MOUNTAINS AND OIL.

By J. V. Harrison.

It may be of interest to review some features of geography with an object of investigating what connection, if any, there may be between mountain ranges and oil production or discovery. Any map of the world showing the principal physical features and the exploited oilfields puts one aspect of the question before us. Perhaps the most notable fact which emerges is that there are great areas of land without mountains and without any oil at all, like the bulk of the African and Australian continents. They are lands of plains and plateaus, where mountains are confined to a narrow margin. The Baltic Region, including all but the west of Scandinavia, much of Siberia and adjoining provinces of China, the north-east of North America and the north-east of South America are also areas of plateaux or plains formed by the wearing down of areas of old rocks, and from them no oil has been won. If the high mountains themselves be examined, with one exception at Lake Titicaca, it will be seen that oilfields do not occur *in* them. It is in the intermediate lands between the mountain crest and the naked rumps of the old plains and plateaux that the deposits of petroleum must be sought, and they are found in nearly equal numbers along the flanks of the mountain ranges and amidst the low hills and plains extending far away from them.

About 70 per cent. of the world's surface is covered by oceans, and the emergent land forms the other 30 per cent. First, the barren plains of old rocks, where no oil is, make up about 25 per cent. of this total. Their foundations of twisted, hardened ancient rocks, long since worn smooth by wind, water, and ice, have not been swamped extensively by the sea during the last 500 million years, and hardly any sedimentary deposits overlie them. Next, the main plains and the low sporadic hills associated with them, from which about half the world's production has been won, make up about 65 per cent. of the land area. These regions have often been covered by the sea, but they have risen gently above it from time to time, and the waters have ebbed back, leaving dry land, which sometimes became desert temporarily. In these areas sediments have been freely deposited as packets which may be a fraction of a mile or as much as 3 miles thick. The strata are usually well consolidated and upon the outer skirts of the old cores lie all but undisturbed. Farther away from these shields of old rocks the sediments are often warped, and, in a few cases, gently or even strongly folded.

Last, the mountain belts make up no more than 10 per cent. of the total land, but they contain about 50 per cent. of the world's oil. They are long, narrow strips of country where deposits have accumulated during many marine incursions to a thickness of usually 3 miles or more, and occasionally to as much as 10. These strips have long been restless. Their sediments have been compressed and folded in several stages, whilst their centre may have been punctured by masses of eruptive rocks like granite. In many cases the compression affecting these zones has been sufficient to produce a suite of large and relatively regular folds in the beds, but in others the compression has been much more intense, giving rise to so great a humping up of the outer rocks of the crust that the ridge has grown higher than the mechanical strength of the rock materials can support. Part has had to slip aside, until the height has been reduced sufficiently to again ensure mechanical equilibrium—that is to say, until the rocks will stand up themselves without further sagging or bursting. Some of the excess load seems to have slipped off by a kind of flowage, for, given time, many bodies of sedimentary rock seem to act as if relatively plastic, and some to have been squeezed out from near the base on the flanks. Complicated flow sheets of both types are clearly exposed in many sections of certain well-known mountains, like the Swiss Alps. They are far too disturbed and have travelled far too uncomfortably to contain oil themselves, but they overlie a platform not nearly so churned up which may still retain its oil. This flight from earthly exaltation

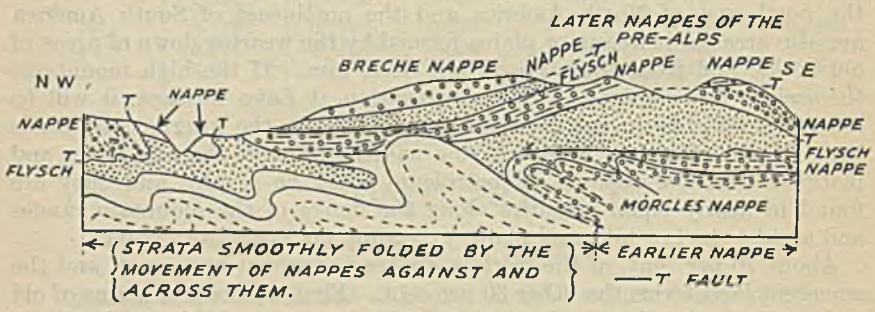


FIG. 1.

FLOW SHEETS N. OF THE SWISS ALPS AFTER A. LILLIE.

experienced by large packets of rock in the very tightly compressed mountains has produced a marked effect on the postures of the rocks below, and has given rise to structures in them very like those encountered in the belts of moderate mountain-building (Fig. 1). Wrinkled structures in the strata, however they may have been produced, may be satisfactory for the accumulation of oil, and it is in zones of undulations that the search for oil has been most logically and successfully conducted by geologists. The area of such zones in the mountain belts does not amount to more than 3 per cent. of the total land surface.

