batteries of boilers, isolated and at some distance from each other ! Each battery has to be capable of dealing with the maximum requirements of each particular drilling rig. For safety reasons it has to be situated a considerable distance from the well to which it is supplying steam, and the length of steam pipe between the boilers and the well is frequently unlagged or inefficiently lagged. The resultant heat efficiency will be probably less than 3 per cent.; in other words, out of every 100 B.T.U.s generated in or applied from the boiler, not three will be expended usefully at the point of the drill.

The first step that the engineer would take had he a free hand and the necessary capital would be to merge all these batteries of boilers into one large battery of boilers of an efficient type, capable of dealing with the average maximum load of all drilling engines at any time, and the necessary energy at each well would be supplied naturally through the medium of electricity. That has been done in a number of oilfields both inside the British Empire and elsewhere, resulting in great economy, safety from fire, and the many other advantages contingent upon an electrical supply being available.

The question naturally arises as to why all oilfields are not electrified. Thirty years ago the exploitation of an oilfield was considerably more speculative than it is to-day. The funds made available for a first operation either were used without results or were used with such successful results that economies for the time being did not seem to be of great importance. For various reasons, it has been stated that at that time the number of failures due to mechanical or other causes throughout the world, was one in every four wells drilled. The position is a very different one to-day. In my opinion, a case for electrification could be made out at almost any time in the life of an oilfield.

There are many cases of the application of electricity other than just for drilling operations. In those fields which are entirely electrified probably not more than 30 per cent. of the electricity is utilized for the requirements peculiar to an oilfield, such as drilling. Where wells are closely spaced it is possible to establish a battery of boilers on a permanent site for perhaps as long as two years. In such cases, with well-lagged pipes to the various locations, a reasonably high efficiency can be reached. Even if good boiler water is available in quantity and there is ample fuel, such as surplus gas, it is still economical to utilize these efficiently, as the life of the boiler plant is prolonged thereby and the expenditure for new boilers delayed.

One curious tradition exists in the engineering oil world—that is, giving a boiler a size, calling it so many horse-power. It is probably a relic of the old American days. Really all that a boiler does is to turn so much fuel into so much steam, and it is immaterial whether that steam is used in a turbine at 12 lb. per h.p. or in a non-condensing engine at 60 lb. per h.p. It is preferable to buy a boiler on its evaporative capacity.

Another point I should mention is the application of superheated steam. In most cases this is merely an attempt to rectify what was initially a bad steam lay-out. Superheat is very easily gained and just as easily lost. The place to instal the superheater, if it were practical and safe, would be almost next-door to the engine to which the steam is being supplied.

I have been talking a good deal about efficiency, but there are occasions when efficiency has to be sacrificed to expediency. There is one field at the moment, in which I have some measure of responsibility, where seawater is used to raise steam in Cornish boilers. An interesting point in this connection is that with salt-water mud used for drilling it is impossible to use the electrical survey apparatus, but the advantage of electrical coring is so great that it is profitable to incur considerable expense to provide fresh-water mud in the well during the time that the survey is being made.

The development in drilling plant consists of general improvements, making for greater strength and ability to drill to greater depths. The troubles with broken drilling jars and all the difficulties that were experienced in the old percussion-tool days now appear like a very bad nightmare, almost forgotten. The rotary, on the other hand, can now be considered to be a piece of engineering plant. The separate engine drive to the rotary table is a notably progressive step, as is also the use of variable cut-off to engines operating the mud-pumps. Heavy oil engines have been adapted for drilling and operating the mud-pumps. The gearing and clutches are a complication in these drives. An oil engine driving an electric generator supplying energy to motors will probably be found to be the most suitable. Here electricity is being used as a clutch and gearing of almost infinite speed variation. It has the advantage that as a first unit on a new oilfield it can form the nucleus of full electrification. Further (a point which should have been previously mentioned) all the electrical plant required for oilfield work is now completely standardized.

Considerable progress can be recorded in the development of special rock-bits for drilling in hard formations, and in the attachment by welding of hard-facing material to reinforce the cutting edges of all bits.

The drilling superintendent has to deal with all sorts and conditions of formations, which vary in many parts of the world. I have known a case where the rate of progress in rock was 5 ft. per week, and not very far away, geologically speaking, the rate in another formation was 2000 ft. per week.

Ingenious devices have been developed by members of the Institute for the prevention of blow-outs, drilling in under pressure, and all the other operations that one wishes to perform whilst the well is flowing under pressure, both for rotary and for percussion drilling. Barytes has become popular for increasing the weight of the mud, also for drilling a well in under pressure, or for making adjustments whilst the well is under pressure. Mud is being used up to 140 lb. per cu. ft., and by the use of quebracho the viscosity is reduced so that this mud is easily pumpable.

Photographs of spectacular blow-outs no longer occupy the best position on the Board-room wall. The cost of fishing tools no longer forms a large item in the annual budget. Considerable progress has been made in directional drilling, particularly where the means of making an electrical survey are available. The main well is drilled down to the ultimate depth; then, having run the survey and found out where the various horizons of oil are, several "pup" wells, as they are called, are drilled into the various horizons, so that oil can be taken from all of them simultaneously. Where a fresh-water source is shown by the survey, a well is drilled to produce the water for field requirements. In the West Indies and Venezuela there are as many as four wells under one derrick. Furthermore, when directional drilling becomes even more developed, with the electrical inclinometer, to which I have referred, it will be just as easy to maintain the required direction as it is to-day to drill a vertical well; in fact, in some respects it will be easier.

With all this advancement, which has reduced almost to nothing the number of failures due to mechanical reasons, what is the important factor which has changed the position to the extent that to-day drilling plant can be purchased which is guaranteed to drill to 15,000 ft., whereas thirty years ago a well of 3500 ft. was considered to be a deep well, and, furthermore, there were often failures down to that depth?

Casing and drill-pipe used in the petroleum industry is, as you all know, screwed and coupled, having a tapered thread. To-day there is a standard

accepted throughout the world. It is possible to purchase tool-joints and couplings in this country to the standard specification which will, fit accurately with easing or piping produced in America or any other part of the world, whereas prior to this standardization there were many differences.

Tapered threads introduced many variations. First, what is the number of threads per inch and what is the degree of taper? Are the threads to be at right angles to the axis of the pipe or to the taper? What is the shape of the threads? How many are complete and how many incomplete? All these little points are now forgotten, but for some years round about 1914 they were a source of constant discussion and argument, and, more important, they were often the cause of mechanical difficulties, even resulting in the loss of wells.

Whilst it is largely immaterial who is responsible, provided the object is achieved, it is a fact that British oil engineers played by far the greater part in effecting this standardization. Prior to complete standardization and accuracy of screwing, threads of couplings were electro-galvanized to introduce a form of metallic lubricant, but, if the threads of pipe and coupling were not accurately matched, when screwed up they forced each other into a neutral position, and on unscrewing it would be found that the well-known "galling" of the threads had occurred. If the threads were perfect to begin with, however, the galvanizing had a very beneficial effect, and it is of considerable use to-day. Where there is no corrosive effect on the casing, either in the ground or in the water passed through (and there are many such places), the galvanized thread permits of recovering casing for re-use, which is particularly valuable at the present time, and the threads of the casing extracted are almost the same as they were when the casing was installed.

In my opinion, therefore, the answer to the question is that the improved quality of the casing and the strength and accuracy of the screwed couplings and tool-joints are the main reasons why we can reach these hitherto unthought-of depths.

The next big development will be a method of delivering power to the point of the drill. There is no other example in engineering history where considerable power is applied at one end of a drill pipe to be used at the other end which may be up to three miles away.

## Production.

In the production branch of the industry great progress has been made. It has been stated cruelly and quite erroneously that the production superintendent in the old days was the least efficient driller to be found on the property. Whatever he may have been in the past, he is now, and has to be, a man of very considerable scientific knowledge and experience.

Pumping systems have been improved, both with individual and with collective drive.

Indirect and direct gas-lifts are employed to a greater extent. They are, of course, directly allied to air-lift, which has been used for many years by engineers for the transference of liquids. The plunger lift provides a good example of engineering workmanship. The plunger, which is about 8 in. or 9 in. in length, operates in special reamered production tubing 2 in. or  $2\frac{1}{2}$  in. in diameter, forming, in effect, a cylinder several thousand feet in length. The plunger, operated by the formation of gas in the well, carries upwards a plug of oil and falls back by gravity. The number of trips per day is recorded graphically.

The first of these plunger lifts to come under my observation, examined after having travelled 35,000 miles, showed no measurable amount of wear. Excess of wax or sand in the oil definitely affects the behaviour of the plunger lift, the former being more easy to deal with than the latter. A plunger lift is probably the cheapest form of production next to a flowing well, although perhaps on an electrically equipped field some of the largegroup pumping systems may be a little more economical. Whether flowing or artificially produced, whether high- or low-pressure production, whether large or small wells, each well on an oilfield to-day has individual consideration and attention from the production superintendent and his staff, who know the strong and weak points of their wells as a doctor knows his patients. Probably they know them better, because the doctor's patients do not always tell him the truth.

There is a marked reduction in the waste of gas. The gas/oil ratio is carefully studied, and the gas produced with the crude oil is utilized in lifting the oil or in re-pressuring or for fuel, and finally any surplus is manufactured into products which at any time are of value, and are particularly so at the present time. A little surplus high-pressure gas is very useful on a property. In one case the production engineer has made a number of small vessels out of large-sized casing. These receive the oil from the collecting tanks. When the oil reaches a pre-determined level, a ball valve operates and admits high-pressure gas, which expels the oil forward to the service tanks. All that remains to be done is to instal a meter of some kind to measure the number of shots a day, and the amount of oil that has been passed from a certain area to the service tanks is recorded.

## Refinery.

The general requirements of the refinery are high-pressure and lowpressure steam, electric power, water, and sewage. The first three can be, and have been, dealt with by utilizing the flexibility of the steam turbine. . High-pressure steam is generated at 250 lb. and supplied to the turbine, and it passes out of the turbine at 40 lb., the energy in the steam in reducing pressure from 250 to 40 lb. being expressed as electrical energy. The machine is quite automatic. It will produce all electricity or all lowpressure steam, or any varying proportions of them. In the case of a shale-oil refinery, steam can be drawn from the turbine at about 3 lb. or 4 lb. pressure for use in the retorts.

#### Distillation.

The distillation plant of 1914 is well known, if only as a historical piece. It consisted of a number of horizontal cylindrical stills, assembled at different levels, and connected either in parallel or in series, as required. Should those stills be 19 ft. long and 7 ft. in diameter, they would probably be a product of Scotland. The introduction of internal flues, as in a Lancashire boiler, increased the heating surface, which we now know to be, for the most part, a step in the wrong direction.

It must be remembered that at this time there was an air of secrecy regarding all petroleum matters, and that also applied to distillation plant. For example, it was not thought possible or desirable that any single engineering firm should be able to manufacture a complete bench of stills. When called upon to develop some such units, one asked the latent heat and the specific heat of petroleum and its products and other similar questions, the replies given indicated that, if those queries were not actually improper, they were probing far too deeply into the matter.

One question asked at that time has, in the light of to-day, proved to be momentous-namely, what was the ratio of heating surface to evaporative surface. This question was rather unfair to our mentors, as we, as engineers, did not know what the ratio was for a steam boiler. Some of us, struggling towards the light, built a vertical cylindrical still, in which the crude oil presented a large disengaging surface, it being turned over and over as it was falling down a structure similar to a spiral staircase. Although the still received very severe criticism, in my opinion it had at least one good feature-namely, it showed that greater disengaging or evaporative surface was required. Distillation practice had been jogging along for thirty or forty years without any change. Certainly for some years there had been pipe-stills, but in my opinion the great change came when someone definitely provided the heating and evaporative services in two distinct vessels, which could be varied in any direction and to any extent, irrespective of each other. These are now well known as the pipe-still and the fractionating column. From an engineering point of view, I think that was the milestone in the progress of distillation. Since that time distillation plant has been continuously progressive, to such a degree that a well-known U.S.A. designer said a year or two ago that a new plant which took a year to build was almost obsolete before it was in commission.

Time does not permit me to give details of a modern distillation unit, but I may say that it includes many additional features which have been absorbed from ordinary engineering practice, and there are no insoluble or very difficult problems facing the engineer. The position is now very different. There is no longer any mystery. A sample of oil is taken to a firm that builds distillation units, with the statement: "This oil contains the following products. A plant is required with a throughput of 3,000 barrels a day. What is the price of it, and when will the plant be in commission?"

# Cracking.

'A matter of historical interest which is little known is that one of the earliest cracking plants, known as the New Oil Refining Process, was installed in the London area under the advisory supervision of our Founder President, Sir Boverton Redwood. Its operation ceased at the outbreak of the last war. It proved to be a pioneer in its particular direction, and a number of plants were modelled later on its principles.

The plant required for cracking operations calls for stresses and strains of materials of which engineers at that time had no previous experience to guide them. Even new formulæ for calculations had to be evolved. For example, in estimating in those days the pressure to burst a 1-in. boiler plate, it was assumed that the whole plate fractured simultaneously. With a steel wall 4 in. or more thick, such an assumption could not apply. Our first experience of this type of plant came when we were asked to provide a unit for large-scale experimental work. We, like everyone else, had no previous experience to guide us, particularly with regard to the reactor vessel. We obtained a specially forged ingot of steel, bored out to the required inside diameter, and made a special high-pressure metal to metal cover-joint, of which we were rather proud. The remainder of the unit presented no particular difficulties. The plant worked for some time as an experimental unit, and it was finally installed as a works experimental unit in a large refinery. It was designed by two Past-Presidents of the Institute, with of course help from the engineers.

There is continual development in the manufacture of cracking plants, but from an engineering point of view they no longer present insoluble problems, although there is doubtless room for improvement, which is continually taking place. Further experience is available from other engineering industries in the matter of stresses and strains of materials.

# Refinery Treatment.

The first impression of the layman-that is, anyone other than an operative chemist-is that refinery treatment operations appeared, at any rate at that time, to consist of administering strong doses of sulphuric acid followed by doses of caustic soda. This method was repeated at intervals so long as the oil showed any recalcitrancy or resistance, and until it yielded up, in a most objectionable form, the deleterious matter which the chemist wished to remove. The engineer's problem was in the handling of sulphuric acid, the construction of the washers, and, most important, the disposal of the acid sludge. The last of those points became such a difficulty that investigations took place in all directions to find alternative methods of treatment. One enthusiastic research chemist was asked to concentrate his whole time and energy on finding a method of desulphurizing benzine without the use of acid or soda. Some months later he produced a treatment which had the great advantage that the equivalent to the acid sludge was dissolved in the spent treated liquid. With natural enthusiasm, he introduced this to the oil refiner and the engineer. The former pointed out that the medium proposed would attack steel washers to such an extent that the process would be impracticable. The research chemist for some days suffered from great depression, until the engineer pointed out that even if the washers were destroyed and replaced every year, the treatment would still be economical. On this basis large-scale operations were carried out. A point that had been overlooked was that the material had such an affinity for the sulphur compounds that the washers were left untouched. That was some years ago, and the washers still exist, but not as washers, as they have been displaced for a long time by counter-current continuous washers (another progressive improvement developed by members of this Institute). Thus an engineer expedited the introduction into the petroleum industry of the hypochlorite treatment, which otherwise might have been delayed, though not for long, and which is familiar to all of you to-day. Incidentally, the hypochlorite was first produced electrolytically.

Another problem of treatment for the engineer was the handling of 50 or 60 tons a day of sulphur dioxide for the Edeleanu plant. Much less was known about welding then than is known to-day. The various vessels were riveted, and the rivets and seams were afterwards welded. The plant was free from leakage, although combined riveting and welding is considered nowadays very bad practice.

As there has not appeared in the Press for a long time any injunction restraining a refinery from making a nuisance with its acid tar, presumably some method of dealing with it has been evolved, or other methods similar to those mentioned above have been developed, which Sir Boverton Redwood would describe as follows : "The tendency is for refinery treatments to be of the *suaviter in modo* type rather than the *fortiter in re*".

#### Storage and Transport.

With regard to surface storage tanks, it is doubtful whether there were many of them with wooden roofs in this country in 1914, but there were a great many in America, and they were the primary cause of some of the huge fires that occurred there. The general improvement of our surface storage tanks here was, first, in the direction of reduced steel consumption wherever possible without reducing the factor of safety in essential places. For instance, it was quite common to find bottom plates 3 in. in thickness, and they are now 1 in. A 10,000-ton tank has a surface area of about 10,000 sq. ft., so every 1 inch represents roughly 50 tons; therefore by reducing a 3-in. bottom to a 1-in. bottom one saved 100 tons in the storage of 10,000 tons of oil. In the ordinary storage tank there is a ratio between the height and the diameter which provides a maximum storage of oil for a minimum weight of steel. In actual fact, it is the roof and its supports which provide the limit. In a riveted and caulked tank the factor of safety of strength of the tank was always calculated through the rivetholes section which meant that the body of the plate was always much stronger than the joint. A further step was to cut down the thickness of the whole plate and to reinforce the joint with a butt-strap or butt-straps such as are used on the Lancashire boiler. Gradually the riveted and caulked tank is giving place to the all-electrically-welded tank. For the very reason that I have just mentioned, the joint in this case is the strongest part of the job, and consequently the plates can be reduced in thickness while still providing the same factor of safety. The welded tank with the floating roof will probably prove to be the ultimate development in surface storage. With floating roofs there is no limitation in size and no risk from fire, a fact which is recognized by the insurance companies, who charge a much lower premium. The great saving is in the elimination of breathing losses. In one case, where small tankers were continuously loaded from shore tanks, the breathing losses were estimated to be 5 per cent. with the old-type tanks. These were replaced by floating-roof tanks, with the result that the breathing losses were less than 1 per cent.

# Transport.

With regard to pipe-lines, ordinary screwed and coupled pipe-lines have given place to all-welded lines on large permanent installations (an outstanding example is the Iraq pipe-line), whilst for lines which are periodically lifted and re-laid there are the various types of proprietary or patent joints, There is nothing much to say here in connection with reciprocating pumps, which, when they are driven by steam engines, are extravagant in steam, and I am inclined to look on them now as a faithful servant of the past.

With regard to centrifugal pumps, this country probably holds the premier position in the design, construction, and use of centrifugal pumps, particularly high-pressure pumps. There has, of course, been ample opportunity to gain experience, owing to their extensive application in the mining industry here, where they deal with water not only of a highly corrosive nature, but heavily charged with solid matter. Their use effects economy in every direction. Let us take the case of a pipe-line running from an oilfield to the coast or to a refinery through miles of jungle or desert, where good water is not very plentiful and boosting stations are necessary. Usually oil is found in difficult outof-the-way places, and all material of every kind has to be transported to the various pumping sites, including cement, bricks and so on; there is just a plain desert or jungle, and everything has to be transported to the sites. The reduction of material to the minimum possible amount is therefore essential, and this involves the use of high-speed plant.

Another point to remember in the case of a main pipe-line operating continuously 168 hours per week is that reliability of pumping plant is the first essential. An hour lost is lost for ever. There are cases in which steam turbines have run without a stop for two years (I can vouch for one which came under my supervision), so that this form of prime mover can be considered fairly reliable. It is doubtful whether any other prime mover has such a record. As the centrifugal pump is also a very reliable piece of machinery, turbines coupled to centrifugal pumps fulfil our requirements. Further, the flexibility of centrifugal pumps permits of their operation in series either at short or long distances apart. I will give you some particulars in round figures of such an installation, as follows: 750-h.p. turbines direct coupled to high-lift centrifugal pumps capable of pumping 2,000,000 gallons per day at a pressure of 600 lb.; four stations, 50 miles apart, all capable of being connected in series—*i.e.*, the discharge of one pumping into the suction of the pump in the next station at a slight pressure, which is an advantage, particularly in the case of an oil of high volatility. So far as can be ascertained, this was the first installation of its kind in the world. The plant has been in continuous operation since 1919, which is an indication of its reliability. These units were direct coupled, and operated efficiently from 1750 to 2000 r.p.m. Turbines of much higher speed would have been even more efficient with reduction gears to the pumps. Those responsible for the installation considered that there were sufficient innovations in what was at the time a revolutionary departure from ordinary pipe-line practice. High-speed gears have been introduced in extensions of this installation, where the turbines operate at 6000 r.p.m., reduced to 1200 for the pumps, and in these further developments the units are twice the capacity-namely, 4,000,000 gallons per day.

Centrifugal pumps can, of course, be driven by oil engines, although the gearing occasionally presents some difficulty. Provided the cost and reliability can be adjusted, the alternative would be to use electrical reduction gears by employing a generator and motors. The centrifugal pump is now in common use in every refinery for every purpose, either for hot or for cold liquids. In the old type of washer it was used as the agitator. It has broken down the conservatism of marine engineers as it is used in many ways on board ship, and has even found its way into tankers as a cargo-pump.

One criticism of the centrifugal pump is that it cannot exert pressure beyond that for which it was designed; but that is often turned to an advantage. For instance, in the case of a ship being moored a long distance from the bunkering station, perhaps round the corner or out of sight, the engineer who is receiving the tankers can, when he has the right quantity, close the delivery valve; the pump at the pumping station does not build up any appreciable rise in pressure.

The centrifugal pump has also been criticized as being weak on the suction side. My experience is that with any pump where the material to be pumped has access to the suction side of the pump it will operate. One of our operations in drilling is to pump mud loaded with barytes, weighing up to 140 lb. weight per cubic foot, through reciprocating pumps. Up to date I have not tried a centrifugal pump for this work, but there is a record of a mine shaft being sunk in Yorkshire when running sand was encountered and centrifugal pumps were installed to pump this sand until such time as a refrigerating plant could be commissioned to freeze the sand and enable the sides of the shaft to be bricked up and sealed off. There was, of course, a certain amount of wear and tear on the pumps but they operated successfully.

Another example of the use of centrifugal pumps to pump almost solid material was an installation for the recovery of tin from tin tailings in Cornwall, where since the time of the Phœnicians tailings had been run into a valley and practically filled it. A barge was equipped with a large centrifugal pump driven by an electric motor, and the tailings were pumped to plant on the mainland where the tin was recovered.

Âgain, there are centrifugal pumps operating at 1800 lb. per square inch in a hydraulic system with no accumulator, which indicates the flexibility of the pump in both directions.

The centrifugal pump must have a place as one of the milestones on our path of progress.

# Tankers.

Engineering development in the tanker vessel has largely taken the form of improvements in propelling machinery, the diesel-engine direct drive having displaced the triple-expansion steam engine. A ship in design may be considered as a girder homogeneous throughout its length—that is, it should not have any variations in rigidity or flexibility. The foundation of a diesel engine calls for rigidity and solidarity. In fact, on land several hundred tons of concrete are considered necessary. In using a diesel engine for marine drive, therefore, a compromise is necessary. Whereas the diesel engine is decidedly superior in regard to fuel economy, the question of reliability and upkeep must also be considered. Assume a tanker makes six voyages a year over a certain distance with a tripleexpansion steam engine and a tanker of similar size propelled by a diesel engine does only four trips a year over the same distance, due to longer periods for overhaul, the economy of the diesel is lost and the commercial operator would revert to his steam engine. To a group of petroleum technologists this may appear to be heresy, but one must look at these matters from a commercial point of view. It should be emphasized that these remarks apply only to the tanker which is loaded and discharged in a few hours, during which time no work is permissible in the engineroom. Vessels carrying ordinary cargo often take two to three weeks to load, a similar time to discharge, and possibly several days at intervening ports. There is no restriction on work in the engine-room during these periods. There is ample time, therefore, to effect repairs and make adjustments without delay to the ship. This is the reason why the diesel engine has displaced steam in the ordinary cargo or tramp steamer.

Steam turbines with double reduction gears have also been introduced. The disadvantage of a mechanically geared turbine is that it is not reversible; consequently the vessel always has to carry a reversing turbine and, in order to reduce the weight as much as possible, its power, compared with that of the ahead propulsion, is very much lower.

The tanker carries cargo only one way, and its pumps for discharging cargo are used only a few times each year; nevertheless, they are of considerable weight, and occupy a large part of the ship which could be used for cargo space.

I suggest that an electric power-station, consisting of high-speed turbogenerators, should be installed on the vessel, and that the propeller shaft should be driven with slow-speed motors of the rolling-mill type. The pumping machinery should consist of centrifugal pumps submerged in the cargo tanks, driven by vertical-spindle, totally enclosed motors on deck. The space occupied by the older type of pumps should be used for additional cargo space, and it would give an increase of at least 10 to 15 per cent. Such a vessel could be controlled directly from the bridge, and could reverse as well as it could go ahead, and it is very probable that the speed could be considerably increased with a small extra cost.

You may say that there have been electrically propelled vessels in existence for many years, such as tramps, liners, and warships. I agree with you and I made the above proposal in 1920, after I had been on the trial trip of an electrically propelled cargo ship built in this country. There is plenty of room for development in this direction. This is one branch of the industry where progress lags. After the last war there were extraordinary expansions in various directions, and after this war also we shall see similar developments.

To-day I am here to give you a retrospect and not a prophecy, but I would ask you to consider the possibility of amphibian air tankers carrying 1000 tons. The Suez or Panama Canals would present no obstacle to them. The 1000-ton air tanker is a probability after the war, and will prove a formidable competitor to sea-borne tankers.

I have taken a great interest in the electric propulsion of ships, and should not be at all surprised to hear after the war that victory at sea or avoidance of defeat had been due to the greater manœuvrability of electrically propelled ships.

You may have noticed that I have devoted a considerable amount of

time to the electrical side of my subject and to the part that electricity has played in our industry. At any rate, it is proportional to its importance. The applications to which I have already referred may be termed the benevolent applications. Let us turn now to the malevolent side, which comprises lightning, static electricity, and corrosion, the effects of which are not confined to the oil industry.

# Lightning.

Lightning discharge, as you know, is a dissipation of electrical energy generated by the heat of the sun. When the energy is dissipated in a short space of time it is popularly known as a flash of lightning. In temperate climates the energy is more frequently dissipated quietly, over a longer period of time. In neither case is the popular idea borne out that the discharge always takes place towards the earth; it is just as common the other way. In fact, the flow is not necessarily unidirectional; it may alternate with a very high frequency.

Our problem is to protect our plant from possible damage. I have stated on previous occasions that there is no record so far of the destruction by lightning of a gas-holder, although it is possible that they are in continuous operation dealing with electrical discharges. The reason is that the water tank of the holder forms an excellent and permanent good earth. In the older type of gas-holders the guides had ornamental finials, which, although not necessary, were of assistance in promoting silent discharge. In order to complete the analogy, it was the practice at one time to extend every third or fourth hand-rail stanchion on the roofs of oil-tanks to a height, so that the points of the extensions were above the top of the cone of the tank roof, so that, as it were, the whole of the tank was below the earth.

The primary essential in the case of surface storage tanks and similar all-metal structures is to ensure that they are effectively and permanently earthed. This is of vital importance, as an imperfect or intermittent earth is a source of danger. If complete security is desired, arrangements should be made whereby the efficiency of the earth connection can be periodically tested. Structures which are non-metallic should be enclosed for safety in a metallic cage. Good examples of this are Westminster Abbey and the London County Hall. There is no method of protection against a direct stroke of lightning, but every such stroke is accompanied. often at considerable distances from it, by smaller discharges produced by induction, and the so-called lightning conductors deal with these and the silent discharge previously mentioned. Lightning arrestors fitted to overhead wires, tramcars, and telephones are also for this purpose. It is probable that in a modern refinery the number of tall metallic columns, probably earthed by virtue of the method of installation, form in themselves a protection by silent discharge against a violent discharge of lightning. Throughout the atmosphere, and probably through the earth crust as well, there are always small differences of potential per inch, and it is when some atmospheric disturbance takes place and builds these up in opposing directions that we get the difference in pressure which may result in a destructive discharge. The important thing to do to eliminate that is to promote the silent discharge. Generally speaking, the risk from lightning, provided reasonable precautions have been taken, is very small.

Reference has already been made to storage tanks with wooden roofs. Those wooden roofs are covered, for protection from the weather, with thin iron sheets, about 24 gauge. Thousands of square feet of that metal insulated with the wood in between are in effect an enormous condenser, and even with silent discharges, some miles away, the roof becomes literally charged up, until finally it discharges over the edge, where, it not being oil-tight, explosive gases are escaping. That has been the cause of the large fires that have taken place, which could easily have been prevented if the roof-plates had been properly earthed at various points.

In some parts of the world these subsidiary lightning discharges are called "statics," a misnomer which endows static electricity with power which it never can possess.

# Static Electricity.

I have referred to static electricity as a malevolent agent, but perhaps in petroleum and other industries it has been benevolent, inasmuch as it has on occasions supplied the answer to a mystery problem which would otherwise have been insoluble. Some years ago, in a short paper on the causes and prevention of fire, which I presented to this Institute, I enumerated the elementary principle essential to a fire or explosion namely, an explosive mixture and a means of ignition coincident and of sufficient incendivity to ignite the mixture.

With regard to the existence of the explosive mixture, at some time when a tank or other vessel is being emptied or filled with crude petroleum or a product thereof there must be a point when the mixture of air and petroleum is explosive. Some years ago a special investigation was made by specialists both here and in the tropics, and very rarely, if ever, could they succeed in collecting a sample which was explosive. Hence the comparative immunity from fire in our industry.

The other point is whether static electricity can be generated of sufficient incendivity and duration to raise the mixture around it to ignition temperature and ignite it. This is the most debatable point. It is probable that static electricity is generated when certain petroleum products are\_ pumped at turbulent flow, well above the viscous flow. When centrifugal pumps were used as agitators in intermittent washers no trouble was ever reported. Possibly the mixture was always too rich. Then it was previously assumed that the static electricity was generated by dry particles of petrol insulated from each other and rubbing together to form frictional electricity. So-called dry cleaning was the only really positive case in which static electricity could be depended on to create a fire or explosion four or five times out of ten, and it was effectively remedied by adding a small percentage of a chemical to the petrol, which made it conductive. It is only a comparatively short time ago that oil companies received enquiries from dry-cleaning firms for petroleum which was safe for their particular industry. We now hear of mixtures of oil and water causing trouble which rather contradicts what has been said above. There should be no mystery about this matter. Our Standard Methods of Test are accepted throughout the world, and they are based on the practical work

of our members. With a little special work on this question we should be able to issue equally valuable and authoritative information on this and other similar points, and this work could be carried out by no body better than by the Institute. Should anyone feel disturbed on the matter, the preventive action recommended is to maintain oil velocity at viscous flow or near to it, and to maintain metallic contact, so that there is no possibility of a spark occurring between various portions of a plant; even a small piece of chain is quite sufficient.

## Corrosion.

We may not all accept the theory that all corrosion is caused by galvanic action, but there is enough evidence to support that theory. Theories of corrosion cause as much discussion as the origin of petroleum, although the two great one-time opponents, the acid theory and the electrolytic theory, became united some time ago in a common interpretation. The experiment will be remembered in which a strip of steel is cut into two halves. one half being then subjected to strain. If those two halves are placed in an electrolyte and connected through a galvanometer it will be seen that a current is flowing—that is, the two pieces originally alike have now opposite polarities. This is what occurs in a steam boiler. The shell plates of the boiler have not been subjected to torsion or stress, whereas the ends of the drum have been, and that accounts for the difference of polarity. There is enough material in the water of the boiler to act as an electrolyte; consequently we get all the multitudinous little galvanic couples which give the effect that we know as corrosion. The first attempt to deal with this was the introduction of zinc plates, which were eaten away in protecting the boiler-plates. What they actually did was to superimpose one large galvanic battery to neutralize the effect of all the small ones. When the zinc plates became coated with other material, as they frequently did, their polarity changed, and, instead of protecting the boiler-plates, they became attacked themselves. Later a method was used which included the fitting into the boiler of a renewable iron anode. and an external adjustable supply of electricity was transmitted between this and the boiler plates, with effective and permanent benefit.

In an account in a periodical about a year ago it was stated that, on a pipe-line running across a wide-open plain where the soil was corrosive, windmills were built at intervals to drive small electric generators, which supplied current between the pipe-line and iron anodes driven into the ground, to protect the pipe-line from corrosion at the expense of the anodes. Quite recently there appeared in the abstracts in our *Journal* a reference to similar protection by the utilization of zinc plates, a retrograde step at any time, and particularly undesirable at the present time. In case someone is coming forward after hearing this with a scheme to save the inner casing of a well in corrosive soil at the expense of the outer casing, I had better state at once that Dr. Dunstan and I made this proposal in 1916. It had a mixed reception, but we had the satisfaction of knowing that several years later it was successfully applied on an oilfield.

As a good deal of this address refers to the past, I should say that in connection with boilers there is no question of using zinc plates or any other similar method now. It has been discovered that oxygen is the real POLITECONIKI

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#### 18 DALLEY: ENGINEERING DEVELOPMENT IN PETROLEUM INDUSTRY.

culprit, and, when the first feed-pump was devised (accidentally, I believe) and pumped water into the boiler with no air in it, no corrosion took place. Now, of course, de-aerating or de-gasing plant is used in order to remove any air from the water, so that no corrosion occurs.

I might digress for a moment to say that the process of putting an external current into the boiler was known as the Cumberland process. During the last war I was interested in the building of some tankers, and I was also interested in this question of corrosion, so when the first ship came along the builders were requested to have the Cumberland process fitted to the boilers. The reply was to the effect that they would not take any responsibility for any new-fangled process in their boilers. Our reply to that stated : "Will you kindly advise us how much credit you are going to give us for the zinc plates that are not now required for the boilers", and the incident was temporarily closed. The first ship fitted with the Cumberland process went to the East. After the usual six months of the guarantee operation, the guarantee engineer had to open up the boilers to make his report, and the report, which was handed to me, read something like this: "Never in my long history and experience as a guarantee engineer have I opened up boilers and found them in such marvellous condition as those of this vessel. This, of course, I attribute in a large measure to the infinite care that I always bestow as a guarantee engineer and in some small measure to the Cumberland process."

It will be appreciated that to describe adequately and in any detail the subject with which I have dealt to-day would require a whole pre-war volume of the *Journal* and a specialist on each subject for each number. I have attempted to give a selection of milestones on the road of progress. Electricity I have given a prominent place for various reasons, one being that it has probably been the greatest contributor to our progress. You will have realized already that there are many applications of electrical engineering to which I have made no reference.

 $\overline{I}$  hope that such information as I have been able to give you to-day is sufficient to show not only the great progress made in the period reviewed, but also the contribution to that progress made by our members, a record of which the Institute can be justly proud.

# THE INSTITUTE OF PETROLEUM.

# LUNCHEON.

#### TUESDAY, 1ST DECEMBER, 1942.

A joint luncheon of the Institute of Petroleum and the Oil Industries Club was held on Tuesday, 1st December, 1942, at the Connaught Rooms, Great Queen Street, London, W.C.2, when MR. C. DALLEY delivered his Presidential Address.

DR. A. E. DUNSTAN, in opening the proceedings, said it was a remarkable fact that the Institute was meeting on the present occasion under two Presidents and had the assistance of two very excellent Secretaries. There were not, however, four incomprehensibles but only two incomprehensibles, Mr. Dalley and Mr. Coe.

Many long years ago St. Paul referred to a certain course of action as one of supererogation. The work of supererogation which he had to perform now was to introduce Mr. Dalley, who was about to deliver his Presidential Address. He was sure that he could speak for all the members when he said how glad they were to see him amongst them again with renewed health and vigour. Both Colonel Auld and he had known Mr. Dalley for nearly a quarter of a century, and neither of them had found any serious fault in him. At one time he had held an important position in the Westinghouse Company, and then, at the end of 1914, he had taken up another more important position in the Anglo-Persian Oil Company. He remembered Mr. Dalley telling him that one of the first things he was told to do there, almost before he had got settled down in his office, was to design a dozen tankers. He did it, and the tankers actually floated and carried cargoes from various parts of the world ! All the time that he had known Mr. Dalley he had found him conscientious and immensely hard working, and, most important of all, a friend in the truest sense of the word.

COLONEL S. J. AULD said he regarded it as a great privilege to be present and to support Dr. Dunstan in his words of commendation of the President. He thought the members of the Institute were extremely fortunate in having their great friend Christopher Dalley as their President at the present time. Mr. Dalley had a hard row to hoe, because it was necessary to consider now the building up of the Institute and its activities after the war, and in the present difficult times it was a good thing for the Institute to have a President who would guide it in the future and build up, on the foundation which had at any rate been partly laid, the steel work on which the structure would afterwards be carried.

MR. DALLEY then spoke, a full report of his address being on pages 1-18. MR. T. DEWHURST closed the proceedings by saying :—In view of the subject-matter of the early part of Mr. Dalley's Address, it is perhaps meet and fitting that a geologist should express thanks and appreciation to Mr. Dalley on your behalf. The well-known Parliamentary procedure known as the debate on the Address is not permissible in the case of a Presidential Address, but fortunately a wise provision enables us to

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express our thanks and appreciation. In the famous lawsuit between Turner and Whistler, Whistler admitted that the disputed picture was painted in two hours, but he claimed that it did not represent two hours' painting but the knowledge and the experience of a lifetime. Similarly, although the preparation and delivery of Mr. Dalley's Address may have occupied a comparatively short period of time, I claim that nevertheless the Address represents the crystallization of the knowledge and the experience of a lifetime. It demands and will receive and amply repay the closest study and consideration of all of us. Meanwhile all that we can do is to express our appreciation and thank our President for giving us the fruits of a very long and valuable experience. I invite you to signify in the usual way your appreciation of the Address and your thanks to our President. (Applause.)

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# THE NEW EDITION OF THE I.P. STANDARD METHODS FOR TESTING PETROLEUM AND ITS PRODUCTS.

#### By J. CANTOR, E. P. DRISCOLL and A. OSBORN.

#### SUMMARY.

The new edition of the "I.P. Standard Methods for Testing Petroloum and its Products" represents a thorough revision.

In the interests of uniformity all the methods have been rewritten in a standard format, and in many cases technical improvements developed since 1935 have been incorporated. A few methods, which are no longer in use, have been discarded, while several new methods have been added. Certain methods prescribed in official specifications and not previously standardized by the Institute have now been included. Thus the lubricating-oil oxidation test required for Ministry of Aircraft Production Specification D.T.D.472 has now been published in detail for the first time. Official bodies such as the N.P.L. and the M.A.P. have co-operated in the work.

Amongst new methods may be mentioned the following : Aniline point of products which develop high vapour pressure at the aniline point temperature, diesel fuel diluent in crankcase oils, Abel flash point of viscous materials, specific gravity by displacement, flotation, and Westphal balance, and a rapid method for sulphur estimation by combustion in a quartz tube.

Methods for calculating diesel index, viscosity index, and Redwood seconds from kinematic viscosity units have been included. A.S.T.M. methods newly adopted include colour by Saybolt chromometer, Cleveland flash point, gum stability, aviation fuel knock-rating, centrifuge method for sediment in fuel oils, and kinematic viscosity by the suspended-level and the Fenske viscometers, although the viscosity method has been substantially medified.

The specification for I.P. petroleum spirit has been altered, and the thermometer specifications altered and expanded. Certain standard methods, previously published only in the *Journal*, for example, Specific refractivity, have been incorporated.

The paper runs through the present methods, and discusses briefly the technical alterations which have been made and the reasons for them.

THE Institute decided to take advantage of the necessity of reprinting the Standard Methods book to introduce a number of new methods and modifications of existing methods developed since the previous edition. The Editorial Panel was appointed to write the new methods, and was also requested in the interests of uniformity, to rewrite all the existing methods according to a generally agreed standard format. The task proved to be of considerable magnitude, but eventually all the corrected proofs were returned to the printers. The Standardization Committee then decided that, in view of the extensive nature of the revisions, it would be helpful to the users of the methods to have some explanation of the changes and of the reasons for them. The members of the Editorial Panel were accordingly invited to present a paper on this subject.

It is not intended to discuss the strictly editorial changes, except to mention that we are aware of misprints and inconsistencies; some, such as the occasional variation in style, which will no doubt have been noticed, have been due to the rapidity with which the book has been produced. We found, as time passed, that our "journalese" had improved (or deteriorated, according to your views), and that our ideas on style had become modified. It was, however, too late to correct the earlier mistakes without considerably delaying publication and, with regret, we were compelled to allow these inconsistencies to remain.

Reverting to the actual technical innovations, we propose to run through the methods, directing your attention to the alterations, and stating, as far as we are able, the reasons for them.

We shall not attempt to enumerate the large number of minor changes, such as the more detailed instructions for making up reagents and the more comprehensive manipulative details given in almost every method. We shall discuss only the major alterations, all of which were authorized by the Standardization Committee.

The first of the major changes is found in the Aniline-Point determination, for which two of the new A.S.T.M. thermometers have been adopted. These have a more open scale than the former I.P.T. thermometer, and are calibrated for 51-mm. immersion, with the result that the immersion mark is just above the surface of the mixture of sample and aniline, instead of in the cork, as with the former thermometer. Consideration was given to the question of adopting the A.S.T.M. method, but it was decided that the more complicated mechanical stirring offered no advantages over hand stirring. For testing the more volatile components of aviation fuels a modification has been introduced requiring the use of a narrow-necked, securely corked tube, the sample and aniline being mixed by shaking. The aniline point of *n*-heptane has been allowed as a criterion of aniline purity. Although no special procedure has been described for dark products, the desirability of such a procedure is recognized.

The method for the determination of Aromatics has been extended to include the range of products from aviation spirit to kerosine. Consequently a formula has been given for calculating the correction for unsaturated components, since the original factor was applicable to motor fuels only.

A procedure for dealing with wet oils has been included in the Ash determination. It is considered that rigid standardization of the temperature of final ignition would greatly improve this method. For ash determination of greases, the sulphation method has been included, in addition to the simple ignition method. Although requiring more time and manipulation, it gives more concordant results.

The estimation of Asphaltenes has been improved by the introduction of a more rigid specification for I.P. petroleum spirit, as there is evidence that the variation in paraffin/naphthene ratio permitted by the old specification caused variation in the results. It is recognized that this test is in need of further improvement, and it is the intention of the appropriate panels to consider the possibility of using other solvents, of fixing the quantity of wash liquid, and of extracting wax by means of a refluxing process.

The Burning Test method is unchanged from the revision published in the *Journal* in 1940. It is included in the current Petroleum Board Specifications and is, in consequence, in use in the U.S.A.

In the Calorific Value test the A.S.T.M. method for correcting for radiation was considered superior to the old I.P.T. method, and has been adopted. The thermometer specification is, however, more stringent than that of the A.S.T.M., a modification considered necessary for the achievement of satisfactory precision. It may be pointed out that a standard procedure is required for the determination of the calorific value of gasoline.

The Ramsbottom Carbon Residue test differs from that of the A.S.T.M. in the use of glass instead of steel bulbs (although the A.S.T.M. now permits glass as a War Emergency measure). Other differences are in sample quantities and closer limits for the sample quantities. The present method is more comprehensive than the old, covering light distillates and residual fuels, and it has been generally amended in accordance with A.I.D. practice.

The method for the Cloud and Pour Points has been modified only by altering the immersion of the Low Cloud-Point Thermometer to correspond with the recent A.S.T.M. revision.

In the Cold Test for motor fuels, etc., the A.I.D. practice regarding apparatus selection has been standardized—*i.e.*, a "go and not-go" procedure for testing against a specified temperature, and a procedure for determination of the actual temperature are provided.

Following the Standardization Committee's decision to introduce tests called for in official specifications—and not previously adopted by the Institute—the determination of Colour by means of the Saybolt instrument has been included. This also applies to Diesel Index and the Cleveland Open Cup Flash Point Methods.

In the Demulsification Number method the American method of reporting in seconds has been adopted in place of the previous method (reporting in minutes).

A tentative method for determining Diesel Fuel Diluent in crankcase oils has been introduced, dependent on steam distillation at 130° C. This method has been in use for many years, and is printed in the hope that eventually it will be adopted as a standard method.

The only difference of note in the Preliminary Distillation of Crude Petroleum test is the reference to water in the distillate. It is felt in some quarters that a standard scheme for the evaluation of a crude oil, such as that suggested in the old test I.P.T.—C.P.3a, should be elaborated. Pending the development of such a complete scheme, the A.S.T.M. method for determining the naphtha available in a crude oil has been adopted.

In the case of Gas Oil Distillation, it was found that the original method adopted by the A.S.T.M. as well as by the I.P.T. was not in general use. The Standardization Committee therefore decided to abandon the collection of 50° F. boiling range fractions in separate receivers, and also to stop the distillation at  $350^{\circ}$  C. The distillation of 200 ml. of sample was retained, so that the same apparatus may be used to obtain the 10 per cent. residuum required for the carbon residue tests. A revision of the Cutback Distillation test, in which the residue is poured at  $300^{\circ}$  C. instead of  $360^{\circ}$  C., was published in the *Journal* in 1941, and the revised method has been included in the new edition without alteration. At the time of the revision consideration was given to the possibility of developing a method for separating the components of a cut-back which involved a minimum of alteration to the properties of the constituents. It was recognized that such a method would be very useful, and that investigation should be undertaken when the opportunity occurred. The present method has, however, proved its value as a rapid, routine, control test.

The Doctor Test has been amplified by adding a method of removing hydrogen sulphide and also a confirmatory test for peroxides.

More rigid specifications have been adopted for Drop-Point cup and thermometers; it is hoped that eventually the metal cup will entirely replace the glass cup, since the former can be manufactured to closer limits. The apparatus and the procedure have been described in much greater detail than before.

Several changes have been made in the procedure for the preparation of the specimens for the Ductility test, the most important being that the specimens are placed in the water-bath for 30 minutes before removing the excess bitumen, as in the A.S.T.M. method.