Very little is known about the swamped 70 per cent. of the earth's surface, but some parts of it have been surveyed in detail, and show that at least portions of the sea-floor are scored and uneven like the land surface. Mountain ranges rise from the ocean bed, and parts of them protrude above the sea level, furnishing chains of islands, some long and straight, some gently and some sharply curved, and some mere dots above the face of the waters. Examples are provided by the Dutch East Indies and the Antilles of the West Indies, by the Aleutian Islands or the group of islands making up Japan or the Philippines, and perhaps by the Antarctic Islands east of Cape Horn, including South Georgia, the Sandwich Islands, South

Orkney, and South Shetland Islands. All of these are akin in structure, being formed in part of strongly folded sedimentary rocks and in part of volcanics. Other submarine ridges exist, also worthy of the name of mountain, but made up wholly of volcanic rocks. A fine example is located in the mid-Pacific. It is 1600 miles long, with Midway Island at its western end and Hawaii at its eastern. Another great submarine range the composition and structure of which are still somewhat obscure follows a curving course for more than 6000 miles aligned roughly north and south in mid-Atlantic. Other mighty ranges have been discovered in the Indian Ocean between Socotra and Chagos Islands, with a spur running north towards Karachi. In addition to these chains of mountains, long, narrow troughs have been located crossing the sea-floor which cannot be matched by land features. The narrow ocean deeps appeal to the imagination, perhaps as the home of mysterious sea-serpents and other monsters, perhaps because the dents are deeper (35,400 feet) on the earth's surface than its biggest peaks are high (29,000 feet), and perhaps as the birthplace of some oil. Some of these great hollows lie close to elevated land masses like western South America, some close to sunken lands just covered by the sea, as between New Zealand and Tonga, and the deepest of all to the chains of islands forming Japan and the Philippines.

After this brief review of world geography we may consider what part mountains play now or have played in the past. Their principal rôle at present is that of barriers. They intercept free movement of peoples, animals, plants, and winds. The winds in turn play a vital part in the control of climates. The Alps separate the colder, wetter germanic plains from the milder, drier one of Italy. The winters of Poland are more severe than those of the Hungarian plains across the Carpathians. The bitter extremes of the Russian steppes are not shared by Mesopotamia across the Zagros Ranges, nor those of Kashgar and Lop Nor by the Indo-gangetic plain south of the Himalayas. There is also a tremendous difference in rainfall between desertic Central Asia and monsoon-soaked India. In the New World, where the ranges run more nearly north and south, a comparison is possible between places at the same latitude but on the opposite sides of the water-shed, and again the differences are enormous. For instance, they occur between foggy Vancouver and dusty Winnipeg; green San Francisco and brown Salt Lake City; equable Los Angeles and El Paso with its large diurnal variation. Where the continent narrows to an isthmus noteworthy differences still obtain, as between Colima and Tuzpan, or Santa Cruz and Vera Cruz in Mexico; between San José and Puerto Berrio in Guatemala; and between Punta Arenas and Puerto Limon in Costa Rica. There is not so much difference across the knot of ranges in Colombia and Equador, but farther south the contrast again becomes acuter between the guano coast of Peru and the steamy rain forests of the Amazon; between the nitrate coast of Chile and the idyllic valleys of Mendoza; and between the cold rain forest of the Chilean fiords and the grassy pampas of Patagonia in Argentina.

The sunken ranges are obstacles as well, although they may have small effect on climate. They arrest the flow of ocean currents, so that basins on opposite sides of them may contain water in different degrees of aeration. Adequate aeration seems to be the vital factor in deciding the state of what are called normal marine deposits. In basins where free circulation is prevented, the lower layers of water may become stagnant, and then sulphuretted hydrogen develops. In this environment the sediments form fœtid and slimy, and, according to one school of thought, it is here that potential oil is most likely to be turned into the real thing. The northern part of the Indian Ocean is divided up by submarine ranges into three basins : the Gulf of Oman in the north-west, the Arabian sea in the north-east, and the Somali basin in the west. The first is collecting green mud in the shallower part and, whilst rich in sulphuretted hydrogen, is almost devoid of life; the second contains a coating of red clay with manganese-rich nodules and has no animal life in its depths; and the third is the gathering ground of a deposit of globigerina ooze with prolific marine life. A recent investigation provided these examples of the effect of sunken ranges.