The Abel Flash-Point method is the only petroleum test covered by legislation, and hence could be altered only editorially. Although the original Acts have been repealed and the current legislation does not mention the use of a stirrer, nevertheless the stirrer apparatus for viscous materials is perpetuated by Orders in Council. The stirrer apparatus was referred to in the 1935 edition, but no instructions were given as to its use. A suitable procedure for the stirrer apparatus has now been included in the method.

The order of the two procedures for determining Existent Gum has been reversed, as the majority of samples tested are of low gum content, and consequently must be tested in the larger dish. Previously the test was first carried out in the smaller dish, and repeated using a larger quantity of sample when the actual weight of gum was less than 5 mg. A specification for glass suitable for the dishes has been given. A shield has been prescribed for the potential gum flask to provide protection against explosion. In addition to these gum tests, the A.S.T.M. bomb test for gum stability has now been included in the I.P. methods. The Gum Panel did not consider that this method shows any decided advantages over certain other bomb tests, but it has been adopted for the sake of conformity with the A.S.T.M.

The Cetane Number determination, now included in the book for the first time, was published in the *Journal* in 1938. The Diesel Fuel Panel was of the opinion that the method possesses certain advantages over the A.S.T.M. method, which involves the use of a special engine.

The 260° F. mixture temperature modification of the C.F.R. method for determining the Knock-Rating of aviation fuel had fallen into disuse, and has been replaced by the A.S.T.M. method. For experimental fuels of over 100 O.N. the modified C.F.R. method, in which the ignition is set at  $17^{\circ}$  early, has been retained : this method was published in the *Journal* in 1941. The motor-fuel method has been brought more or less into line with the 1941 A.S.T.M. modifications, which include the use of an ice-tower for humidity control. The use of an instrument which greatly simplifies the setting of the C.F.R. bouncing-pin has been permitted. This instrument, which was developed in this country, is the subject of a paper published in the *Journal* for September.\*

\* "Spring Tension Balance for Bouncing Pin," by P. Draper, J. Inst. Petroleum, 1942, 28, 209.

The Loss-on-Heating test may now be made on samples containing water, provided the water content is not excessive. The time during which the material is heated in the oven is limited to a maximum of 51 hours. The test is no longer applicable to lubricating oils. It is generally agreed that the oven specification requires amendment, but this has been postponed for the present.

Another method now published by the Institute for the first time is the Lubricating Oil Oxidation Test, prescribed in M.A.P. specification D.T.D. 472, and which appeared formerly in D.T.D. 109. Many details of apparatus and procedure have been made more precise to ensure good reproducibility. As with other methods prescribed in official publications, this test has been standardized in full consultation with the official body concerned.

A modification has been made to the grease worker used for the Consistency test (now "Penetration"), so that when the plunger is removed there remains sufficient sample to be smoothed level with the top of the cup. Spatula working has been eliminated, and a special procedure for petrolatum added.

Pending a thorough revision of the Sampling method, which it is hoped will be ready for the next edition of the Methods Book, a version based largely on the A.S.T.M. has been published as a tentative method. Criticism of this will probably be of assistance to the panel engaged in producing the standard method. The procedure for sampling bitumen in packages, published in the *Journal* in 1938, has been modified, since it was considered that the section referring to specification limits was not relevant to the sampling method.

The A.S.T.M. volumetric method for Saponification Number, published in 1939, has been adopted; it differs but slightly from the former I.P.T. method. The later A.S.T.M. version, using methyl ethyl ketone in the saponification stage, has not been adopted, owing to lack of experience with it in this country. The former I.P.T. gravimetric method has been modified only in minor details.

For the determination of Sediment in fuel oils the A.S.T.M. extraction method has been substituted for the centrifuge method previously published, as it is required in certain Petroleum Board Specifications.

The I.P. Setting Point method has been slightly modified by altering the temperature of pouring the sample into the U-tube to  $40^{\circ}$  to  $50^{\circ}$  F. above the approximate setting point, instead of  $15^{\circ}$  F. No alterations have been made to the Wax Setting Point method, but it is suggested that a specification for a thermometer for higher melting waxes be prepared for the next revision.

In the B.S.I. Transformer Oil Sludging test, the  $60-120^{\circ}$  C. boiling spirit formerly specified has been replaced by I.P. spirit, to simplify the supply position. Other minor modifications include the use of oil in the manometers, to prevent humidification of the air after it has passed through the drying train, and emptying the sludge flask at a temperature below  $50^{\circ}$  C. instead of below  $100^{\circ}$  C. as formerly.

For the Ring and Ball Softening Point method the tapered ring has been made obligatory for materials of softening point above 80° C., while below 80° C. either type of ring may be employed. Stirring has now been specified throughout. The Specific Gravity section has been considerably expanded, and now includes the displacement and flotation methods, and the use of the Westphal balance, as well as the hydrometer and pyknometer methods. The hydrometer specifications have been modified slightly to meet the wishes of manufacturers. A table showing the relation between A.P.I. gravity and specific gravity has been included, together with an extended temperature coefficient table.

In the bomb method for Sulphur it is now specified that the bomb shall remain unopened for 30 minutes after ignition, to ensure complete absorption of sulphur compounds. The volumetric method for determining sulphur content by the Lamp method has been improved by the introduction of bromophenol blue indicator and by advising the use of purified air when the atmosphere is not free from sulphur compounds. The new A.S.T.M. lamp has not been adopted, in view of lack of experience with it in this country, while the use of the new sintered glass absorber has been made optional.

A new rapid method of determining sulphur by combustion in a heated quartz tube, followed by titration of the products of combustion absorbed in hydrogen peroxide, has been published as a "Proposed Method." It is hoped that further experience with this will lead to its adoption as a standard method.

Another new method deals with the detection of corrosive sulphur by means of copper strip tests carried out at temperatures and for periods which depend on the volatility of the sample under test.

The only modification in the method for the determination of T.E.L. is the revision of the factor for converting lead chromate to ml. T.E.L./ gallon.

The Reid Vapour-Pressure method has been modified in accordance with the latest A.S.T.M. method, and provision has been made to cover determinations at temperatures other than 100° F.

The multiple-cup bath for Redwood Viscosity, previously described in a tentative method, has now been included in the main method. The formula for conversion of Redwood seconds to kinematic units has been omitted, as tables for the conversion of kinematic viscosity into Redwood viscosity are given in an appendix.

The Kinematic Viscosity method has been considerably enlarged on the lines of the A.S.T.M. method, from which, however, it differs considerably. Although every endeavour has been made to ensure the highest degree of accuracy, the extremely high limits of accuracy at which the A.S.T.M. aims have been relaxed in the present method, and the maximum permissible error has been raised to 0.3 per cent. In an endeavour to reduce inaccuracy due to slight timing errors, a specification for time recording devices. supplied by the N.P.L., has been included, and the minimum time of flow has been increased from 80 to 120 seconds. The B.S.I. instrument has been included in addition to the suspended level and the Fenske, as well as a modified suspended level viscometer designed to minimize top drainage error. The square-shouldered suspended level viscometer has not been permitted, since its use involves a surface tension correction which is not required for the instrument with a spherical shoulder. For the B.S.I. instruments sugar solutions are permitted as primary calibrating liquids in addition to water, whilst oil standards of known viscosity are allowed as secondary calibrating standards. In the calibration of the No. 1 suspended level viscometer the A.S.T.M. procedure has been modified so that the constant C is dependent on the flow time of water at 68° F., and not on the shorter flow times at 100° F. and 130° F. The minimum flow time for oil standards has been raised to 200 seconds; oil standards whose viscosity has been determined by the N.P.L. are permissible, and a clause has been inserted dealing with the stability of oil standards. A full description of a thermostatically controlled bath capable of keeping within the prescribed temperature limits of  $\pm 0.025^{\circ}$  F. has been appended; this may prove valuable for other purposes. Specifications for the necessary highly sensitive thermometers are also included. Tables are given for obtaining viscosity index from kinematic viscosity at 100° F. and 210° F.

The description of the Standard Tar or B.R.T.A. viscometer has been modified in accordance with the latest S.T.P.T.C. specification. Both the 10-mm. and 4-mm. cups have now been included. A pretreatment (3 hours at 60° C.) has been introduced in order to counteract the effect of previous thermal history on samples of asphaltic bitumen cutbacks. In addition to this, the method by which the sample is brought to the required temperature differs from that of the S.T.P.T.C.

The Water-Content method has been enlarged by permitting the use of glassware with ground-in joints and a wide range of receivers. The nature of the carrier liquid has been altered somewhat to regularize current practice.

The Benzol-Insoluble Sediment and Water determination by means of the centrifuge has been adopted from the A.S.T.M. with a slight modification in the use of 90's benzole instead of American 90 per cent. benzol.

The Thermometer section has been amplified by the addition of a number of new thermometers and, in general, an attempt has been made to conform to A.S.T.M. practice for the new thermometers. A notable exception was made in the case of the kinematic viscosity bath thermometers, since it was considered that sub-divisions of 0.1° F. were not satisfactory for a bath the maximum permitted temperature variations of which were  $\pm$  0.025° F., and a series of instruments has been specified with subdivisions of 0.05° F. A number of minor amendments have been made to the thermometer section, and, in addition, a fundamental alteration has been made in the general requirements. Formerly it was stipulated that all thermometers must be N.P.L. certified, but this clause was in fact observed only for a very small percentage of the instruments in use in the industry. In an attempt to regularize the position and to impose some check upon the large number of uncertified thermometers which are in use, it has now been stipulated that thermometers certified by the N.P.L. shall be used for reference tests, whilst maximum permissible scale errors have been prescribed for all thermometers. Manufacturers are expected to guarantee that these scale errors are not exceeded, but it is finally the responsibility of the user to assure himself that this clause has been satisfied. The maximum permissible scale errors have been so chosen that thermometers which comply will be satisfactory for most routine purposes, without applying any corrections. However, in order to be sure of obtaining the degree of precision quoted for most of the methods, it will be

necessary to use N.P.L. certified instruments and to apply the appropriate corrections.

Alterations to some of the thermometer specifications may be necessary in the future because of supply difficulties, and the newly formed Apparatus Committee intends to consider the desirability of preparing Emergency Specifications for the war period.

In nearly all the methods figures are given for repeatability and reproducibility, and these do not necessarily conform to A.S.T.M. ideas. A great deal of thought and discussion was expended in arriving at these figures, which, in the main, are based on actual experience obtained in some large petroleum laboratories. The figures are not considered impeccable, and co-operation in improving them for the next edition will be welcomed.

Certain methods have been discarded, since they appear to have fallen into disuse; these are determination of expressible oil, dirt, and moisture in paraffin scale and of non-volatile matter in white spirit.

In conclusion, the members of the Editorial Panel would like to thank all those who have co-operated with them in their part of the production of the new edition.

#### DISCUSSION

THE PRESIDENT said he had not yet had an opportunity of studying the new methods, but he hoped that the test with regard to the evaluation of crude petroleum had been revised. He did not like to introduce an element of commerce, but it should not be possible to buy oil on one method of test given in a publication of the Institute of Petroleum and sell it on another method in another publication of the Institute and lose money. Ho thought that such a possibility ought to be eliminated.

DR. F. H. GARNER said that the Institute had been particularly fortunate in having Mr. Driscoll, Mr. Cantor, and Mr. Osborn as the members of the Editorial Panel, because of the vast amount of work that had been necessary in the rovision. At one time it had been hoped to issue the new odition in January of this year, but the work had proved to be too much for that to be done. He wished to stress the fact that the three members of the Editorial Panel had maintained their keenness throughout, even during the stage when the index had to be compiled. Their work had been ably helped by the permanent staff of the Institute.

A special effort had been made to bring the methods of test into line with those of the American Society for Testing Materials. At the moment a reorganization of tho Standardization Committee was taking place. He was glad to be able to tell the members of the Institute that the Council had approved the name of "Standardization Committee" in place of "Chemical Standardization Committee," because it more fully expressed the work which the Committee was doing for the Institute. In the reorganization of the Committee which was taking place there were two particular aims in view. The first was to make the greatest possible contribution to the war effort, and he thought one of the points that had been impressed upon the members of the Committee was the importance of the various methods of test from the point of view of supplies for the various Armed Forces. There are still several test methods dealing with petroleum products in official specifications which are not included in "Standard Methods for Testing." It was hoped that the details of such tests will be standardized in co-operation with the Government Departments, so that all test methods required for potroleum products will be included in future editions. The second aim in view was to establish closer collaboration with the American Society for Testing Materials, which was equally engaged in helping the war effort, and in that connection arrangements were being made for the various Sub-Committees of the Standardization Committee to collaborate closely with the corresponding Committees of the American Society for Testing Materials. As Mr.

Driscoll had montioned, one of the new Sub-Committees which had been formed was an Apparatus Sub-Committee, under the chairmanship of Mr. Jackson, who had been very much interested in the subject for a number of years. The Apparatus Sub-Committee would consider what relaxation was necessary in the thermometer specifications, and so forth, in view of the difficult supply situation at the present time.

It was hoped that the various Sub-Committees would get to work soon with a view to the preparation of a further edition of "Standard Methods for Testing" by January 1944.

DR. A. E. DUNSTAN said that, like Professor Garner, he had been concerned with the Standardization Committee from its inception, and it might interest the members to know how far back the efforts of the Institute went in this vastly important matter. It was in 1917 that Mr. Alexander Duckham addressed a meeting of the Council and put forward his own views on the urgent necessity of the Institute sponsoring definite standardized methods of test, and the Council agreed that that was the right thing to do, but it was not until 1922 that the Institute actually began to take the work in hand. It might interest the meeting to hear of the various Committees that were in operation in that year. The Chairman was Mr. Alexander Duckham. Committee No. 1 dealt with natural crudes and methods of analysis thereof, the Chairman being Mr. James Kewley; Committee No. 2, of which he had the honour of being Chairman, dealt with gasoline and other light distillates; Committee No. 3 dealt with kerosines and suchlike materials, under the presidency of Mr. Robert Redwood; Committee No. 4 dealt with lubricating oils, the Chairman being Dr. Thole; Committee No. 5 dealt with fuel oils, the Chairman being Professor Brame, and Committee No. 6 dealt with bitumens, asphalts, and suchlike materials, under the chairmanship of Mr. Hackford.

He did not think the Institute realized the vast amount it owed to its Standardization Committee. That Committee to-day, under the chairmanship of Dr. Garner, comprehended 106 members. Many of them were members of the Institute, and some were specialists who had been called in to give the Committee their co-operative service. He thought the Institute should express its indebtedness to all those gentlemen for the perhaps somewhat thankless work which they had done month after month and year after year, in order to give the industry authoritative tests on which the fullest reliance could be placed. Their names were set out in the volume, but it frequently happened that members did not recognize their indebtedness to those who carried out work of the kind in question, but just accepted the results of it as a gift from the gods.

With regard to the paper, he thought it would be agreed that Mr. Driscoll had given an extremely informative account of a subject which at first sight might not be regarded as particularly interesting. He himself had listened with the greatest interest to the way in which Mr. Driscoll had put the various emendations forward and the reasons that had led the various Committees to propose them. The volume bore favourable comparison with the corresponding A.S.T.M. publication, and he thought the Institute might well be proud of producing such a book in the fourth year of the war. It contained nearly 400 pages, the paper was extremely good, and the format, typography, and diagrams were excellent.

He thought there should be associated with the 106 members of the Standardization Committee the names of some members of the staff of the Institute who had done valuable work in connection with the volume, especially Mr. Noble, who had seen it through the press, and, before him, Miss Tripp and Mr. George Sell. They had all done yeoman service.

With regard to the collaboration of the Institute with the A.S.T.M., Mr. Kewley and he had helped to bring about that collaboration many years ago; in fact, they had both been present at the eventful meeting in Chicago when the first octane rating method was put forward. The Institute fully realized that nothing could be done without such collaboration, and that it must have the active co-operation, sympathy, help, and advice of the A.S.T.M., which, in fact, it had had in full measure. He hoped that one day there would not be an I.P. standard method book and an A.S.T.M. standard method book, but an Anglo-American standard method book, covering the requirements of the industry all over the world.

MR. J. S. JACKSON said that, although the new method book was an exceedingly fine work, and he could compliment everybody who had been connected with its production, the Institute should face up to the fact that it was an overflow from the past, and that the Institute was still living on its capital. The new book had almost been forced upon the Institute by the action of the enemy in destroying the stock of the former edition. He wondered whether, if the Germans had not been good enough to remove those books, the new edition would have appeared. He had heard one or two whispers of criticism from people who wanted to know why in war-time, when everyone had so much else to do, the Institute had produced a new method book. He thought he was now speaking to a very sympathetic audience, who probably knew why it had been produced, but he had heard people say : "We have got the A.S.T.M. book. Is not that good enough ? In any case this is only a transcription of the A.S.T.M. Why not use those methods, or are you just changing them for the sake of changing them ?" He had a very real admiration for the A.S.T.M. methods, and he acknowledged their value, but he thought it was quite obvious that they had never met the whole of the requirements of this country, and he did not think they ever could. There must always be an I.P. book of methods as well as an A.S.T.M. book. There would always be characteristic English methods which would not appear in American publications, such as the Redwood Viscometer method, the Abel Flash-Point method, the B.S.I. methods, the Air Ministry oxidation method and the method for determining the engine performance of diesel fuels. All those were very important methods and they must be published in a collection of methods. He thought the Institute had a contribution to make on the subject; it should not merely sit still and wait for the A.S.T.M. to produce methods.

He had taken the trouble to go through the new volume to find how many I.P. methods there were in it, and he found there were eight unmodified A.S.T.M. methods, twenty-six modified A.S.T.M. methods, and forty-one I.P. methods, so that more than half were I.P. methods. With regard to the modified methods, he wished to remove the impression, if it existed, that they were modified just to make the English method different from the American. Every Committee with which he had been associated had modified an A.S.T.M. method only if they felt confident that they had an improvement to offer.

It was no use the Institute designing a different method from the A.S.T.M. if it was going to do nothing more about it. Dr. Garner had referred to the collaboration and co-operation with the A.S.T.M., but personally he thought that this co-operation had been more theoretical than practical in the past. He sincerely hoped that it would be more active in the future, and that when the Institute decided that it had improved an A.S.T.M. method, it would forthwith take the matter up direct with the A.S.T.M. That had already been done very effectively in connection with oil measurement; the Americans had welcomed the suggestions made, and co-operation was proceeding very satisfactorily. He hoped that whenever a Committee of the Institute decided on a modification it would not let the matter rest until it had come to some final agreement with the A.S.T.M. to carry it through or to drop it. He thought it was rather a defect in the new book that there were twenty-six modified A.S.T.M. methods in it, because the word "modified" always aroused suspicion. People wanted to know why the method was modified, whether there was some commercial consideration, and so forth. It was rather difficult to find out what the modification was; one had to put the two methods side by side and compare them. He would like to see the modifications underlined in red, so that one could see what they were, but he hoped they would be removed as soon as possible. He thought that twentysix modified methods were far too many.

He agreed with Dr. Dunstan that standardization meant nothing if it did not become international, or at least Anglo-American. The main aim and object on each side of the Atlantic should be to reach a common method.

He would like to make a few comments on the paper that Mr. Driscoll had read. The use of heptane presented a problem with regard to the aniline point, and his company had found it necessary to establish a secondary standard. It was a simple matter for a laboratory to establish its own secondary standard.

The Apparatus Sub-Committee was going to tackle the question of thermometers and hydrometers for war-time use.

He thought it was a pity that a drawing of the bouncing-pin spring-tension apparatus was not included in the book, because it was not an easy thing to describe, but it could be understood easily from a drawing. In conclusion, he would suggest that, however important the Standardization Committee and the method book might be, standardization still remained only a subsidiary part of the activities of the Institute. He thought the Institute should not expend too large a proportion of its energy on the question of standardization, because without the general background of the Institute, the status and the influence of the method book would be completely lost.

MR. J. ROMNEY said he had not had time yet to go through the new volume very carefully, but there were a few minor points that he would like to raise.

With regard to the sludge tost and the question of glassware in that test, no tolerances appeared to be included, with the result that there would always be a liability for trouble to occur with the suppliers of glassware. Obviously there must be tolerances of some sort, and the buyers might have ideas quite different from the suppliers as to what the permissible tolerances should be. He therefore thought it would have been a very good idea to include tolerances, and also B.S.I. standard ground joints, which quite a number of the leading suppliers of the apparatus in question were offering.

A very important point, which he had raised before the method was published, was the influence of condenser-water temperature on the sludge value obtained. The present specification permitted a range of 59-68° F., and that could make a considerable difference to the results obtained. If one worked at 59° F. one would get a distinctly lower figure than at 68° F. It was true that the Committee had decided finally to drop the figures for repeatability and reproducibility in this particular instance, but he thought that, had they included even those originally put in, it might have been found that the influence of the condenser-water temperature was sufficient in itself to introduce variations permitted for reproducibility and certainly for repeatability. Apart from that, he had every reason to believe that many laboratories did not observe the requirements with regard to condenser-water temperature. During the summer months in many parts of the country it was not possible to get down to 68° F. in the case of water from water mains or any normal supply. To cool water over a period of 45 hours was a difficult and very expensive business. He thought it would have been reasonable, therefore, to raise the condenser-water temperature to a figure of 70° F. and fix it rigidly within a degree or so on either side. It was quite easy to arrange a circulating water system at a slightly elevated temperature. It was true that at certain times of the year oven 70° F. would be difficult to attain, but to raise the temperature above 70° F. would cut across certain other matters. There was a B.S.I. specification for transformer oils, and if the condenser-water temperature and the sludge values obtained were raised considerably, the effect on that specification would have to be considered. But in any case he thought a temperature of 70° F., which was very near the present upper figure of 68° F., would have been a definite advantage.

With regard to the demulsification number, the change from minutes to seconds was not very important, but there was no regulation for differentiating oils of very poor demulsibility. He was not thinking of new oils, but of used oils, in which 20 plus was quite a normal figure. The oil was 20 plus whether there was a separation of 19 ml. after 20 minutes or 1 ml. after 20 minutes. Therefore he thought the scheme adopted in his laboratories was a good one—namely, to indicate after the 20 plus the percentage of the necessary 20 ml. that had separated. Thus an oil described as 20 plus 90 per cent. was better in demulsification characteristics than one described as 20 plus 25 per cent.

With regard to the drop point, the specification quite rightly advised that in filling the cup every care should be taken to eliminate air bubbles, but when a cup was filled with grease or petroleum jelly by means of a spatula, it was almost impossible to eliminate air bubbles. He would like to know whether anyone present could give some definite information as to the difference in the results obtained if the material was melted into the cup, which was a very simple operation, and made it very easy to eliminate air bubbles, as compared with pressing the material in with a spatula.

With regard to specific gravity, a formula was given for the conversion of specific gravity into A.P.I. figures. He believed there were different formulæ for materials with a specific gravity above 1 and for materials with a specific gravity below 1. Certain products—for instance, some of the solvent extracts from oil—had specific

gravities above 1, so he thought that, strictly speaking, it might have been better to mention that the formula given applied to materials with specific gravities below 1.

On the subject of reproducibility and repeatability, he did not think any regulations covering disputes could have been included in the book, but such cases might occur, and it would be interesting to hear the views of the meeting on the correct procedure to adopt. For instance, a material might be bought at a certain specific limit, and the supplying firm might get a figure inside and the purchasing firm a figure outside that limit. On the reproducibility clause, if those two differed from the mean of the two by an amount not greater than the limit set for reproducibility, the mean figure was acceptable. If that mean figure was just under, did that mean that the purchasing firm, which had decided that the material was outside the specification, must accept it?

With regard to acidity, all who had had experience in testing used oils knew how very difficult it was to get results which agreed with other laboratories on dark used oils. It required a great deal of experience to detect the end point, and he thought it would have been a very good idea to introduce a potentiometric method, as the A.S.T.M. had done. It was a safer method, and not very expensive for people who were using an electrical meter of some sort for pH determination.

On the subject of viscosity, emphasis was placed now on the use of kinematic viscosity. The International Petroleum Congress wanted to make use of kinematic viscosities only, or perhaps to introduce specific gravity as well. He wondered whether the Redwood viscometer had been retained more or less as a matter of sentiment. The instrument itself was a fairly poor one, and he did not think there was much point in retaining it. It was suggested in the book that viscosity tests should be carried out by kinematic methods, and then, if desired, the results could be converted, by means of the table given, into Redwood seconds.

MR. E. A. Evans said that those who had been connected with the subject of standardization for many years, as he had been, might perhaps regard it with a little more sentimental feeling than those who had come to deal with it during recent years. Dr. Dunstan had already said that a great deal of very useful pioneer work had been done, and he admired the patience of those who had carried it out. It was true that the work of sorting out the various standard methods required a great deal of patience. because so many people's points of view and policies had to be considered, as well as the question of accuracy. He could foresee a great many remarks being made in the very near future on the question of accuracy. In the book the limits of accuracy were stated. There were people who worked accurately normally, having all the apparatus, the facilities, and the acumen for it, but there were others who were not so happily situated, such as consulting chemists and people in industry of various kinds, who had not specialized in the art of examining oils, and they might feel that many of the methods given in the book demanded far too high a standard of accuracy. The Standardization Committee would be very glad to receive comments from any laboratories that felt too high a standard of accuracy was aimed at. It must be remembered that the standard method was what might be described amongst the members of the Institute as a legal standard. It was a thing to be aimed at. If people decided to work to a lower degree of accuracy, they were perfectly at liberty to do so in their own organizations; the Institute could not lay down any standards for them. He did not, however, see eye to eye with Mr. Romney about difficulty arising between buyer and seller in connection with the limits of accuracy, because if a person contracted to buy a particular article, it was surely the duty of the seller to make quite sure that the article was within the agreed limits inclusive of accuracy tolerances. Supposing, for instance, a person said that he must have a minimum V.I. of 85; if there was an error of 3 points by the standard method, it was the duty of the seller to give a V.I. of 88. A commercial man might say : "That is going to cost me ld. or 11d. per gallon more." That was just too bad, but if he had given a definite guarantee of 85, it was his duty to give 85, and that was all that the Institute was concerned about in the standard methods.

Mr. Romney had referred to difficulties in the determination of acidity and domulsification value of used oils. The Standardization Committee had definitely eliminated from its standard methods the subject of used oils. It had given a great deal of thought to the matter, and had decided that there were too many difficulties connected with standardizing the examination of used oils. Perhaps at some future time it might be able to deal with them, but at the moment it could not.

With regard to defining the demulsification value in seconds, he was rather sorry that that had come to be standardized. He could remember when, not very many years ago, the loss on evaporation of transformer oils caused electrical engineers a good deal of consternation, because they said the figure was too high. They said : Imagine putting an oil into a transformer with an evaporation loss of 7 per cent. At the end of a year how much oil would be left?" They had not realized that it was purely an empirical figure. To ease the difficulty, the method of estimation was changed to give a figure of about 3 per cent. Happiness has reigned ever since. Now that the demulsification value is to be given in seconds instead of minutes, it would be changed from, say, 3 to 180. What will the users do about it ? He thought it would need a good deal of patient education to convince them that the higher figure was not alarming. He did not feel very happy about describing demulsification in any other way than that in use at the present time. If what happened after 20 plus was reached was described, he thought it would frighten the turbine engineers. At present, when they see the maximum value put on reports, there is at times a tendency for alarm. It should be possible to convince them that the demulsification is merely pointing out a hazard and nothing more. If there was no water in the set, then there was no hazard.

With regard to the electrical method of determining acidity, the Standardization Committee had given it a great deal of thought, and had decided that the method was not sufficiently far advanced to be included as a standard method.

MR. R. A. FRASER said there were a few points that he would like to mention in connection with lubricating oils, with a view to their being considered before the publication of the next edition of "Standard Methods for Testing."

One was a point that he had noted in connection with the testing of dark-coloured oils for acidity. Some time ago, when testing dark-coloured oils for acidity, he used thymolphthalein as an indicator; it gave a dark blue colour at about the same pH as phenolphthalein, and it worked quite well.

In connection with the Ramsbottom carbon residue test, in the description of the apparatus there was a warning that care should be taken to see that the recording instrument was protected from the heat radiated by the bath. He suggested that the words "and leads" should be added after "recording instrument," because he had experienced some difficulty through those leads being affected by the heat, and had to wrap them with asbestos string to overcome this.

With regard to the demulsification number, it was suggested in the test that steaming should be carried on until a definite volume of oil and water had condensed in the tube, and that this should take a certain time—*i.e.*,  $4-6\cdot5$  minutes. That volume of oil and water was very difficult to estimate, although it was true that the statement was made that the apparent volume would be greater than the actual volume by 12–15 ml., owing to the displacement caused by steam, thermometer, and steamdelivery tube. He suggested that some consideration should be given to the question of steaming for a definite time, and then repeating the test if the volume of oil and water in the oil-container was not 40+3 ml.

A very useful table was given for viscosity index based on centistokes at  $100^{\circ}$  F. and  $210^{\circ}$  F. This meant that one had to have the centistokes at  $210^{\circ}$  F., which would involve a separate determination, and he wondered whether some use could not be made of the charts by Docksey, Hands, and Hayward, published in the *Journal* in 1934, giving viscosity indices from the kinematic viscosity at  $100^{\circ}$  F. and  $200^{\circ}$  F., which anyone doing viscosities for conversion to Redwood seconds at the usual temperatures would already have.

With regard to the conversion of kinematic viscosity into Redwood viscosity, he wondered whether in the next edition of the volume the nomogram could be reproduced which was published in the *Journal* in 1936, and which gave centistokes and Redwood viscosities on either side of the line. It was much easier to use than a table.

MR. E. P. DRISCOLL, in replying to Mr. Romney's points not already dealt with by Mr. Evans, said that the draft of the Sludge Test method had been referred to the British Standards Institution by the Standardization Committee. The B.S.I. Committee accepted the proposed amendments, and stated that the test was in course of revision, particularly as regards the condenser-water temperature and, he believed, the use of ground-glass apparatus. As these modifications had not yet received the official approval of the B.S.I., they could not be published in the present edition of the book.

With regard to the drop-point method, the difficulty of eliminating air bubbles when filling the cup by means of a spatula had been considered, but it was decided to rotain this procedure.

Referring to the points raised by Mr. Fraser, Mr. Driscoll said that, in the Ramsbottom carbon test, it was intended that the term "recording instrument" should include the leads. He agreed that the phrase "and leads" should be inserted in the next edition. With regard to the demulsification test, perhaps the appropriate sub-committee would consider Mr. Fraser's suggestion.

The viscosity index based on determinations of viscosity at 100° F. and 210° F. was adopted in order to come into line with the A.S.T.M. In this case the modification to the A.S.T.M. method consisted simply in the examples and the omission of Saybolt viscosities.

With regard to the inclusion of the nomogram for the conversion of kinematic viscosity to Redwood seconds, Professor Garner could deal with that better than he could.

DR. F. H. GARNER said there was a danger in including a nomogram in addition to the table, as if there were two alternative methods in any standard methods of test there might be slight disagreement. It was therefore better to have one definite method.

With regard to the question of basing the viscosity index at  $100^{\circ}$  F. and  $200^{\circ}$  F., instead of on  $100^{\circ}$  F. and  $210^{\circ}$  F., that was a difficult problem, because there were slight differences in the conversion from  $200^{\circ}$  F. to  $210^{\circ}$  F., which depended on the viscosity index. It would probably be possible to make  $100^{\circ}$  F. and  $200^{\circ}$  F. the basis for viscosity index determinations, but in view of the adoption of  $210^{\circ}$  F. for viscosity determinations in centistokes for certain types of lubricating oils, there was no immediate necessity; viscosities at  $100^{\circ}$  F. and  $210^{\circ}$  F. can be readily determined from viscosities at any other two temperatures in the same range with almost as great an accuracy as the original determinations of viscosity.

MR. J. CANTOR said that the change from minutes to seconds in the case of the demulsification number had been made in order to conform with the A.S.T.M. practice. There did not seem to be much point in recording in minutes when the A.S.T.M. recorded in seconds.

With regard to the acidity of used oils, he agreed that the end point could in the case of dark oils be seen more easily by the use of a different indicator such as alkali blue or thymolphthalein, and he thought the Standardization Committee should give consideration to that point.

As to the viscosity index, the reason that had been put forward for using a temperature of 200° F. instead of 210° F. was that that was the temperature more often used in the Redwood viscosity test. The advantage of being able to calculate Redwood viscosity from kinematic at that temperature instead of at 210° F. was not great and the revorse process, *i.e.*, calculating kinematic from Redwood and then calculating viscosity index was not possible since the Redwood viscosity method was not accurate enough to lead to a true figure for viscosity index.

MR. A. OSBORN said the reason a sketch of the bouncing-pin spring-tension apparatus was not given in the volume was that a complete description of the instrument was to be published in the *Journal* shortly, and had, in fact, been the subject of a paper in the September issue.

With regard to the conversion of specific gravity to A.P.I. figures, the formula given applied to all petroleum products in accordance with the decision of the American Petroleum Institute, the U.S. Bureau of Mines, and the U.S. Bureau of Standards to adopt this formula, and so avoid any confusion resulting from the use of two scales.

On the motion of THE PRESIDENT, a vote of thanks was accorded to the authors of the paper, and also to all those who had contributed to the production of the new edition of the "Standard Methods for Testing," and the meeting then terminated.

#### EDITORIAL NOTE.

It has been suggested that a useful purpose would be served by continuing the discussion on methods of test in the *Journal*. The Editor will be pleased to receive criticisms of the present methods, suggested modifications or new tests for consideration by the appropriate Sub-Committee of the Standardization Committee. Such criticisms and suggestions, together with the views of the Sub-Committees, should, it is felt, form a valuable new section of the *Journal*.

#### ERRATA.

p. 268. Table IV, last column: The sp. gr. at 60° F./60° F. corresponding with 83 Deg. A.P.I. should be 0.6597.

p. 380. "I.P. Aniline Point-Low" thermometer specification should read "Range-38° C. to 42° C."

p. 381. "I.P. Cleveland " thermometer specification should read "Figured at each . . . 10° F."


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#### Geology and Development.

1. The Oil Industry in Alberta. A. W. Farmilo. Canad. Min. J., January 1942, 63 (1), 17-27.—The author states in a preface that this paper is an attempt to study the oil industry in Alberta from two separate angles—namely, the geological and the economical—and to bring these two view-points together at the conclusion, by a speculation as to the future of the industry.

Oil areas in Alberta are divided into four major geological units, related to oil : the Rocky Mountain and Foothills region; the Alberta Geosyncline region; the Plains region; and the Southern Alberta border and Sweet-Grass Uplift Region.

The Rocky Mountain and Foothills Region embraces approximately 36,500 sq. miles, of which some 175 sq. miles have been proved to contain oil or gas. Turner Valley, the largest producing area of petroleum in Canada, falls within the foothill belt forming the eastern margin of the area. The Alberta Geosyncline region occupies

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an area of some 66,000 sq. miles, but it has been estimated that oil and gas have only been produced from an area amounting to 500 sq. miles. The region extends from the International Boundary northwards to Lesser Slave Lake. It consists of a large basin derived as a result of thrust pressures from the Rocky Mountain Uplift to the west. Hitherto it has yielded little oil but considerable gas, although on 3rd January, 1941, a well situated at Steveville, on the eastern edge of the geosyncline, after being plugged back from 4250 ft. to 3325 ft. yielded a 25° A.P.I. sweet oil, flowing at the rate of 521 brls. per day.

The Great Plains Region extends for approximately 141,000 sq. miles, and includes all the area north and east of the Alberta Geosyncline. Depths to producing zones are not so great as in other parts of Alberta, and the several fields which have been developed have yielded a rather heavy oil from fairly thin sands.

The Southern Alberta border and Sweet-Grass Uplift Region falls into a different category by reason of its own particular structure, which is not related either to the Alberta Geosyncline or to the Plains Region. It includes the fields directly associated with the Sweet-Grass Uplift or Arch, and occupies an area of some 3000 sq. miles to the immediate north of the Southern Alberta Boundary. The region has had several small producers, but it would seem on all counts that it contains large gas accumulations rather than commercial quantities of oil.

Economically Alberta's greatest problem is not the need for wider markets, but the need for greater reserves and new oil-fields. Steveville is a step in the right direction, but whether or not it will be opened up as a new field is still undecided.

As regards future prospects, the author has several observations to make. There is lack of consolidated legislation, which is not conducive to efficiency in the industry. Greater exploration is required in new areas. Until Alberta's supplies are insured, self-sufficiency in the Dominion will not be achieved and imports will be necessary. Hope of wider markets is dependent on reduced transport rates on gasoline made from Turney Valley crude between Saskatchewan and Regina refineries and Winnipeg. H. B. M.

2.\* New Frontiers in Micropalæontology. With especial reference to Petroleum Exploration. C. Croneis. Econ. Geol., January-February 1942, 37 (1), 16-38.—It is advocated in this paper that the micropalæontology of oil-field waters should be extensively re-examined; also that the oils themselves should be further exhaustively studied by microscopical methods. Methods conducive to increased speed and efficiency of separation of organic remains from crude oils are being evolved in the author's laboratories. The basis of this work is Sander's method ("The Microscopical Examination of Crude Petroleum," J. Inst. Tech., 1937, 23, 527-573). It is essential, though, that more efficient water-soluble filters be devised and that the gold size commonly employed to entrap the remains during centrifuging be improved or a substitute found. It may be that the key to the solution of the problem of oil origin will be found by means of such micropalæontological investigation of organic remains entombed in the oil.

In the past much work has been undertaken in an endeavour to establish the validity or increase the value of certain fossil groups as stratigraphic markers, also to increase the speed of stratigraphic diagnosis in petroleum geology. Experts have, however, now reached a position where it is possible to examine as many as 100 samples a day and to log from 3000 to 4000 ft. of section, using only a few "marker" foraminifera. Present bias of research is, therefore, less towards speed than towards discovery of new "markers."

The author discusses current trends of researches embracing foraminifera (fusilinids and arenaceous foraminifera), Early and Middle Palæozoic micropalæontology (radiolaria, scolecodonts and conodonts, bryozoa), echinoderm fragments and microscopic and semi-microscopic plants (diatoms, charophytes, flagellates, spores and pollon, algal dust).

In conclusion it is pointed out that however many new micropalæontological groups are discovered, their full academic and economic possibilities will never be realized until they are studied in their proper and complete ecological relationships. Emphasis must be given to this type of investigation, particularly now that the location of stratigraphical rather than structural traps for petroleum has assumed importance. Evolution of a suitable technique of investigation cannot be left to the geologist alone: it must be referred to experts in the sciences of sedimentology, micromineralogy, and biology. H. B. M.

**3. Development of Alberta Oil in 1941.** J. L. Irwin. *Canad. Min. J.*, **63** (2), February, 1942, 99–103.—During 1941 the province of Alberta established a new record in oil production, the official figure being 9,908,643 brls. In addition 21,476 brls. of crude oil, gasoline, diesel, and burner oil were recovered from the McMurray tar-sands.

Statistics are given of monthly and yearly totals for the past four years, and totals for each of the years from 1914 to 1941. Production from the whole of Canada was well over 10 million brls. in 1941, and, as on previous occasions, Canada, of the seven oil-producing countries of the British Empire, took second place. There was, however, a difference of over 2 million brls. between Canada and Burma, which came third. Of total Canadian production in this year, Alberta contributed 98-08%, and Turney Valley field produced  $99\cdot22\%$  of Alberta's total. As regards world crude-oil production for 1941, it is significant that the United States records an increase of nearly 60 million brls. Venezuela for the first time takes Russia's place as second largest producer, with an increase of nearly 41 million brls.

Alberta, as the principal oil-producing territory of Canada, has a great responsibility, and great achievements are expected. Among these are the continued lengthening of the Turner Valley field, increased production in other fields, discovery of new fields, and further developments in the McMurray tar-sand area. H. B. M.

4. Canadian Mineral Production. Min. Mag., April 1942, 66 (4), 139. It is reported that in 1941 the value of fuels, including coal, natural gas, and crude petroleum, produced in Canada amounted to \$83,363,000. In Alberta petroleum production advanced to a new peak in this year, and much exploratory work was carried out for new fields both in the plains and foothills. A number of new wells were drilled.

H. B. M.

5.\* Oil in Netherlands Indies. Min. and Metall., July 1942, 23 (427), 395.—A report is given of the speech made before the New York Section A.I.M.E. by Mr. Kay, a member of the Secony-Vacuum Oil Co., on the petroleum situation in the Netherlands Indies.

Production of crude oil from the islands under Dutch control amounted to 160,000 brls./day before the Japanese invasion. Of this 12,000–15,000 brls. came from North Sumatra, 5000–7000 from Tarakan, North-east Borneo, 15,000–16,000 from Balik, Papan, South-east Borneo, and a small amount from Java. It is believed that the Japanese may be able to obtain a little oil from some of these areas by drilling new wells, most possibly at Tarakan, where the oil is shallow and of asphaltic base. Refineries were completely destroyed, so that it would be necessary to transport the crude oil to Japan for processing.

Mr. Kay gave some interesting information on the octane value of aviation gasoline used by the Japanese. Apparently the highest grade used is 87 octane, obtained by adding lead to regular grade gasoline. It is thought that Japanese planes may be equipped with supercharges to overcome the lower octane value. H. B. M.

**6.\*** Oil Search in Western Australia. Min. Mag., August 1942, **67** (2), 88.—The Freney Kimberley Oil Co. (1932), N.L., has suspended all drilling in the Kimberley district in the north-west of the State, where extensive exploratory work is in progress, pending receipt of new equipment from America. Instructions have since been given by the Government that drilling must cease in that part of the country which is situated inland from Broome, owing to danger of enemy action.

The total depth reached at the time of reporting is 4271 ft. H. B. M.

7.\* The Problem of Petroleum Reserves in the United States. Part 2. J. H. McCammon. *Oil Wkly*, 21.9.42, **107** (3), 23.—Texas, Oklahoma, and California are the areas with the most favourable geological conditions for the accumulation of petroleum, and must therefore be depended on to offset the decline in reserves which will probably occur in other States.

Oklahoma has given 20% of the total U.S. production, and this has been provided by over 500 separate pools. Thirty-two of them have given over 25 million brl. each. eleven have given over 100 million brl., and one over 500 million brl. The discovery of large pools in Oklahoma has passed its peak, and it has been estimated that Oklahoma will yield only 5.3% of the future U.S. production. At the end of 1941 the State's reserves were 1,035,820,000 brl. The main structural features are well known, and were thoroughly tested a decade ago. The Nemaha Granite Ridge of Kansas in passing into Oklahoma gives rise to a series of en echelon ridges with anticlines on which lie fields such as Garber, Tonkawa, and Oklahoma City. To the north and east are prolific Bartlesville sandfields, mainly of the stratigraphic type. Only in the southern part of the State are there sizeable areas where drilling has not gone to the base of the productive column. Gas has been found on structures in the McAlester basin, where the Pennsylvanian is very thick. Since 1917 no field of over 40 million brl. has been found in the area of the Red River Uplift. Deep tests on geophysically located structures in the Anadarko-Ardmore basin have mostly been disappointing. In this basin the Ordovician will be very deep, and the strong compression involved in the folding has given low porosity in the shallow fields.

California has provided 23% of the U.S. total, and it may yield 16.5% of the future production. Four isolated districts in Southern California are responsible for the oil, and each of them has been known since before 1900. The relatively recent geophysical discoveries of deeply buried structures in the San Joaquin Valley are insignificant, from the point of view of production, compared with the superficially expressed anticlinal folds. The downward trend of reserves in California seems likely to continue. Vertically the Tertiary oil-bearing column has been thoroughly explored; the Cretaceous below has given only a little oil and some gas. The most promising possibility seems to be the discovery of other structural stratigraphic traps.

The likelihood of the discovery of many major fields of the pinch-out type appears remote, and even though some will be found, it is doubtful whether they can greatly alter the character of the reserve curve. Thus it appears that the U.S. reserves will decline in terms of demand, and also in terms of gross volume. G. D. H.

8.\* Trenton Enhances Illinois Discovery Prospect. K. A. Spitznagel, *Oil Wkly*, 21.9.42, 107 (3), 41.—Most of the production from the Illinois Basin is from the McClosky limestone, the porosity of which is very variable and seems to be erratically related to structure. Production from this limestone declines rapidly. The Chester sand discoveries have been declining in the past year. The average daily production in the week ended 22nd August, 1942, was 274,000 brl., a rise of 19,700 brl./day over the average for the previous week. Most of this increase was undoubtedly due to the St. Jacobs field and to the new discovery at Covington, where large McClosky wells are being developed. The gross Illinois production in the first seven months of 1942 was 66,420,000 brl., compared with 71,808,000 brl. in the same period of 1941.

The St. Jacobs pool was opened in May 1942, in a porous zone 24 ft. below the top of the Trenton, at a depth of 2343 ft. Ten producers have been completed, and three dry holes. The average initial production was 450 brl./day after acid treatment. The field may cover 2600 acres, with 45 ft. of closure above the water-table.

Trenton production is also found at Dupo, Waterloo, Centralia, Salem, Westfield, and Martinsville. The first two are on the extreme western rim of the basin; St. Jacobs lies to the east; Centralia and Salem are still farther east on the west flank of the basin; and the other two fields are on the eastern flank of the basin. No commercial Trenton production has been found in the lower part of the basin.

The Dupo field has yielded about 3000 brl. of oil/acre, and may ultimately yield 4000 brl./acre. It is possible that St. Jacob may exceed this figure.

A good, thick porous section of Trenton extends from the southern boundary of Macoupin County to the southern boundary of Randolph County, with its western margin probably defined by faulting or a deep syncline near the Mississippi. Structures outside this porous zone have failed to give production.

St. Jacobs was located by seismic work.

Quite a lot of sub-surface data are available to indicate structural conditions in western Illinois, and these, used in conjunction with knowledge of the characteristics of the producing horizons, should facilitate the location of some major oil reserves in the central, eastern, and southern parts of the basin. G. D. H. **9.** Texas Oil. G. B. Barbour. Geog. J., October 1942, Vol. C. (4), 145–155.—Some remarkable summarized statistics on Texas oil are given in this paper. In 1941 new wells were drilled in this State at the rate of 870 a month. The average dopth (3627 ft.) of these wells was over two-thirds of a mile, and the aggregate footage drilled in that year amounted to nine-tenths the diameter of the earth. Even after allowing for dry holes (practically every fourth borehole) and those producing gas instead of oil (1 in 37), there were 7652 new wells producing oil by the end of the year. Texan production was thus raised to the enormous total of 7,087,198,000 brl.

In 1901 Captain Lucas, a retired Austrian Army officer, obtained a production of 25,000 brl./day from a well drilled on a hillock marking the site of a buried salt-dome near Beaumont. This proof of Lucas' salt-dome theory did much to stimulate drilling activity, and within  $2\frac{1}{2}$  years production reached 20 million brl., while the price fell to an all-time low level of 5 cents./brl.

Throughout the State underground structural features vary considerably, and each is studied with extreme care to discover clues for further prospecting. The most common structural type likely to trap oil is an elongated dome or anticline formed where strata have been warped by crustal pressures. Other traps may develop round the margin of salt plugs the upward thrust of which has gradually pushed up claycapped layers of sand. The importance of such traps was first realized as a result of Lucas' famous discovery.

Some two years ago the author spent several days in the oilfields of the San Antonio and Corpus Christi regions of South Texas, in company with Professor Robert H. Cuyler, of the University of Texas, who was responsible for the discovery of many of the producing fields. Descriptions are given of each of these districts which illustrate not only various modes of occurrence of oil, but equally many features common to other fields both in the methods of oil recovery and subsequent handling of it. Formations in South Texas dip seawards. Thus as the coast is approached wells

Formations in South Texas dip seawards. Thus as the coast is approached wells must be drilled deeper to strike the same horizons. The base of the Catahoula formation which caps the Frio deposits actually outcrops at the surface 70 miles inland, but is 5000 ft. below ground at the coast. In the Saxet field, 5 miles west of Corpus Christi, the Frio deposits yield oil from depths of 9900 ft. To take care of drilling to such depths, new and improved technical methods are constantly being devised. One of the special hazards is due to the enormous pressure generated in some of these fields. Special precautions have to be taken to prevent the escaping oil from blowing out the whole of the equipment and thus letting the well get out of control.

Reserves of Texas crude oil still in the ground, and therefore ultimately available, according to the 1942 estimate, exceed 10,623,516,000 brl., or nearly 56% of the whole reserve of the U.S. In December 1941 the "net daily allowable" in Texas was 1,555,192 brl., but following the declaration of war by the U.S. this was increased in 1942 by 65,467 brl. per day.

By Midsummer 1942 the volume of rail-transported oil in tank cars had risen to 700,000 brl./day, and Congress then decided to act on proposals to co-ordinate and extend the pipe-line service to Atlantic Coast ports. The scheme included a \$35million pipe-line from Long View in North-east Texas, across Arkansas to Salem in Southern Illinois, a route of 550 miles, scheduled to be laid in five months. Ten motor-driven pumps designed to transmit 300,000 brl./day were installed at 55-mile intervals. It takes two weeks to fill the 24-in. pipe, since 31 million brl. must go in at the Texas terminal before any oil can be delivered at the other end. H. B. M.

10.\* Development and Exploration Active in Argentina. W. A. Sawdon. Petrol. Engr, October 1942, 14 (1), 119.—Argentina produced 22,015,658 brl. of oil in 1941,  $6\cdot8\%$  more than in 1940. Even this was only 63% of the country's requirements. Shipping has limited oil imports, and also restricted the acquisition of equipment.

70% of the 1941 output came from Comodoro Rivadavia, where the production rose by 740,529 brl. as a result of further development and the addition of the El Tordillo field. The Plaza Huincul output fell in 1941. The area containing the Tartagal, San Pedro, Aguas Blancas, and Rio Pescado fields had its maximum production in 1934, but extension to the fields caused the 1941 output to exceed that of 1940. The Mendoza production began in 1926, but approached the million-barrel per year mark only after the discovery of the deep zone at Tupungato in 1939. The Lulunta-Barrancas area has 8000-ft. wells, the deepest in Argentina. Wildcatting has taken place in Patagonia during the past few years. Wells in Chubut were unsuccessful. 125 ml. west of Santa Cruz a large gas-flow was found below 2600 ft. Several shows were noted in a well near Zapala, south-west of Plaza Huincul, and 10 ml. west of Plaza Huincul a well had an initial production of 140 brl./day, but its high gas/oil ratio caused it to be closed in. Farther to the northwest, and 20 ml. from Plaza Huincul, a well drilled to 3600 ft. found three good gassands. This structure was located geophysically. 15 ml. south-east of Plaza Huincul a 1000-brl. well was brought in at a depth of 3270 ft. A test on the Carrizal structure found no oil in the lower horizons, but had oil-showings in the upper formations.

2 ml. north-west of the centre of the Tupungato structure the discovery well of the Refugio structure came in at 100 brl./day from the same producing horizon as at Tupungato. Dry gas and numerous oil-showings have been encountered on the Pampa Palauco structure of South Mendoza. 22,000,000 cu. ft. of gas/day and a little very heavy oil were produced. G. D. H.

11.\* Geophysical Exploration in Brazil. W. A. Sawdon. *Petrol. Engr*, October 1942, 14 (1), 122.—Four areas of Brazil have oil-producing prospects, but drilling is largely confined to the most easily accessible region, which extends through coastal Bahia, Sergipe, and Alagoas. Oil production has been found near Bahia. Much of Brazil has been geologically surveyed, and in recent years geophysical work has been carried out where the oil prospects seemed most favourable. The drilling around Bahia and Maceio was based on geophysical surveys.

South and west of Sao Paulo is the Parana synclinal basin, which, while not so accessible as the Bahia-Alagoas area, will probably be explored in the near future. A number of unsuccessful wells have been drilled in the past forty years.

The Para area south of the Amazon delta appears to have petroleum possibilities. The Acre area is near the Peruvian border, relatively close to the Aguas Calientes field of Peru. There are oil-seeps in Peru near this last area. Accessibility is difficult, particularly in regions which are not close to the Amazon or its tributaries. Considerable geological and geophysical work will have to be carried out. G. D. H.

12.\* Oil from the Garden of Eden. W. F. Foran. Petrol. Engr., October 1942, 14 (1), 85.—About 6000 B.C. there were flourishing lime, plaster, asphalt, salt, and shipbuilding industries near Hit, and boats were used to carry the materials from Hit to Ur. Ur and other places were destroyed by extensive floods, and later the city of Kish was built with bitumen and lime mortar, some 190 miles upstream from the site of Ur. Large quantities of asphalt were mined at Hit, and oil was recovered for use in lamps. Oil-seepages were also cultivated at Persepolis near the site of the present Anglo-Iranian oilfields, and at Nineveh in the Kirkuk region. After many vicissitudes the ancient oil industry declined, and was almost forgotten for a long period, until it was revived in the twentieth century.

13.\* Petroleum Development in Canada. Part I. F. K. Beach. *Petrol. Engr*, October 1942, 14 (1), 128.—The first oil-well in Canada was drilled in 1858, and obtained oil from a gravel. In 1861 a gusher came in at a depth of 160 ft. in Ontario. The Ontario production rose to a maximum of 800,000 brl. in 1895, when there were 8000 producing wells, declined to 475,000 brl. in 1903, and had a second sharp peak of nearly 800,000 brl. in 1907.

The New Brunswick production was 22,000 brl. in 1942. Exploratory work has been carried out preparatory to further exploratory drilling.

Oil was discovered near Fort Norman in 1920. The two successful wells there have been pumped for about four months each year, giving 15,000–30,000 brl./year, and the oil has been cracked in a small plant to provide aviation gasoline. The reservoir rock appears to be a shale. Drilling on the coastal plain of British Columbia has not yet revealed oil production, but in the strip of sediments in the east of the province oil-showings have been found in the Flathead Valley.

Natural gas has been found at widely scattered points in Saskatchewan and Manitoba. A well in South-west Saskatchewan has penetrated 4000 ft. of post-Palæozoic sediments. These thin to the north and east, and disappear in Central Manitoba. The Cretaceous has not been thoroughly tested, and only a few wells have been drilled to the Palæozoic.

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In the geosyncline east of Turner Valley there are about 9000 ft. of relatively flat post-Palæozoic beds, which rise and thin to the east for about 100 ml., and then show a dip to the east. The general trend is disturbed by the Sweetgrass Arch, the effects of which extend 60 ml. north of the U.S. border. Oil and gas occur on terraces on this structure, chiefly in U.S.A. Oil is found at Red Coulee, Skiff, and Taber, and gas at Foremost and Bow Island. The Lower Cretaceous continental beds show little evidence of structure, but oil has been found at numerous points, including Wainwright, Vermilion, Dina, and Athabaska. Other discoveries have been made at or near the top of the Palæozoic at Princess and Tilley. G. D. H.

14.\* Production of Oil in the World To-day. W. A. Sawdon. *Petrol. Engr*, October 1942, 14 (1), 67–70.—Although the fields of the East Indies were put out of action before the Japanese occupation, it is possible that the Japanese may have built up supplies of drilling equipment beforehand, and so may have been able to rehabilitate some of the fields more quickly than was expected. It is also possible that skimming plants may have been erected. It is less likely that they will have been quite so anxious to put the Burma wells into commission again. The Punjab oil is safe from attack at present, but the Digboi production could easily be denied to the Allies by the cutting of the railroad over which the production is transported.

The fields of Iraq, Iran, Arabia, Bahrein Island, and Egypt gave  $4 \cdot 4\%$  of the world's output last year, and they have a much greater potential. If Germany gets the Baku oil there may be a battle for the Near East oil. Exclusive of Sakhalin Island, Russia obtained 239 million brl. of oil last year, 72% of which came from the Baku area. Only 16% came from areas outside the Caucasian region. The Ural-Volga area provided  $11 \cdot 5\%$ . The Kuban-Maikop fields have been thoroughly put out of action, and even if the Germany will not be able to meet her own demands. The loss of all the Caucasian fields would not necessarily put Russia out of the war, since she has large stores of oil in addition to the Ural-Volga production. It is believed that the European production is still declining.

In Venezuela the 1941 production reached the peak of 224 million brl., but the submarine menace has curtailed output this year. Argentina gave 22 million brl. of oil in 1941, while Trinidad's output was 21 million brl. Colombia's output declined a little to 25,600,000 brl., Peru's output fell to 12 million brl., and that of Ecuador to  $1\frac{1}{2}$  million brl. The Mexican output was less than 43 million brl., a further decline, but Canada had a slight rise to over 10 million brl. U.S.A. provided 63 1% of the world's output. G. D. H.

15.\* Venezuela Marks Time. W. A. Sawdon. *Petrol. Engr*, October 1942, 14 (1), 102.—The inability of Venezuela to ship oil and its products to Britain and U.S. has restricted the oil output, after a peak production had been attained in 1941. However, geological and geophysical prospecting have not been as seriously curtailed as the production and refining activity.

Oil was first produced commercially in Venezuela in 1917, and a sharp rise in output began in 1924, giving a peak about 1930, and, after a decline, further peaks in 1939 and 1941. Venezuela seems likely to have good marketing prospects after the war. Europe, Brazil, and other Atlantic coast South American countries are probable markets in addition to U.S.A.

The Lake fields provide 62% of the Venezuelan output. In the early part of 1942 the production was about 700,000 brl./day, but a decline set in in March, and the production is now about 400,000 brl./day.

Oil transport is one of the major problems to be considered in developing the interior part of Eastern Venezuela. In 1938 a pipe-line was laid from Temblador to a branch stream in the Orinoco delta. In 1939 a 16-in. line from Oficina to the Caribbean was completed, and later connections to this line were made from Leona, Santa Rosa, El Roble, Santa Ana, and San Joaquin. The Jusepin field had a pipe-line connection to Quirequire.

Most of the producing wells are 2000-5000 ft. deep, but at Oficina there are 7000-ft. wells, and at El Roble and Santa Ana wells which are 8000-10,000 ft. deep.

A table gives the average daily production during 1940 and 1941, together with the types of producing wells in action on 31st December, 1941. G. D. H.

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16.\* Increased Rate of Completing Wells. Anon. Oil Wkly, 12.10.42, 107 (6), 33.— The average of 61.5 completions per day during the four weeks ended 26th September was about 10% above the completion rate of 55.4 per day for August, and also higher than the 59.5 per day for July. The September figures were the highest since February. Increased rates of completing wells were recorded in September in Arkansas, California, Colorado, Illinois, Indiana, Kansas, Kentucky, Mississippi, Ohio, Pennsylvania, West Virginia, and Wyoming. The relaxation of spacing regulations in Illinois was responsible for a considerable increase in completions in that state.

Tables show by States the drilling activity on 1st October, 1941, 1st September, 1942, and 1st October, 1942, and the state of the rigs; the numbers of completions in September 1941, August 1942, and September 1942, as well as the types of completion in September 1942 and the cumulative completions during the first nine months of 1942. G. D. H.

17.\* Typical Oilfield Structures : Truncated Shore Line; East Texas Field, Texas. Anon. Oil Gas J., 15.10.42, 41 (23), 48B.—The East Texas basin was originally continuous with the Mississippi river embayment, and bordered the folded Palæozoic continent formed by the uplift of the Appalachians and the Ouachitas. At different times during the Mesozoic, a large area within the basin was uplifted to give the Sabine Uplift, which subdivided the basin, while leaving a connecting channel north of the uplift. Beds pinched out on the flanks of the uplift. In East Texas the Lower Cretaceous sea extended right across the uplift, and at the end of the period it retreated to a point west of the East Texas field. As the sea again advanced the Woodbine sand was deposited. Possibly following this, and certainly following the deposition of the overlying Eagleford shales, the sea retreated, and the sand was eroded in parts of the field area and wholly in the area to the east. Later readvance of the sea deposited the Austin Chalk and younger beds.

The Woodbine sand is the only oil reservoir in the area. It is largely non-marine, with silts, ashes, and conglomerates. Much of it may be re-worked detritus on the old land surface. The reservoir is made up of many overlapping lenses. The oil may have migrated into its present position from deeper in the basin, or, alternatively, the oil-forming materials may have entered the Woodbine in its second submergence.

There are many other wedge-edge fields formed near the shore-lines of advancing seas. This type of sand is the basis of the numerous trend-plays of the Gulf Coastal area, the San Joaquin and Los Angeles basins, and Eastern Kansas and Oklahoma. Surface geological methods are of little use in locating these traps, but convergence studies and the reflection seismograph are helpful. G. D. M.

18.\* Completions at Third Quarter Remain at 50 per cent. of Last Year. Anon. Oil Gas J., 22.10.42, 41 (24), 97.—September, a five-week month, had 196 more well completions than August. The number of wells actively drilling was forty-three more than in August. The September completions numbered 1542, compared with 3073 in September 1941. In the first quarter of 1942 the completions were 30% below the 1941 figures, and by June the drop was 40%. Since August the drop has increased to 50% below the previous year's figures for the same period.

A table gives the number of completions, footage, types of completions, and the numbers of completions in different depth ranges, for September 1942. G. D. H.

19.\* Wyoming Discovery Directs Attention to the Lakota Sand. T. R. Ingram. Oil Gas J., 29.10.42, 41 (25), 25.—An oil discovery has been made in the wildcat on the Horse Creek structure of South-eastern Wyoming. The well is 24 ml. north-west of Cheyenne. It logged the top of the Dakota at 5265 ft., and oil-saturated cores were recovered from 5270-5290 ft. The Lakota lay at 5451-5489 ft. A drill-steam test at 5490 ft. gave 27 brl. of oil in thirty minutes. The total depth was 5531 ft., with some 58 ft. of Lakota sand. A packer was set at 5490 ft., and oil was obtained at the rate of 15 brl./hr. from the lower 24 ft. of the sand.

A major pool seems to have been located, and the discovery is also of areal significance. It is on the north-west rim of the Denver (Julesburg) basin, which is outlined by the Hartville, Cambridge, Sierra Grande, and Apishipa Arches, and the front mountain ranges. All the earlier fields but one were on domal structures near the

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front mountain ranges. The exception is Greasewood, out in the basin, the discovery of which was followed by an extensive search for the Dakota, during which several wildcats had good shows of oil and one had much gas, although no fields were developed. Later the Pennsylvanian and older beds were sought, with tests based on seismic surveys. This work indicated favourable prospects.

Horse Creek is in a line with the fields on the western rim of the Denver basin in Colorado, and will revive interest in the prospects of the Dakota–Lakota of the adjoining counties. The structure was located by aerial photography, and then by surface geological and seismic work. G. D. H.

20.\* Dakota Activity Centres around Black Hills. Anon. Oil Gas J., 5.11.42, 41 (26), 60.—Four wells are being drilled in the Black Hills area of South Dakota, while there are four seismograph parties at work, three in North Dakota and one in South Dakota. A well in Oliver County, North Dakota, was abandoned as a dry hole in September, having entered the pre-Cambrian at 8831 ft. In South Dakota a well on the Flint Hill structure of the Chilson anticline is temporarily suspended in the Minnelusa sand at a depth of 2335 ft. It is the same section as one drilled in 1925, which reported oil-showings at 2085 ft. A second well is being drilled in Fall River County on Hat Creek. The two other wells are near Rapid City, north of the Fall River County locations. The well on the Black Gap structure reported a gas showing at 300 ft.

About 7 million acres are under gas or oil lease in the Dakotas.

Several deep water wells have been watched with interest. One showed oil in the Leo sand at the Black Hills Ordnance Depot in Fall River County. A number of natural gas wells occur in the Pierre area.

A well south of Baker, Montana, near the Dakota boundary, had oil shows at 6815-6825 ft., 8320-8350 ft., 8455-8500 ft., and 8644-8659 ft. Acidization was applied, and the well gave 707 brl. of liquid (77% oil) in four days, but was later abandoned. G. D. H.

21.\* Exploration in South Texas Needs Strong Stimulation. W. V. Howard. Oil Gas J., 5.11.42, 41 (26), 20.—Wildcatting in the coastal area of Texas and Louisiana in the third quarter of 1942 was 40% below the average quarterly level for 1941. Oil prices and legislation are said to have been largely responsible for this state of affairs. Last year 13.2% of the wildcats were successful in finding either oil or gas, but this year there have been only 8.1% of successful wildcats. There is a relationship between discoveries and new tests.

South Texas has not adequate reserves to tide it over a period of slackened exploration, for while there are large fields, most of the fields in this sector are approaching the stripper stage. South Central Texas is in an even worse position in this respect.

Coastal Louisiana has large probable, though undeveloped, reserves, but the deep drilling required to locate them is not attractive at present.

Tables compare the wildcatting in 1941 and 1942, and give the numbers of wildcats and discoveries by districts for the Upper and Lower Gulf Coast, and South and South Central Texas. G. D. H.

#### Drilling.

22.\* California Deep-Drilling Rig Uses Direct Electric Current. L. D. Banderob and P. L. Savage. Oil Gas J., 8.10.42, 41 (22), 45. The equipment is unique for several reasons. It is the highest-powered electric drive so far built for rotary drilling. It is the only existing direct-current drilling equipment using alternating-current power supply, as the direct-current generators for such a drive are usually driven by internal-combustion engines. The arrangement of the electrical equipment, especially the direct-current power supply and the portable substation, offers the maximum in portability; and once the equipment is in place, electrical connections are a matter of minutes.

A conventional type draw-works is driven by two direct-current drilling motors each rated 250 h.p. These two motors are capable of delivering considerably in excess of 800 h.p. for hoisting operations. Since the motors may be required to run

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at very low speed for long periods during the drilling operation, ventilation is supplied to them by a blower, which takes air from a remote point to insure against the presence of explosive gases. Provision is made in the control scheme so that the ventilating fan is started a short time before applying power to the motors, in order that all explosive gas will be purged from the ventilating system. The two draw-works motors are connected to a twin gear, which is chain-connected to the draw-works jackshaft. There are two motor-generator sets, each mounted on a self-supporting skid base. Each set is complete in itself and consists of a 350-h.p. induction motor. driving a 200-kw. direct-current generator. Each set also includes a direct-connected exciter rated 15 kw. at 125 volts. Either exciter is capable of providing all excitation required.

The first well, being exploratory, was subjected to considerable testing, involving many and frequent trips in and out of the hole under varying conditions, which afforded experience with the drilling motors comparable to drilling several deep wells. This experience provided an excellent opportunity to gauge the performance of this new equipment, the following being apparent : (1) The flexibility equals that of the finest steam equipment. (2) The ease and smoothness of control exceed that of any other equipment of the authors' experience, either steam, gas engine, or alternating-current electric. (3) The torque limiting feature inherent in this equipment is of great value in hoisting through tight places, through keyways in the hole, when rotating in difficult drilling, or when fishing. This feature provides at all times a cushion beyond which it is impossible to load the driven equipment. (4) The motor speed increases automatically as the load becomes lighter to a maximum of 1270 r.p.m. with an empty hook, which is ample. Therefore each stand of pipe is hoisted at a higher speed than the preceding stand. In effect, this is comparable to a mechanical drive with an infinite number of gear ratios and with each correct gear ratio automatically selected. (5) The performance of the electric equipment does not decline A. H. N. with continued hard use.

23.\* Graphical and Mechanical Determination of the True Dip from Magnetically Orientatable Cores taken in Crooked Holes. G. D. Hobson. J. Inst. Petrol., November 1942, 28 (227), 274-280.- A practical means for obtaining the true dip from cores with relative ease and in a short time is described in detail. The apparatus is simple A. H. N. to construct and use.

#### Production.

24. Calculation of Productivity Factors for Oil-Gas-Water Systems in the Steady State. H. H. Evinger and M. Muskat. Petrol. Tech., January 1942, 5 (1), A.I.M.M.E. Tech. Pub. No. 1416, 1-10.—A method of calculating productivity factors for oil, gas, and water systems in the steady state in presented as an illustration of the quantitative application of the fundamental data on the flow properties of heterogeneous fluid systems. Starting from the permeability-saturation data of Leverett and Lewis,

and of Wyckoff and Botset, a series of curves have been derived for  $\frac{k_g}{k_o}$  and  $\frac{k_w}{k_o}$  against

oil saturation for different water saturations, of  $\frac{k_o}{k}$  against  $\frac{k_g}{k_o}$  for different water

saturations, and of  $\frac{k_s}{k}$  against water saturation for different values of  $\frac{k_g}{k}$ . k is the permeability, and the subscripts o, g, and w refer to the oil, gas, and water phases. The next step involved the determination of the reservoir oil and water saturations required to give specified values of gas-oil ratio and water-oil ratio. These data permit the drawing of curves showing the variation of gas-oil ratio with oil saturation for fixed values of water saturation. Curves for the water-oil ratio plotted against water saturation for different gas-oil ratios are given, and also curves for water-oil ratio against the oil saturation-water saturation ratio, which are relatively insensitive to changes in gas-oil ratio.

The curves show that with the gas-oil ratio and water-oil ratio given it is possible. in principle, to calculate the reservoir saturations, and hence the permeabilities and productivity factor. Conversely, the reservoir saturations can be used to deduce the gas-oil ratio, the water-oil ratio, and the productivity factor.

While the numerical results of the calculations cannot be applied directly to field conditions, because they are based on permeability data for uncemented sands and involve specific assumptions regarding the nature of the reservoir fluids, the methods of analysis and interpretation should have significance in considering certain specific field conditions when the necessary field and laboratory data become available. It seems likely that even under the idealized conditions to which the numerical calculations refer they should serve to give at least the order of the magnitude of the effects of gas-oil ratio and connate water on the observed productivity factors. Within the indicated limitations the computations imply that the foregoing factors can explain only a part of the apparent discrepancy between the homogeneous fluid productivity factors and those obtained recently in field measurements on the West Coast.

G. D. H.

G. D. H.

25. Dimensional-Model Studies of Oilfield Behaviour. M. C. Leverett, W. B. Lewis, and M. E. True. *Petrol. Tech.*, January 1942, 5 (1), A.I.M.M.E. Tech. Pub. No. 1413, 1-10 —The theory underlying the design of two kinds of dimensionally scaled models of parts of idealized oil-fields is given, and the construction and operation of the models are described. The unique features in the design of the models are : (1) the treatment of the permeability-viscosity quotient as a single variable, and (2) the use of previously reported experimentally developed relationships between relative permeability and saturation, and between capillary pressure, saturation, porosity, permeability, and interfacial tension. The models simulate the flow of oil and water only through uncemented sands.

One model represents an oil-well and its surrounding sand for a distance of 16 ft. radially from the well, and is designed to study the effects of various methods of well completion. Data which are presented show the effect of production rate on waterconing. In the other model the effect on recovery, by water-flooding, of a patch of fine sand within a coarse sand is capable of being investigated for linear flow. The experiments in this case showed a higher total recovery from the sands at low rates of flow than at high rates of flow.

These models are superior to unscaled models, which may give rise to erroneous conclusions. Thus the models include such features as boundary effect in their more nearly correct significance than in short tube experiments.

The limitations of the model technique are discussed.

26. The Electrical Resistivity Log as an Aid in Determining some Reservoir Characteristics. G. E. Archie. *Petrol. Tech.*, January 1942, 5 (1), A.I.M.M.E. Tech. Pub. No. 1422, 1–8.—The usefulness of the electrical resistivity log in determining reservoir characteristics is governed largely by : (1) the accuracy with which the true resistivity of the formation can be determined; (2) the scope of detailed data concerning the relationship of resistivity measurements to formation characteristics; (3) the available information concerning the conductivity of connate or formation waters; (4) the extent of geological knowledge regarding the probable changes in facies within given horizons, both vertically and laterally, particularly in relation to the resultant effect on the electrical properties of the reservoir.

A series of brine-saturated cores have been examined, and it was found that the following simple relationship holds between  $R_0$  (resistivity of the sand when saturated with brine),  $R_w$  (resistivity of the brine), and F (a "formation resistivity factor"):  $R_0 = FR_w$ . Also  $F = \theta^{-m}$ , where  $\theta$  is the porosity fraction of the sand, and m is a constant ranging 1.8-2.0 for consolidated sandstones, and being about 1.3 for clean uncemented sands. For sands with the pores partly filled with connate water and

the rest of the pores occupied by oil or gas,  $S = \sqrt[n]{\frac{R_0}{R}}$ , where S is the fractional water

saturation, R the measured resistivity, and n a constant which is about 2. In practice R may be derived from an electrical log after making due allowance for certain factors.  $R_0$  may at times be derivable from electrical logs, but otherwise it must be determined from measurements of  $\theta$ , m, and  $R_m$ .

Electrical log values of R must be corrected for the presence of the borehole and the thickness of the layers in the formations in relation to the electrode spacing. Calculated tables show the approximate influence of these two factors. Invasion of the formation by the mud filtrate may also affect the measured values, although mud conditioning may keep this factor small.

Examples are given of the calculation of the connate water content of a reservoir from electrical log measurements and other data. It is also possible to obtain a measure of the amount of invasion by mud filtrate. G. D. H.

27. Unsteady Flow of Gas through Porous Media. C. R. Hetherington, D. T. Mac-Roberts and R. L. Huntingdon. *Petrol. Tech.*, January 1942, **5** (1), A.I.M.M.E. Tech. Pub. No. 1398, 1-9.—Since the equation of continuity governing the transient flow of gases through porous media cannot be integrated mathematically into a simple usable expression free from series terms, empirical and approximate equations have been advanced relating cumulative production and future production rates from gas reservoirs with time. In order to check the accuracy of these empirical equations and to obtain an insight into the initial conditions pertinent to the solution of the fundamental equation of continuity, experimental work has been conducted on a vertical 2-in. tube, 91.6 ft. high, packed with loose Wilcox sand. The sand had a porosity of 33% and a permeability of 7.2 darcys, and it was found that turbulence set in at a Reynolds number of 1.00-2.00.

Close agreement was obtained with the "characteristic equation" of the "backpressure" method of testing gas wells:  $\frac{Q}{T} = a(P_s^2 - P_f^2)^N$ , where Q is the total pro-

duction to the time T,  $P_s$  the pressure at the external boundary of the system,  $P_f$  the pressure at the outlet of the system, and N an experimental constant. Curves show the pressure distribution at different times, the pressure change with time at different stations, the change of rate of flow with time, the increase in cumulative production with time, and the relationship between pressure and cumulative production at different stations.

It was found that after about three or four minutes the rate of pressure decline was essentially independent of the position in the system, and in this phase the equation

$$Q = Q_0 \Bigg[ 1 - \left( rac{1}{1 + rac{(2N-1)C_0T}{Q_0}} 
ight)^{rac{1}{2N-1}} \Bigg]$$

gave better agreement with observations than for the initial phase.  $Q_0$  is the initial quantity of gas in the reservoir,  $C_0$  the initial rate of flow, and the other symbols have the same significance as before. The initial 3 or 4 min. constitute a transient period which has been inferred from field data, and which is probably of longer duration than is commonly supposed.

The experiments tend to verify the accuracy of the "back-pressure" method of testing gas-wells, provided that the period of transient conditions for the reservoir is not of too long a duration. The assumption of successive steady states is seen to hold with fair validity in calculating future production and rates of decline.

G. D. H.

#### Transport and Storage.

28. Engineering Economics of Long Petroleum Pipe-lines. E. G. Hill. Petrol. Tech., January 1942, 5 (1), A.I.M.M.E. Tech. Pub. No. 1433, 1-13.—The engineering and economic aspects of the design of long petroleum pipe-lines are discussed, with special reference to the following points: application of basic flow formulæ; comparative costs of lines; capacities of lines and cost per mile; effect of viscosity on the over-all transportation costs; basic costs of transporting crude oil; the effect of increased line size on costs; the functions of pipe-lines for refined products; the handling of different products through pipe-lines; basic principles governing the flow of gasoline through pipe-lines; and the importance of a high load factor.

Diagrams show the approximate daily delivery capacity at 100% load factor of oil and gasoline for lines of different diameters with a 15 lb./in.<sup>2</sup> pressure drop per mile; the approximate cost per mile and per mile per barrel daily capacity for different sizes; and the factors determining the pressure drop.

While the cost per mile increases as the diameter increases, the cost per mile per barrel daily capacity decreases as the diameter increases. For 10-in. and 12-in. lines

the tariff is probably 5c./brl./100 ml., but for a 24-in. line the figure would probably be  $2\frac{1}{2}c./brl./100$  ml. at reasonably good load factors. A large line which might operate at 3c./brl./100 ml. at 100% load factor would probably show a cost of  $3\cdot25c.$  at 90% load factor,  $3\cdot6c.$  at 75%, and  $5\cdot4c.$  at 50% load factor. G. D. H.

29.\* Flow of Liquids Under Critical Conditions. A. H. Nissan. J. Inst. Petrol., November 1942, 28 (227), 257-273.—Experiments on the flow of water through a copper pipe of circular cross-section under critical regime are described, and their results analyzed. It appears that the critical regime is similar to the viscous regime in having linear relationships between frictional head and rate of flow, and it is similar to turbulent flow in the small direct influence that viscosity appears to have. A. H. N.

#### Cracking.

30. Notes on the Conversion of California Residuum. R. F. Naeve. *Refiner*, September 1942, 21 (9), 269-270.—A brief report is given of experiments on the conversion of a residuum, catalytically, into lighter products. The author requests correspondence with those interested in the problem for exchange of data and ideas. A. H. N.

**31. Patent on Cracking.** G. Egloff. U.S.P. 2,297,695, 6.10.42. Appl., 12.8.40.— A hydrocarbon distillate consisting of naphtha and heavier naphthenic oil is subjected to catalytic reforming in the presence of a powdered dehydrogenation catalyst. Resultant conversion products are passed to a secondary reaction zone, where conversion is continued in the presence of a powdered cracking catalyst. Products of this reaction are separated into cracked vapours and residue containing mixed catalysts. The cracked vapours are fractionated to form reflux condensate, which in turn is passed to the secondary cracking zone. Fractionated vapours are cooled and condensed, and the resultant distillate is separated from undissolved and uncondensed gases. At least part of these gases are returned to the primary reaction zone. H. B. M.

#### Hydrogenation.

**32.** Patents on Hydrogenation. B. B. Corson and G. S. Monroe. U.S.P. 2,298,346, 13.10.42. Appl. 30.10.39. Catalytic hydrogenation process for effecting substantial desulphurization of a gasoline containing both olefinic hydrocarbons and sulphur compounds in such a way that the anti-knock value of the gasoline is not materially reduced. The vapours of the gasoline are contacted with a nickel sulphide catalyst in the presence of an amount of hydrogen approximately four times as great as that required for complete hydrogenation of the olefinic hydrocarbons and removal of sulphur. The operation is carried out at a temperature of approximately 350° C, under a hydrogen pressure of approximately 900 lb. per square inch and at a liquid space velocity of between 1 and 2.

B. B. Corson and G. S. Monroe. U.S.P. 2,298,347, 13.10.42. Appl. 30.10.39. Process as described in U.S.P. 2,298,346 above, except that a heavy metal sulphide is employed instead of a nickel sulphide catalyst. H. B. M.

#### **Polymerization and Alkylation.**

**33.\*** High Temperature Alkylation of Aromatic Hydrocarbons. A. N. Sachanen and A. A. O'Kelly. *Industr. Engng Chem.*, 1941, **33** (12), 1540.—Yields and operating conditions are given for the experimental batch and continuous alkylation of benzene and toluene with the following olefins: propylene, butylene, and amylene. At atmospheric pressure this reaction takes place at  $800-900^{\circ}$  F. without the presence of a catalyst. At high pressures, in the presence of an activated clay catalyst, an improved yield of the alkylated aromatic is obtained. Yields of alkyl benzene may be as high as 67% and as high as 83% for alkyl toluene. J. W. H.

**34.** Patent on Polymerization and Alkylation. V. N. Ipatieff and H. Pines. U.S.P. 2,298,383, 13.10.42. Appl. 7.10.40. Substantially saturated hydrocarbons of motor fuel boiling range are produced by alkylating isobutane with ethylene in the presence of hydrogen chloride and a solid composite comprising aluminium chloride adsorbed in a solid adsorbent. H. B. M.

#### Synthetic Products.

**35.\*** Ameripol—Synthetic Rubber Developed by U.S. Scientists. C. C. Pryor. Petrol. Engr, August 1942, **13** (12), 31.—The first experiments on the manufacture of dienes and their polymerization to produce synthetic rubber were carried out in 1926 by W. L. Semon, under whose direction the development and manufacture of Ameripol and other butadiene synthetic rubbers have been brought to a commercial basis. The first pilot plant was completed in 1939, with a capacity of 100 lb. of rubber a day, and by 1940 two distinct types of synthetic rubber had been developed, (a) a tyre rubber, and (b) an oil-resistant speciality rubber. Hycar Chemical Co., jointly owned by Phillips Petroleum Co. and the B.F. Goodrich Co., constructed a plant capable of manufacturing 2000 tons per annum of both types of synthetic rubber.

The butadiene molecules will readily polymerize with themselves or copolymerize with other substances to produce synthetic rubbers. When emulsified under pressure with soap and water, polymerization proceeds rapidly, resulting in a milky suspension similar to natural latex. Coagulated with acid, in much the same way as natural latex, the synthetic is sheeted, and thus is produced the synthetic crude rubber. The same equipment and almost identically the same technique are employed in compounding and vulcanizing Ameripol as are used for natural crude rubber, except that less sulphur and more accelerator are ordinarily required and larger quantities of softener may be used. Ameripol rubbers are compounded differently for each of a large number of special uses. Compounds of high tensile strength and elasticity are easily manufactured. Special compounds possessing high resistance to swelling or deterioration in the presence of petroleum products, vegetable oils, fats, etc., and others possessing special heat-resisting properties are also prepared. Some of the special applications of Ameripol, in which advantage is taken of its superiority to natural rubber for specific purposes, are listed. Synthetic Ameripol rubber for tyres is said to cost about 60c. per lb., but it is believed that a cost of 25c. lb. could be achieved in plants having a capacity of 36,000 tons per annum. R. A. E.

#### Refining and Refinery Plant.

36.\* Mean Temperature Difference in Multipass Heat Exchangers. K. A. Gardner. Industr. Engng Chem., 1941, 33 (12), 1495.—It is sometimes preferable to design heat exchangers in which the shell fluid is not mixed, and the conditions under which this is advantageous are discussed. Data are given which enable the mean temperature correction factor to be estimated for these conditions, and it is shown that the factors are higher than those for which the shell fluid is mixed. J. W. H.

**37.** Automatic Control of Absorption Oil Flow Improves Plant Recovery. Anon. *Refiner*, September 1942, **21** (9), 271–273.—In the plant described, sufficient quantity of absorption oil at 150 lb./sq. in. gauge is circulated to remove the propane and heavier components from the field gases. By absorbing all of the propane it is inevitable that some of the ethane will be dissolved in the absorption oil. To control this a combination tail absorber and fat—oil flash-tower is stepped into the line of absorption-oil flow. Liquid-level controllers vent the fat oil from the high-pressure absorbers directly into the combination column, which reduces the pressure on the oil from 150 to 50 lb. This immediate drop in pressure releases the undesirable fractions together with some of the more desirable ones, which, if not checked, would flow into residue gas-lines. Since the recovered vapours from the accumulator and storage tanks are gathered and compressed and piped to the combination column, a quantity of lean absorption oil is pumped over this tower, so that none of the desirable fractions will escape. The lean oil enters the column above the absorbing trays, while the fat oil from the high-pressure absorbers enters below the bubble-plates. The oil

flowing down in contact with the rising vapours merges with the fat oil and passes outward to the distillation system.

In combination with this system of pre-stabilization of the fat absorption oil, a surge tank is placed in the line of flow between the flash column and reabsorber and the fat-oil pumps. Liquid-level controllers vent the oil from the base of the combination column to the surge-tank, which is equipped with both a high and a low liquid-level controlling installation, each working independently, but both hooked-up to operate the diaphragm valve in the steam line to the fat-oil pump. When the operation of the plant is on a basis of constant flow of absorption oil, the level-controllers float in their cases and the fat-oil pump runs at sufficient speed to remove the oil from the surge-tank as rapidly as it is vented into it from the combination column. If the rate of flow changes only slightly from the normal rate, the high-and low-level controllers act to establish equilibrium by changing the speed of the fat-oil pump.

38. More Steam with Minimum Materials. P. W. Foster, Jr. Refiner, September 1942, 21 (9), 265-268.-The present scarcity of raw materials has made it difficult, if not impossible, to secure additional steam for increasing refinery requirements by the installation of new boilers of conventional design. Therefore when an increase in total steam production is needed, new ways of accomplishing this by the use of a minimum amount of critical material must be devised. Furthermore, as this additional steam requirement may end at the termination of the war, it is essential that the cost of the steam-generating equipment be kept to a minimum. Some methods of doing this have already been developed, but there are also new ways which are worthy of consideration. The paper discusses the use of waste-heat boilers and of combination direct-fired boiler and still. Definite saving in material and first cost can be made by installing steam-generating surface in combination with an oilheater, as compared with the cost of a separate direct-fired boiler and an oil-heater. A single boiler unit to give 100,000 lb. of steam/hour is cheaper than two 50,000 lb./hr units. On the same basis if 50,000,000 B.t.u./hr. is put into oil, and 25,000,000 B.t.u./hr. into steam, a combined unit is cheaper in first cost, and in material required, than a separate oil-heater and boiler for the same capacities.

The paper ends with the following conclusions: Heating oil and generating steam in the furnace of an oil-heater have the following advantages: (1) The first cost of the steam-generating and oil-heating equipment is reduced. (2) The total material required for steam generation is reduced. (3) Steam can be generated with the same efficiency as in a separate, direct-fired boiler plant. (4) The efficiency of heating the oil can be increased. (5) Auxiliary motor drives can be eliminated. When both steam and power come from a central power-plant, auxiliaries such as pumps, fans, etc., are usually arranged for both steam- and motor-drive. With a combination boiler and still, the motor-drives can be omitted, as steam will always be generated when the still is in operation. (6) Large savings in first cost and material in elimination of steam and power lines from power-station to refinery unit location. A. H. N.

39. Multicomponent Distillation. C. D. Shiah. *Refiner*, September 1942, 21 (9), 261-264.—In a previous article of this series the author has presented a graphical method for the stepwise calculations of multi-component rectification. It is probably the quickest method for carrying out the detailed calculations. The advantage of a stepwise solution lies in the fact that it gives a complete picture of the concentration gradients of each component along the plates as well as the temperature on each plate. The inherent disadvantage of this method, however, is its stepwise nature, which, in the case of a large number of plates, is unavoidably time-consuming.

This paper presents a quick method, which is simple and which gives a complete picture of the concentration gradient of each component along the column with reasonable accuracy. The methods were checked against the step-by-step method and the agreement is good. A. H. N.

40. Patents on Refining and Refinery Plant. Standard Oil Development Co. E.P. 548,375, 8.10.42. Appl. 10.1.40. In an improved solvent-treating process, separation of the highly aromatic constituents of an initial feed-oil in a pretreating zone

allows a second solvent to displace the first solvent substantially completely from the relatively intermediately soluble aromatic constituents of the feed-oil. Thus the initial solvent, so displaced by the second, can be returned to the initial extraction zones without distillation and without returning to these zones any appreciable quantity of dissolved aromatics.

C. G. Dryer and C. Wirth. U.S.P. 2,297,751, 6.10.42. Appl. 8.9.39. Method of treating a sour hydrocarbon distillate with a copper-containing sweetening agent in the presence of oxygen-containing gas. The mixture of distillate and gas is introduced into the upper portion of a vertical chamber having a free space in its upper portion and a layer of copper-removing agent in its lower. The gas is separated from the distillate, and the latter is allowed to gravitate through the copper-removing agent. In this way the time elapsing between sweetening of the distillate and removal of dissolved copper is minimized.

W. L. Benedict. U.S.P. 2,297,866, 6.10.42. Appl. 25.9.39. Method of sweetening sour hydrocarbon distillate which contains mercaptans. The distillate is treated with an alkali metal hydroxide dissolved in a solvent consisting of a relatively lowboiling alcohol and a higher-boiling alcohol. Afterwards the mercaptan-containing alcohol is separated from the treated distillate. The mercaptan-containing alcoholic solution is regenerated by vaporizing the lower-boiling alcohol from the solution. Then the mercaptans are vaporized from the remainder of the solution, thus leaving a residue containing the higher-boiling alcohol and alkali metal hydroxide. The residue is mixed with the lower-boiling alcohol and the whole passed to the distillatetreating operation. H. B. M.

#### Chemistry and Physics of Petroleum.

41.\* Isomerization of Polymethylene Hydrocarbons under the Influence of Aluminium Chloride. M. B. Turova-Poliak and F. P. Sidel'kovskaya. Trans. from Zhurnal Obshchei Khimii, II, 1941, 817. Foreign Petrol. Tech., Jan.-Feb., 1942, 10 (1/2).—Article VII. Isomerization of cycloHeptane (pp. 7-12). The paper describes experiments concerning the behaviour of cycloheptane in the presence of the isomerization-promoting agent aluminium chloride. It was found that in the interaction of aluminium chloride with cycloheptane, the latter is isomerized by 97-98% to methylcyclohexane. In this way is effected the isomerization of the seven-member polymethylene hydrocarbon into a six-member one.

Article VIII. Isomerization of Hexahydromesitylene (pp. 27-30). As a result of experiments, the authors obtained through the action of aluminium chloride on hexahydromesitylene a mixture of hydrocarbons which is composed of 88% hexamethylene hydrocarbons (unchanged hexahydromesitylene), 9% pentamethylene, and 3% paraffin hydrocarbons. The group composition of separated hydrocarbons confirms the observation made previously that the derivatives of *cyclo*hexane are extremely stable towards the isomerizing effect of aluminium chloride.

Article IX. Isomerization of 1:2-Dimethylcyclopentane (pp. 31-37). As a result of investigations concerning the process of isomerization of 1:2-dimethylcyclopentane under the influence of aluminium chloride, it was found that a yield of 96.7% methylcyclohexane is normally obtained. It was also proved that the presence of substituents in the molecule of cyclopentane does not interfere with its isomerization to cyclohexane hydrocarbons. H. B. M.

42.\* Determination of Beattie-Bridgeman Constants from. Critical Data. F. W. Brown. Industr. Engng Chem., 1941, 33 (12), 1536.—A brief discussion is given on the Maron-Turnbull equation for the calculation of the Beattie-Bridgeman constants. It is shown that this equation is an expression of the law of corresponding states in terms of the intermolecular forces. The constants for hydrogen are calculated on the basis of a model of the intermolecular forces. Theoretical reasons are given for expecting deviations from the Maron-Turnbull equation. J. W. H.

43. Viscosity Nomographs for Organic Liquids. D. S. Davis. Industr. Engng Chem., 1941, 33 (12), 1537.—From relationships between viscosity, density, and molecular weight two nomographs have been drawn which enable the viscosity of some 166 compounds to be estimated, twenty-nine of these compounds being hydrocarbons. J. W. H.

44. Ternary Systems for Extraction Calculations. J. C. Smith. Industr. Engng Chem., 1942, 34, 234.—The theoretical methods available for the interpretation of ternary solubility diagrams are discussed and a list of ternary systems, for which the solubility data are complete, is given. The bibliography includes extensive references to theoretical and experimental work on this subject. J. W. H.

45.\* Molecular Refraction Nomograph. D. S. Davis. Industr. Engng Chem., 1942, 34, 258.—A nomograph is presented which enables the molecular refraction, as expressed by the Lorentz-Lorenz formula, to be rapidly estimated. J. W. H.

46.\* Molal Volume Nomographs for Aliphatic Hydrocarbons. D. S. Davis. Industr. Engng Chem., 1942, 34, 351.—The liquid molal volumes of aliphatic hydrocarbons at the boiling point are correlated against number of carbon atoms and boiling point in the form of two nomographs, which enable allowance to be made for the degree of branching in the hydrocarbon. J. W. H.

47.\* Effect of Pressure on the Enthalpy of Pentane, Heptane, and isoOctane. E. R. Gilliland and M. D. Parekh. Industr. Engng Chem., 1942, 34, 360.—The isothermal enthalpy changes with pressure have been investigated over the pressure range 200–2900 lb./sq. in. and over a temperature range of 330–660° K. The experimental results obtained are compared with results calculated from other published data obtained by different techniques. Excellent agreement is shown at all pressure ranges except at very low values of reduced pressure, where the experimental curves were extrapolated, and hence might not be so accurate. J. W. H.

**48.\*** Molecular Volume of Liquid Alkanes at Corresponding Temperatures. G. Egloff and R. C. Kuder. *Industr. Engng Chem.*, 1942, **34**, 372.—Correlation of the molecular volumes of the paraffin series with boiling point or melting point is not satisfactory, but it is shown that if a correlation is made between the molecular volume and the reduced temperature, there are no complications for paraffins containing up to 8 carbon atoms. J. W. H.

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49.\* Application of Thermodynamic Data to Industry. J. G. Aston. Industr. Engng Chem., 1942, 34, 514.—The various methods available for calculating the free energy data for a reaction are discussed, and the methods by which these values can be calculated from a knowledge of (a) equilibrium at two or more temperatures, (b) the equilibrium at one temperature and a knowledge of the heat of reaction and heat capacity, and (c) heat of reaction, entropy, and heat capacity data. Examples of the use of these methods are applied to the isomerization of *n*-butane and to the hydration of ethylene. A method is also given by which the pressure effects on free energy calculations can be estimated. J. W. H.

50.\* Prediction of Critical Constants. H. P. Meissner and E. M. Redding. Industr. Engng Chem., 1942, 34, 521.—Equations are given which enable the critical pressure, temperature, and volume to be calculated from a knowledge of the boiling point, vapour pressure, and liquid density at some temperature. These equations have been derived from data on 100 substances, and can be applied to any substance which is not highly associated and the structural formula of which is known. J. W. H.

51.\* Applications of Thermodynamics to Multicomponent Systems. B. H. Sage and R. H. Olde. Industr. Engng Chem., 1942, 34, 526.—The value of the fugacity in the estimation of phase behaviour in multi-component systems is discussed, and the value of enthalpy in studying the behaviour of multi-component homogeneous systems is reviewed. The manner in which the enthalpy can be used to study the change of state, work, and heat associated with both steady and transient flow conditions is demonstrated. J. W. H.

52.\* Compressor Design for the Process Industries. R. York. Industr. Engng Chem. 1012. 34, 535.—The design and performance of compressors for the com-

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pression of perfect gases are discussed from a theoretical aspect, and the methods by which the fundamental equations can be modified for dealing with non-ideal gases are reviewed. A numerical example is given of a compressor operating on an imperfect gas mixture. J. W. H.

53.\* Generalized Thermodynamic Properties of Gases at High Pressures. S. H. Maron and D. Turnbull. Industr. Engng Chem., 1942, 34, 544.—The advantages and limitations of the following methods of obtaining compressibilities and thermodynamic properties of gases at high pressures are discussed: (a) direct experimental study, (b) experimental measurements of compressibilities and evaluation from these of the various thermodynamic properties, (c) the fitting of equations of state to determined P-V-T data and the analytical calculation of the thermodynamic properties, (d) estimation of the compressibilities and thermodynamic properties from the generalized graphical correlations of the theorem of corresponding states. J. W. H.

54.\* Degrees of Freedom in Multicomponent Absorption and Rectification Columns. E. R. Gilliland and C. E. Read. Industr. Engng Chem., 1942, 34, 551.—An analysis is made to determine how many of the design variables may be arbitrarily fixed before the system as a whole can be physically defined in equilibrium and non-equilibrium contacting systems. From this point it is shown that the greatest difficulty in applying any of the existing methods of design is that it is necessary to fix more variables than are independent in order to expedite the process design as a whole. Thus the rapidity with which these methods can be evaluated depends to a certain extent on the experience with which the initial assumptions can be made. J. W. H.

55.\* Vapour-Liquid Equilibria of Non-ideal Solutions. H. C. Carlson and A. P. Colburn. Industr. Engng Chem., 1942, 34, 581.—Several equations, based on thermodynamic principles, are reviewed which enable vapour-liquid equilibria in non-ideal solutions to be correlated. These equations enable experimental data to be examined critically for accuracy. With an integrated form of one of these equations complete vapour-liquid equilibria may be calculated from measurements of azeotropic composition, total pressure or boiling-point curves, or liquid-liquid solubility. The use of these equations to calculate the effect of pressure or temperature on the equilibrium composition is demonstrated, and the manner in which data on three binary, systems can be applied to the estimation of ternary data is shown. A short note on the value of activity coefficients in the calculation of extraction equilibria is also given.

J. W. H.

56.\* Thermodynamic Properties of Light Hydrocarbons. D. E. Holcomb and G. G. Brown. Industr. Engng Chem., 1942, 34. 590.—The thermal properties of hydrocarbons and hydrocarbon mixtures covering the pressure range 0-10,000 lb./sq. in. and the temperature range of -200 to  $+1100^{\circ}$  F. for the vapours, and from  $0^{\circ}$  to  $320^{\circ}$  F. for the liquids are presented in graphical form. In addition to this thermal data, the compressibility factors and activity coefficients are given, which enable extensive thermodynamic properties to be calculated.

Actual examples are given illustrating the following applications of the data given : overall heat balance on a high-pressure absorber, heat balance for a natural gasoline fractionator, the construction of an enthalpy-entropy (Mollier) diagram for a natural gas and the use of this chart in determining the H.P. required to compress the gas isothermally and adiabatically and to estimate the temperature change on free expansion through a valve. J. W. H.

57. Density of Liquefied Petroleum Gas Hydrocarbons. Their Mixtures and Three Natural Gasolines. B. R. Carney. Refiner, September 1942, 21 (9), 274–282.—Paper Presented at the Annual Meeting of Natural Gasoline Association of America. It is pointed out that in loading liquefied petroleum gases it is necessary to convert volumes at actual loading temperatures into standard volumes at  $60^{\circ}$  F., or vice versa. Bulk transactions in these products are becoming increasingly common, and for such deals reliable and generally acceptable volume-correction factors are desirable. The various standards in use do not agree well—particularly in the temperature range below  $60^{\circ}$  F. Also it was felt that the temperature range covered by these standards was somewhat too limited for all possible requirements.

Accordingly the original rather modest programme of checking densities for the

temperature range  $0-60^{\circ}$  F. was extended to a range of  $-50^{\circ}$  to  $140^{\circ}$  F., and at the request of the A.P.I. Committee on Measuring, Sampling, and Testing Natural Gasoline, some tests were made on typical natural gasolines of low, medium, and high volatility. Also a few determinations were made on propylene and butene-I. The direct results are orthobaric absolute densities for the individual hydrocarbons, two component mixtures, and the three natural gasolines. From these data can readily be computed the required temperature v. volume factors, using the density at  $60^{\circ}$  F. as a reference point.

The paper discusses in detail the apparatus, technique, and results of measuring these densities. Full tabulated and graphical data are presented. The densities of propane, *iso*butane, *n*-butane, normal pentane, and of the two olefines, propylene and butene-I, as determined in this work are compared with values obtained by other workers.

Certain of the data on the mixtures do not permit the conclusion that the twocomponent mixtures behave as perfect solutions. Nevertheless, even for this blend temperature-volume factors at  $100^{\circ}$  F. based on the observed and the calculated densities vary by less than two units in the third decimal place, being respectively 0.9422 and 0.9403. Based on these results, which confirmed previous investigations in the laboratories of a member company, it was concluded that for the commercial liquefied petroleum-gas products, densities, and volume factors at various densities could be ascertained by interpolating between the values for the pure compounds using the density or specific gravity of the mixture at  $60^{\circ}$  F. to identify it. The Bureau of Standards has used this same method in applying the earlier work of Dana to this problem.

Accordingly a graph was prepared plotting the data isothermally with respect to specific gravity (density) at 60° F. The correlation with specific gravity is considered commercially accurate for the liquefied petroleum-gas products—which usually consist of two or three closely related components, over the entire temperature range,  $-50^{\circ}$  to  $140^{\circ}$  F. Beyond the liquefied petroleum-gas range, *i.e.*, for specific gravities above 0.600, the correlation is likewise considered commercially accurate for the narrower temperature range  $0-100^{\circ}$  F. By commercially accurate is meant that the volume correction factors will be correct to one unit in the third decimal place. For the extreme temperature range,  $-50^{\circ}$  to  $0^{\circ}$  F., and  $100-140^{\circ}$  F. and above 0.600 specific gravity the data are less accurate, but perhaps represent the best information available in these ranges. A. H. N.

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58. Hydrocarbon Structure of Petroleum is Complex. A. W. Trusty. Refiner, September 1942, 21 (9), 257-260.—It is explained that knowledge of the structure of petroleum is still comparatively meagre. The hydrocarbon analysis of a petroleum product heavier than natural gasoline is very complicated. Difficulty in analysis by fractional distillation and other methods are due to : (1) Difference in boiling points of hydrocarbons diminishes with increasing molecular weights. (2) The number of isomers increases rapidly with increasing molecular weights. (3) Constant-boiling mixtures. (4) Polymerization and depolymerization occurring before the boiling point is reached. A simple study of isomers and the number of possible isomers for hydrocarbons of certain number of carbon atoms is given. Classification of crudes is briefly discussed, followed by a study of hydrocarbons in gas, gasolines, kerosine, etc.

The hydrocarbon structure is so complex and the number of hydrocarbons present in lubricating oils so great that very little success has been had in isolating pure hydrocarbons therefrom. Several investigators have studied synthetic hydrocarbons and have made deductions regarding the chemical composition and nature of the heavy, viscous oils. Hugel has concluded : (1) Ring formation has a great effect in increasing viscosity. (2) The branching chains in acyclic hydrocarbons have little or no effect on viscosity. (3) Unsaturation (olefins) has very little effect on viscosity in acyclic hydrocarbons, although it may be a factor in cyclic compounds. (4) In general, a cyclic nucleus in a molecule is necessary if such factors as branching of the chain or unsaturation are to have any effect on viscosity, and in acyclic compounds viscosity is materially increased only by increasing the molecular weight. (5) Of two oils with the same viscosity at a given temperature, say  $100^{\circ}$  F., the oil with the lower molecular weight is characterized by greater viscosity change with change in temperature.

The lubricating fraction of a Mid-Continent petroleum from which the wax and

asphaltic constituents had been removed appears to have the following constitution: (1) About 60% of the material consists of naphthenes with from one to three rings/ molecule (a very small amount of material containing four naphthenic rings is probably present also). (2) About 15% of the material consists of molecules with one aromatic ring and from one to three naphthenic rings/molecule, and with this material is associated a small amount of sulphur and oxygen compounds. (3) About 14% of the material consists of molecules with two aromatic rings (linked through two common carbon atoms) and about two naphthenic rings/molecule, and with this material is associated a small amount of sulphur and oxygen compounds. (4) About 11% of the material consists of molecules with more than two aromatic rings (each probably linked through two common carbon atoms) and one or two naphthenic rings/molecule, and with this material are associated some sulphur, nitrogen, and oxygen compounds. A. H. N.

**59.\*** Interstitial Flow. R. T. Hancock. *Min. Mag.*, October 1942, **67** (4), 179–186.— All that the author claims in this article is a brief introduction to a wide subject namely, the nature of the relations between solids and liquids when they are moving relatively to one another. Among the considerable ramifications of the subject, the paper is relevant to the flow of oil towards wells and springs, and is, in fact, an investigation of the resistance encountered by a fluid as a function of its velocity.

Factors which affect behaviour include such things as diameter of channel or particle, velocity of flow or movement, specific gravities of the solid and fluid, fall in pressure over unit distance, loss of kinetic energy through friction or by conversion into potential energy, and the nature of the flow, *i.e.*, whether viscous or turbulent.

Physicists have made important discoveries concerning the nature of flow through smooth pipes and the nature of fall of smooth spheres in liquids. The relations can be expressed in a manner which shows their absolute applicability to a wide range of conditions by plotting them in the form of dimensionless co-ordinates. The present treatment is based on this method of presentation.

The author reaches the conclusion that in the case of immobilized beds and of suspensions the resistance experienced by a fluid traversing them may be expressed in dimensionless co-ordinates by :

$$\begin{aligned} R &= \frac{\psi d\rho}{\mu} \\ \Psi &= \frac{4}{3} \cdot \frac{g d}{\rho \nu^2} \cdot \frac{P}{L\lambda} \cdot \phi \text{ (voidage)} \end{aligned}$$

where the function in the case of suspensions is  $(1 - \lambda)^6$  and in the case of beds is  $\gamma$   $(1 - \lambda)^4$ .

The following (usual) notation is employed in this paper :

- $g = \text{gravitational constant, 981 cm./sec.}^2$
- $\mu = \text{viscosity of the fluid or gas, gm./sec.cm.}$
- $\rho = \text{density of the fluid or gas, gm./cm.}^3$
- s =specific gravity of the solid, gm./cm.<sup>3</sup>
- $P/L = \text{pressure drop over unit distance, gm./cm.}^3$ 
  - d = diameter of solid or pipe, cm.
  - v = velocity of fall or flow, cm./sec.

 $(1 - \lambda) =$  ratio of fluid to total volume, dimensionless.

- $\lambda$  = ratio of solid to total volume, dimensionless.
  - R =Reynold's number, dimensionless.

 $\Psi =$  the resistance coefficient, dimensionless.

H. B. M.

#### Analysis and Testing.

60. Rapid Method for the Determination of Tetraethyl Lead in Leaded Gasolines. M. P. Khaikin. Trans. from *Prikladnoi Khimii*, 1941, 14 (4/5), 13–26.—The molybdate method for the determination of tetraethyl lead has for some time past been employed in Russia. It is, however, a complex method involving several reagents, including a titrated solution of ammonium molybdate and a great deal of time. This paper describes a new gravimetric method for the detormination of tetraethyl lead, which, because of its simplicity, should prove of particular value for the operation of automobile depots.

#### ABSTRACTS.

100 ml. of the gasoline under test are placed in a weighed Erlenmayer flask, and a 10% solution of bromine in carbon tetrachloride is added drop by drop to complete precipitation of lead bromide. After a final ml. of the bromine has been added to ensure complete precipitation, the liquid is carefully decanted through a filter-paper. The precipitate formed in the flask is decanted a few times with petroleum ether, which is decanted through the same filter.

The neck of the flask is washed with a boiling hot 15% solution of nitric acid. The funnel, with the filter, is placed in the flask, and the precipitate on the filter dissolved by the same solution of nitric acid. The dissolution is carried out with three portions of the solution of the acid, using 10 ml. each time. The filter is then opened and again washed over the funnel, and the latter is then washed over the neck of the flask.

The solution obtained is heated to boiling point and is left on the hot plate until 3-5 ml. of the solution remain. The rest of the solution is disposed of by gentle heating, and the separated precipitate is dried (not over  $200^{\circ}$  C.) until vapours disappear, also the odour of nitrogen oxides. The flask with the residue is cooled in a desiccator and weighed. H. B. M.

61. Optical Rotation of Petro eum Fractions. M. R. Fenske, F. C. Carnahars, J. N. Breston, A. H. Caser, and A. R. Rescosla. *Industr. Engng Chem.*, 1942, 34 (5), 638.—Measurements of the rotary power of distillate fractions from Oklahoma and other crude oils have been made which show that a rotational maximum is reached between the gas oil and lubricating-oil fractions. The magnitude of the rotation is a function of the geographical origin of the crude. Concentration of the optically active material by distillation is less effective than by solvent extraction. The optically active components are concentrated in the non-aromatic portion, but do not appear to be due to any one compound. The optically active constituents are unchanged by treatment with anhydrous aluminium chloride, sulphuric acid, clay, or use in an engine.

#### Motor Fuels.

62. Patents on Motor Euels. E. R. Kanhofer. U.S.P. 2,297,773, 6.10.42. Appl. 31.7.42. Method of production of a motor fuel having a high octane rating and a relatively low olefin content. The process involves subjecting a hydrocarbon oil to catalytic cracking at a temperature between  $800^{\circ}$  and  $1200^{\circ}$  F. for a sufficient length of time to form olefinic gasoline. The resultant products are fractionated to separate the olefinic gasoline. Afterwards a saturated hydrocarbon oil is mixed with the olefinic gasoline, and the mixture is contacted with a cracking catalyst at a temperature between  $500^{\circ}$  and  $800^{\circ}$  F. for a longer period of time than was maintained in the first catalytic cracking operation. In this way the major portion of the olefin content can be recovered.

E. R. Kanhofer. U.S.P. 2,297,775, 6.10.42. Appl. 31.7.39. Production of motor fuel of high octane rating and low olefin content by thermally cracking hydrocarbon oil heavier than gasoline. The resultant cracked gasoline-containing vapours are passed to a fractionating zone maintained at a temperature above the boiling point of the gasoline. In addition there is introduced into the fractionating zone a heavy hydrocarbon charging oil containing sufficient hydrocarbons, vaporizable under conditions prevailing in the zone, to saturate the greater part of the olefin content of the gasoline. The cracked vapours and charging oil in the zone are fractionated, and the resultant heavy reflux condensate and residual charging oil are passed to the thermal cracking operation to provide the oil heavier than gasoline. The cracked gasoline and a portion of the saturated components of the charging oil are removed from the fractionating zone and supplied to a catalytic conversion zone. The mixture is subjected to the action of a cracking catalyst at a temperature between  $500^{\circ}$  and 800° F. and for a sufficient length of time to saturate the major portion of the olefin content of the cracked gasoline. Vaporous products of the catalytic treatment are fractionated and condensed.

P. L. Cramer. U.S.P. 2,299,801, 27.10.42. Appl. 22.7.38. Process for the production of a mixture of highly-branched-chain amylenes consisting for the most part of substantially pure trimethyl ethylene and *unsym.*-methyl ethylene. The process includes treatment of a mixture of amyl alcohols containing dimethyl ethyl carbinol and amyl alcohols with dilute sulphuric acid to dehydrate selectively only the dimethyl ethyl carbinol. H. B. M.

#### Lubricants and Lubrication

63.\* Lubrication of Mine Plant. C. H. S. Tupholme. *Min. Mag.*, March 1942, 66 (3), 99-104.—The author points out that one of the most important factors of crushing machinery maintenance is efficient lubrication of grinders and pulverizers. For crusher bearings it is necessary to employ a lubricant possessing considerable body in order to prevent undue heat. Fortunately there is no objection to the use of a heavy lubricant from the standpoint of speed of operation.

In mine service ball- or tube-mill bearings of the trunnion type many lubricating problems arise, due for the most part to the heavy loads which must be carried, overheating of the trunnions, and dust and grit which may work between the bearing surfaces. The use of an oil or grease having considerable body and a high liquefying point is advocated for bearings of this type.

Attention has lately been paid to the development of suitable means for automatic lubrication of bearings of the two-part type having a cap lined in much the same way as a standard type of plain bearing. Oil is carried in a reservoir below the bearing, and is distributed by a dipper device, which is rotated by the shaft. Usually two dippers are provided, which at each rotation automatically fill themselves, and then empty along the top of the shaft, whence oil is distributed throughout the entire clearance space. In cases where the pinion shafts of ball- and tube-mills are carried by ring-oiled bearings it has been found that the most suitable lubricant is a machine oil of 200-300 sec. Saybolt viscosity at  $100^{\circ}$  F.

The adoption of wick-feed oilers in the lubrication of trunnion bearings has ensured more positive results and rendered the entire operation more dependable by reducing bearing wear.

As regards vertical crushers of the type employing four balls which roll around the internal circumference of a wearing ring at the rate of approximately 160 times per minute, a heavy oil or grease should be used for main-shaft bearings. The intermediate bearing, because of its inaccessibility, is more suitably lubricated with grease. The lower bushing and thrust bearing are arranged to operate in a bath of oil. For this type of lubrication steam cylinder or crusher oil may be used, except in circumstances where the gear-drive and ball-thrust bearing are incorporated in the same housing.

Screening plant presents many problems of lubrication, especially in regard to gears which are subjected to contamination by dust, dirt, and moisture. The most effective way of protecting gearing is to employ a lubricant which will form a film to counteract the abrasive effect of such particles, and which will at the same time function irrespective of temperature, moisture, or weather conditions. A straight mineral residual product of fairly inert characteristics will probably give the best results.

For vibrating screens some form of compression or pressure-grease lubrication designed to employ a medium-bodied grease will ensure as positive results as possible.

In the case of belt-conveyors the adoption of anti-friction bearings and positive lubrication with a low-torque grease capable of functioning over a wide temperature range has proved advantageous, particularly from the standpoint of reduction of power consumption. H. B. M.

64.\* A Note on the Use of Active Magnesia for the Regeneration of Used Lubricating Oils. G. Armstrong Smith. J. chem. metall. min. Soc. S. Africa, May-June 1942, 42 (11 and 12), 321-325.-Both small- and large-scale tests have been carried out in an endeavour to overcome a difficulty experienced in the use of active magnesia in the regeneration of used oils on a commercial scale. It has been found that this material tends to clog the filter and may eventually cause the flow of re-refined oil to cease altogether.

The author's account of these experiments points to certain definite conclusions. Much depends on the state of division of the magnesia. It would appear that the optimum time of grinding lies between 1 and 2 hr. This gives a powder having approximately 60-70% - 240 mesh, 70-80% - 200 mesh, and 85-95% - 120 mesh The other Designation of the local division of the local divisione

material. After this stage had been reached longer grinding only very slowly increased the proportion of -240-mesh size, while the existing -240 particles appeared to suffer further pulverization to an extremely fine powder which materially decreased the filtration rate.

Of a number of filter-aids examined, only kieselguhr and sawdust proved useful, and on the whole kieselguhr appeared less efficient than sawdust. Carbon residue and oxidation tendencies of the oil were not affected by the use of sawdust, but a small increase in saponification value was noted.

As viscosity of the oils increases, filtering tends to become slower. In fact, though, only the heaviest grade of oil utilized (S.A.E. 40) was found to require an increased weight of sawdust for it to be comparable with the other grades (S.A.E. 20 and 30).

The use of a mixture of active magnesia and imported bentonite which has greater activity results in a reclaimed oil of somewhat better colour, and the filtration rate is fair, due to the reduction of magnesite and to the clay acting to a certain extent as a filter aid.

To complete the investigations a number of tests were carried out on a 20-gal. oil-regeneration plant in commercial operation.

From all experiments it would appear that for the commercial production of magnesia the following points should be borne in mind. Calcination must be controlled and temperatures higher than  $800-850^{\circ}$  C. avoided. The burning should be as complete as possible, so that not more than 4-5% carbon dioxide remains in the charge. Afterwards crushing to predetermined grade sizes will give a material which can satisfactorily be used with 25% bentonite or other approved filter aid. H. B. M.

65. Patents on Lubricants and Lubrication. P. S. Clarke and M. T. Flaxman. U.S.P. 2,298,080, 6.10.42. Appl. 19.11.40. Preparation of an oil of suitable type for breaking-in internal-combustion engines. The lubricant consists of a mineral lubricating oil of high viscosity index, a minor proportion of esters of low aliphatic alcohols from synthetic alcohols, and a minor proportion of the calcium soap of phosphonic acids prepared from high-viscosity-index mineral lubricating oils.

A. T. Knutson. U.S.P. 2,298,301, 13.10.42. Appl. 12.8.38. Production of a lubricating composition consisting of a mineral lubricating oil and from 0.1% to 20% of a halogenated hydro-aromatic ketone having a vapour pressure less than atmospheric at  $140^{\circ}$  C.

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H. G. Smith. U.S.P. 2,298,317, 13.10.42. Appl. 27.8.40. Lubricating greases substantially free of occluded gas and vapours are prepared by agitating a grease mixture including a lubricating oil and a soap in a kettle closed to the atmosphere and under a sufficient vacuum to prevent the trapping of occluded gases and vapours.

C. F. Prutton. U.S.P. 2,298,637, 13.10.42. Appl. 4.10.39. Preparation of an extreme-pressure lubricant consisting of a major proportion of a refined mineral lubricating oil and a minor amount of a stable, oil-soluble extreme-pressure addition agent having a vapour pressure less than atmospheric at  $140^{\circ}$  C. The effectiveness of the addition agent is dependent on its ability to react chemically with the metallic surfaces to be lubricated. The composition also has incorporated in it a small amount of an oil-soluble organic nitrogen and sulphur-containing corrosion inhibitor which does not affect the extreme-pressure lubricating properties of the composition.

C. F. Prutton. U.S.P. 2,298,638, 13.10.42. Appl. 4.10.39. Extreme-pressure lubricant of the type described in U.S.P. 2,298,637 above, but containing as corrosion inhibitor an oil-soluble organic oxygen.

C. F. Prutton. U.S.P. 2,298,639, 13.10.42. Appl. 4.10.39. Extreme-pressure lubricant of the type described in U.S.P. 2,298,637 above, but containing as corrosion inhibitor an oil-soluble organic sulphur.

C. W. Muessig. U.S.P. 2,298,833, 13.10.42. Appl. 28.3.40. Preparation of a lubricant consisting of a lubricating oil blended with a minor proportion of a halogenated high-molecular-weight polymer of a normal mono-olefin containing two to three carbon atoms per molecule.

A. A. Schilling and R. B. Curran. U.S.P. 2,298,844, 13.10.42. Appl. 15.2.40. Preparation of a substantially solid bullet lubricant which has incorporated in it a

#### ABSTRACTS.

mineral wax-like lubricant and not less than 5% of a microcrystalline petrolatum wax.

D. L. Wright. U.S.P. 2,298,855, 13.10.42. Appl. 21.10.39. Preparation of a steam cylinder lubricant which has in combination a steam-reduced cylinder oil of viscosity at least 100 secs. Saybolt at 210° F. and a minute quantity of poly*iso*butylene, also from 3% to 20% of auxiliary fatty material.

L. A. Mikeska. U.S.P. 2,300,131, 27.10.42. Appl. 29.9.37. Preparation of a lubricant consisting of a hydrocarbon oil and a small amount of a polymer of a reactivegroup-containing fatty acid ester of an aromatic hydroxy compound. The ester contains more than ten aliphatic carbon atoms. H. B. M.

#### Asphalt and Bitumen

66. Patents on Asphalt and Bitumen. D. E. Carr. U.S.P. 2,298,612, 13.10.42. Appl. 16.6.39. A bituminous emulsion of low viscosity is produced by separating salt contained in asphalt to produce an asphalt containing less than 0.005% by weight of a water-soluble inorganic salt of a divalent metal, and less than 0.005% by weight of a water-soluble salt of a monovalent metal. The asphalt is mixed at a high temperature with water and an emulsifying agent.

L. D'Antal. U.S.P. 2,299,469, 20.10.42. Appl. 28.6.37. Method of treating bitumen and other material of asphaltic character which includes heating the original substance with up to 25% by weight of a material selected from the group consisting of vegetable and animal oils, fats, and fatty acids. The residue is raised to a temperature of about  $250^{\circ}$  C. under sufficient pressure to prevent material escape of sulphur dioxide, in the presence of a substance of the group consisting of inorganic acids of sulphur containing at least four oxygen atoms and their anhydrides. Heating is continued until there is no free acid left in the reaction mass.

A. Holmes. U.S.P. 2,300,119, 27.10.42. Appl. 21.10.39. Preparation of a lightcoloured plastic material from an asphaltic base crude. The petroleum oil is distilled to obtain a black residual oil, which in turn is digested with a naphtha of about  $86^{\circ}$ A.P.I. gravity. Undissolved bodies are separated, and the naphtha solution is treated with a decolorant. After treatment the decolorant is separated and a lightcoloured bituminous plastic material is precipitated from the naphtha solution by the fractional addition of an oxygenated organic solvent, selected from the group consisting of alcohols, ethers, and ketones. The solvent is miscible with the naphtha, but the light-coloured bituminous plastic materials are insoluble in it. H.B.M.

#### **Special Products.**

67.\* Corona Discharge on Liquid Dielectrics. J. Sticher and J. D. Piper. Industr. Engng Chem., 1941, 33 (12), 1567.—The effect of a corona discharge on hydrocarbons is to form a coloured polymer, and it is this substance which results in the development of a high power factor. This polymer is unsaturated, and although the extent of the unsaturation is not high, the reactivity is great. Part of the polymer appears soluble in the hydrocarbon from which it was derived, and part of it appears in the colloidal state, indicating that it may be classed as a hemicolloid. Hypotheses are put forward to account for the development of the high power factor. J. W. H.

**68.** Black-out Paints. C. R. Draper. Paint Mnfr., March 1942, 12 (3), 47-50; April 1942, (4), 77-78.—In a consideration of the various materials available for the manufacture of black-out paints, the author discusses the use of coatings of the bituminous emulsion type. These possess the big advantage of easy removal by solvent after the film has dried out. A great disadvantage is that they are liable to be affected by very wet conditions, such as frequently obtain on roof lights, etc. A further disadvantage of such films is their low opacity, owing to the comparatively low pigment content which can be carried. It is usually advisable to apply two coatings to improve opacity for black-out purposes.

The author points out that conditions for emulsification vary considerably, according to the grade of material employed. Frequently it is not necessary to add a dispersing agent, though some alkali should be present in the aqueous phase which will react with acidic constituents in the bitumen and produce emulsifying agents in situ.

#### ABSTRAOTS.

Emulsions of this kind are conveniently manufactured, using ordinary stirring vessels, by pouring the bitumen gradually, while stirring into warm water containing the alkali and emulsifying agent. If, however, a soft bitumen is employed, with a melting point below the boiling point of water, the warm water can be stirred into the molten bitumen to which the alkali and emulsifying agent have already been added. Bitumen in amount of about 50% of the liquid medium is usually sufficient.

The emulsifying agent should reach 1% or more. A solution of bitumen in a solvent is already dark and somewhat opaque when dry, even before incorporation of pigment, and in fact such solutions will stand pigmentation far more easily than bituminous emulsions. Excellent opacity can usually be obtained with one coat. The dry film is rather brittle unless plasticized with a material such as linseed oil or lanolin. Alternatively soft pitches such as stearin may be added. It is also necessary to add a matting agent, without which the water-sensitivity of these solutions is highly pronounced. To this end clays, drying oils, water-resistant resins and water-repellent greases may be added.

The most suitable bitumen for paint-making is gilsonite. A typical pre-war formula for paint of this description is cited as follows: Gilsonite, 30 lb.; stearine pitch, 15 lb.; naphtha, 3 gals.; turpentine, 12 gals.; white spirit, 5 gals.; linseed oil, 6 lb.; litharge, 4 lb.; rosin, 10 lb. H. B. M.

69.\* Effect of Reinforcing Pigments on Rubber Hydrocarbons. F. S. Thornhill and W. R. Smith. *Industr. Engng Chem.*, 1942, 34, 218.—The unsaturated values, percentages of combined sulphur in vulcanized rubber are correlated with stress-strain data, the curing time, and nature of the filler. From the data obtained it is concluded that whereas there is a loss of unsaturation in a stock containing non-reinforcing fillers, no such loss of unsaturation occurs in rubber compounds containing channel black. This alteration of the mechanism of sulphur vulcanization is mainly responsible for the different physical characteristics of reinforced rubber stocks. J. W. H.

70.\* Industrial Progress in Synthetic Rubberlike Polymers. H. L. Cramer. Industr. Engng Chem., 1942, 34, 243.—The names and origin of some 20 different kinds of synthetic rubber, together with the methods of synthesis of the principal types, are given. The special properties and application of these synthetic rubbers are discussed and data are presented on the economics and U.S. production of synthetic rubber. J. W. H.

71.\* Nitration of Methane. T. Boyd and H. B. Hass. Industr. Engng Chem., 1942, 34, 300.—The direct nitration of methane in the vapour phase over the temperature range  $375-600^{\circ}$  C., using 67% nitric acid has been investigated. The ideal conditions for this reaction involve the use of a 9:1 methane : nitric acid ratio at  $475^{\circ}$  C. at an exposure time of 0.18 sec. Under these conditions the conversion was 13% per pass. The activation energy of the reaction is 52 calories/mol. J. W. H.

72.\* Vinylidene Chloride Polymers. W. C. Goggin and R. D. Lowry. Industr. Engng Chem., 1942, 34, 327.—The structure, properties, and application of this polymer are discussed and it is shown that these resins exhibit crystallinity, a property which enables unique fabrication techniques to be employed. J. W. H.

73.\* Relation of Paint Properties to Surface Areas of Carbon Black. O. J. Brown and W. R. Smith. Industr. Engng Chem., 1942, 34, 352.—The total surface area of eight different carbon blacks have been measured by means of low-temperature nitrogen adsorption isotherms, and the surface area correlated with the intensity of blackness, volatile matter,  $p_{\rm H}$  value, relative paste consistency, and the drying time when embodied in a suitable vehicle. It is shown that the carbon blacks with the largest surface area are the blackest, give stiffer and more viscous pastes, and result in longer drying times. J. W. H.

74.\* Heat Capacity of Certain Halomethanes. G. Glockler and W. E. Edgell. Industr. Engng Chem., 1942, 34, 532.—The heat capacities of twenty-three halomethanes have been calculated by a semi-empirical method based on the contribution of bonds and angles to the molecular structure. These calculated values by this method, at three temperatures, are shown to agree to within 0.6% of the values calculated strictly in accordance with statistical analysis of the Raman and infra-red spectrographic J. W. H.

75.\* Activated Carbon from Hydrocarbons and Chlorine. G. W. Stratton and D. E. Winkler. Industr. Engng Chem., 1942, 34 (5), 603.—A description is given of the production of an activated carbon by the controlled burning of propane or butane with the theoretical quantity of chlorine to form hydrochloric acid and carbon. The carbon can be activated by heating to  $1000^{\circ}$  C. for 90 min., and the product is shown to be superior to commercially available carbons for the decolorization of sugar, absorption of propane, chlorine, phenol, and iodine. By treating the carbon in an atmosphere of natural gas for 35 min. at  $600^{\circ}$  C. a carbon black for use in the rubber industry is formed which is superior to channel black. J. W. H.

76.\* Swelling of Synthetic Rubbers in Mineral Oils. P. O. Poweres and H. O. Robinson. Industr. Engng Chem., 1942, 34 (5), 614.—The aniline point of an oil is a reliable index of the amount of swelling which will take place in a synthetic rubber in contact with mineral oil. The lower the aniline point, the greater the swelling. The addition of polyolefines to mineral oils reduces this tendency to cause swelling. J. W. H.

77. Patents on Special Products. Bakelite, Ltd. E.P. 548,220, 1.10.42. Appl. 29.3.40. Preparation of an electrical insulating material which comprises a copolymer of a vinyl halide and a vinyl ester of a lower aliphatic acid, a flame-resistant plasticizer, an agent acting as a flux for the composition, and a mineral or vegetable wax, a mineral oil, a fatty acid or soap, the copolymer having an average molecular weight of between 8000 and 18,000.

C. H. Angell. U.S.P. 2,298,330, 13.10.42. Appl. 23.10.42. More valuable products are obtained from a hydrocarbon mixture containing olefins and paraffins of two, three, and four carbon atoms to the molecule by fractionating the mixture to separate from it a  $C_2$  fraction, a  $C_3$  fraction, and a  $C_4$  fraction. The  $C_4$  fraction is subjected to selective polymerization to polymerize the *iso*butene. Unpolymerized normal butenes and butanes from this process are mixed with the  $C_3$  fraction and the whole subjected to polymerization to polymerize normal butenes and propene. From the residual gaseous products of this polymerization a  $C_4$  fraction is separated containing *iso*butane, which is mixed with the  $C_2$  fraction. The mixture thus formed is alkylated to react ethylene with *iso*butane.

A. Holmes. U.S.P. 2,298,793, 13.10.42. Appl. 1.7.39. A bituminous paint suitable for use as a protective coating to metallic surfaces consists of a cracking coil tar of  $119-120^{\circ}$  F. softening point. To obtain this a petroleum oil having a gravity of  $30-35^{\circ}$  F. A.P.I. is subjected to a temperature between  $800^{\circ}$  and  $1000^{\circ}$  F. at a pressure of 6-2000 lb. per square inch in a narrow, confined stream. Afterwards the heated oil is introduced into an enlarged container and the cracking coil tar is separated from it.

A. J. Van Peski. U.S.P. 2,299,716, 20.10.42. Appl. 11.5.40. cycloHexane is produced from naphthenic distillates by separating therefrom by fractional distillation a fraction boiling up to  $75-78^{\circ}$  C. and containing paraffin hydrocarbons and naphthenic hydrocarbons of non-hydroaromatic character having substantially equal boiling points. This fraction is treated at a temperature below 200° C. in the liquid phase under isomerization conditions with an aluminium chloride-hydrocarbon complex catalyst. cycloHexane is recovered from the isomerized distillate by fractional distillation. H. B. M.

#### **Detonation and Engines.**

78.\* Mollier Diagrams for Theoretical Alcohol-Air and Octane-Water-Air Mixtures. R. Weibe, J. F. Shultg, and J. C. Porter. *Industr. Engng Chem.*, 1942, 34, 575.— Theoretical data are presented for the above systems, and it is shown that the high latent of vaporization of the alcohol is of practical value, since it lowers the mixture temperature, and this is particularly important in supercharger operations. It is, however, pointed out that thermodynamic data of this type may assist in solving the problem of detonation or that of preignition, but its primary function was the analysis of kinetics and local temperature distribution questions. J. W. H.

#### ABSTRACTS.

#### Coal and Shale.

79.\* Review of the Latest Developments and of the Possible Applications of High Pressure in the Motor Fuel Industry. Trans. from Izvestiya Akademii Nank S.S.S.R. Otdelome Khimicheskikh Nank., 1940, No. 6, by I. B. Rapoport. Foreign Petrol. Techn., Jan.-Feb. 1942, 10 (1/2), 1-6.-The paper gives a general account of the development of the process of destructive hydrogenation of coal in Europe and America. In Germany particularly, production of motor fuels by this method has rapidly increased, owing to the fact that at the outbreak of war stocks of crude oil in that country were not great. In 1939 Germany actually produced 1,500,000 tons of motor fuels in this way. It is interesting to note also that present plants in Germany are operated at a pressure of up to 700 atmospheres, as compared with the first plant, which was operated at 200-250 atmospheres. The explanation would seem to be that the degree of conversion of brown coal into liquid products depends on the chemical composition and age of the coal. Certain coals are incompletely liquefied at a pressure of 200 atmospheres. An increase in pressure has a beneficial effect on liquefaction, and at the same time allows the use of simpler and cheaper catalysts.

Yield in the vapour phase fluctuates considerably, and is dependent on the catalyst used. Data on catalysts used in the United States and in the State High-Pressure Chemical Institute (Leningrad) show that a slightly higher yield is obtained in Russia (0.87-2.24 vols. per volume of catalyst per hour) than in the U.S.

Studies have been made of the influence of the catalyst and of the raw material on the fuel obtained. Gasoline obtained from the products of thermal decomposition of mineral fuel and coal has a high octane number.

It is suggested that search should be made for more types of coal suitable for hydrogenation in the light of information now available concerning the use of greater pressure and the use of cheaper catalysts. The possibility of using pressures up to 1500 atmospheres should be checked forthwith. This will involve investigation of the physical-chemical constants of products and a special study of steel, armature, weldings, and recording instruments to be used. H. B. M.

80.\* The Relation Between Calorific Values and the Road Performance of Producer Gas Vehicles. H. Webster, S. Bairstow, and W. A. Macfarlane. J. Inst. Fuel, February 1942, 15 (82), 93.—It has long been recognized that there should be a close relationship between the calorific value of a producer gas and the power developed by an engine, although some of the results which have been obtained from trials have been anomalous.

To examine this relationship, tests have been carried out on a Dennis lorry with a 2-ton load, a Mark Vc Government Emergency Producer, and "milk-churn" filter containing sisal being mounted behind the driver's cab. Each test consisted of a journey of 97.4 miles, care being taken to choose a route on which traffic variations were unlikely to occur. Anthracite, wood charcoals, and a number of representative low-, medium-, and high-temperature cokes were used as fuels, moisture contents ranging from 2.8-14.0%, ashes varying from 2.3 to 10.7% wt. on the dry fuels and calorific values covering a range of 12,700 to 14,650 B.Th.U. per lb.

In tests without extra ignition advance, anthracite and a low-temperature coke with a high content of volatile matter gave the best performances, followed closely by wood charcoal. Three medium-temperature cokes gave performances varying from good to so poor that the whole journey could not be completed. With extra ignition advance, anthracite and charcoal were still the best fuels, but under these conditions differences between fuels were minimized.

In discussing the results obtained it is pointed out that the effect of the moisture content of the gas reaching the engine is that of a diluent such as nitrogen and the amount of such dilution is one explanation of the observed discrepancies between calorific value and engine performance. Again temperature and pressure of the gas have a great effect on the calorific value and the fuels which give the best performance are those delivering gas to the engine at the lowest temperature.

It is concluded that when due attention is paid to these variables, the expected proportionality between gas quality and performance is revealed. D. L. S.

#### BOOK REVIEW.

#### Beitrag zur Kenntnis der Schmieröle und Triebstoffe für Dieselmotoren. By H. Stager and H. Künzler. Institute of Technical Physics, Zurich.

This article is a reprint (20 pages) from Schweizer Archiv für Wissenschaft und Technik, 1942, 8 (8), and gives an account of the continuation of the authors' researches dealing with the changes which occur in fuel and lubricating oils during use in engines.

In the authors' opinion, new methods of examination of used oils are required because correlation between laboratory and engine tests have hitherto been unsatisfactory, especially because the insoluble residue formed in lubricants as a result of heating and oxidation has not been sufficiently investigated. In addition, it is unknown whether lubricant or fuel or both are responsible for deterioration, and the conclusions reached are therefore frequently erroneous.

For their investigation, the authors have used four oils-one of paraffinic nature, one naphthenic, one of mixed base-predominantly naphthenic, and one inhibited naphthenic oil.

The apparatus employed comprised two polished steel strips (2 mm. apart) between which the oil under test was circulated, the speed of flow being controlled by the angle of inclination of the strips. The latter were arranged to be electrically heated at a constant rate or at a constant temperature.

On the completion of each experiment the residue adhering to the steel strips was examined by a process of solvent extraction and the used oil was subjected to a variety of tests.

Of the conclusions to be reached from the results of the work some of the most illuminating are those which refer to the fundamental differences between the behaviours of naphthenic and paraffinic oils. It is shown, for example, that the paraffinic-oil residue contains more hydroxyl and carboxyl groups than the naphthenic oil residue, that the used naphthenic and mixed-base oils have smaller oxygen contents than the paraffinic oil, and that in some respects the mixed-base oils show no definite characteristics of either component.

The authors observe that the so-called hard asphalt which is normally precipitated with petroleum ether is not truly asphaltic in character but is a highly oxidized product which happens to be insoluble in this particular solvent. It is considered, furthermore, that these types of residues may be misleading when judged by normal characteristics.

The work has obviously not yet attained any degree of finality, and it is not out of place to stress that the object of the work was to study the changes which take place in an oil during use in an engine. Thus, all work of this nature should eventually be paralleled by engine tests, and the conditions employed in the laboratory experiments should preferably not differ widely from those of the engine when working, otherwise the conclusions reached from laboratory work may not be applicable to engine conditions. One of the most essential present-day objects of all such work is to devise some method of laboratory test which would at least grade the oils in the same order of performance as that indicated by the engine.

W. H. THOMAS.

### INSTITUTE NOTES.

#### **JANUARY**, 1943.

#### CANDIDATES FOR ADMISSION.

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 parenthesis.

- Bass, Ernest Leon, Mechanical Engineer, Asiatic Petroleum Co., Ltd. (John A. Oriel; R. I. Lewis.)
- CHARLESWORTH, Percy Allen, Research Chemist, Moore & Barrett. (James Barrett; Harold Moore.)
- CROSS, David Thomas, Patent Agent, Standard Oil Co. (Hugh C. Tett; F. H. Garner.)

#### CONTRIBUTIONS TO THE JOURNAL.

In view of the fact that the orbit of the Institute has now been widely extended, it was decided, at a recent meeting of the Publication Committee, to invite contributions to the *Journal* from members, not only on purely scientific and technical topics, but on those matters that might be of general interest. The Publication Committee will be pleased to accept such contributions from members.

#### BENEVOLENT FUND.

The attention of members is directed to the urgent need for building up a reasonable reserve in the Benevolent Fund in support of the many cases that will undoubtedly arise at the termination of hostilities. Contributions may be made by means of Bankers Orders which are circulated with the Annual Report, or may be sent direct to the Secretary of the Institute at the Imperial College of Science and Technology, Prince Consort Road, London, S.W.7.

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



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