Another function the mountains perform is to offer themselves as the easiest victims of erosion, and because they bar the passage of the winds, they forge the knife for their own sacrifice in the shape of the rain which falls in special concentration upon them. This carries away the mantle of decay, the soil which would provide the solid rock with a defensive sheath against further depredations of the weather. The amount that is worn off the opposite sides of a range may differ greatly, depending primarily on the rainfall, but the distance from the sea determines whether gravel, grit, sand, silt, or clay actually reaches the ocean. The mountains often provide the immense volume of sediment suspended in river water, but as the study of sedimentation progresses it becomes clear that, particularly in the shallower inland seas like the North Sea, the constitution of the neighbouring countries plays an important part in determining the constitution of the sediments. Adjacent exposures of sandstone make for abundant sands in the pan of the local sea, and many outcrops of schist or shale for predominant mud. In the open sea near shore, the effect of climate, frigid, temperate or hot, arid or humid, plays a part, but this is masked or overwhelmed when a big river discharges near by. It virtually monopolizes the building up of the column of strata. Great differences exist between deposits near to land or " within soundings " and those far away at depths greater than 10,000 feet. The former are much thicker, and, being derived from land, are more abundant and more varied than the latter. They are fresher and lighter coloured than their neighbours out to sea, which are largely formed of dust-blown fragments and skeletons of floating marine organisms. They are more freely endowed with carbonaceous organic matter than the deep-sea deposits.

Geologists still argue about the origin of oil and the kind of conditions most suitable for its formation, but most of them are prepared to admit that oil, potential or actual, is a sediment or part of a sedimentary series. Oil deposits usually occur where deposits are thick, and some of the most prolific are encountered where the sediments are thickest. Oil is not known where there is no development of strata, and it is inferred that the greater the thickness of the beds the greater the chance of finding some oil. The geosynclines, the long, relatively narrow oceans of former times, were troughs in which detritus came from two sides, and were, in addition, avenues across the surface of the earth in which limestones were built up with unusual facility. They were the sumps into which the thickest columns of beds have been packed, but at the present time it is difficult to find an example on the face of the earth. The only existing feature which remotely resembles a geosynclinal sea is that between the Sunda shelf on the north-west, made up of Borneo, Sumatra, and the shallow nearly level floor of the Java Sea, and the Sahul shelf on the south-east, made up of a submarine platform skirting the north coast of Australia and the west coast of New Guinea. Some of the Dutch geologists maintain that in this very trough, mountains are now in the making, and even if this be disputed, we have seen that a great chain of a mountain system is already erected in it.

Ancient geography was different. Long, narrow seas persisted for long periods, and the beds assembled in them enable us to trace the distribution of their channels, at least in part. One of the best known was that followed closely by the Alpine Mountain system from Spain to Burma. It was not the same depth everywhere, but was made up of a number of long basins strung together like a chain of sausages, and there is no good reason to think that the string of them ended exactly at either end where the mountains now come down to the sea. It may have gone on much farther, but though the evidence suggests that they did, there is none to indicate how far they continued. Another system of these super canals traversed North and South America, and it, too, had well-defined basins alternating with shoals which may, at times, have been elevated above sea level. It is suggested that this chain extended south of Tierra del Fuego, following the island arc into Grahamland, and perhaps beyond that. Farther off in time, other geosynclines have been in existence. One followed the line of the Urals, one the course of the Allegheny Mountains, and it seems to have been part of a chain with neighbouring basins extending across the U.S.A. to the west, and one crossed Europe from Spain, via Ireland, to Western France and Czechoslovakia in a curving course across Germany. Another seems to have occurred in the southern tip of Africa, and a counterpart of it appeared in the Argentine. All these canals had complicated histories. Sometimes they moved up and were waterways between continents; sometimes they moved down and the contiguous lands themselves were flooded to such an extent that the geosynclines could only have been detected by a geographically minded fish or reptile.

Some maintain that mountains start to rise centrally from the very floor of a geosynclinal basin, and this may be true in certain instances. However, in some clearly exposed and regionally mapped cases, the first ranges formed close to one of the banks of such a great canal. In the construction of the present chains in South-western Persia the remnants of three sheaves of folds thrown up one after the other on the margin of the old geosyncline play a prominent part (Fig. 2). When a new series of great folds has buckled up on the edge of a narrow sea, the floor of the trough seems to have been pressed down just in front of the new wrinkles. This moat is called a "fore-deep." It is frequently about 40 miles wide, very long, and deeper near land than it is out to sea. Thick deposits are caught in it, and these pile up, while the newly formed mountains are rapidly worn down. There are coarse conglomerates over a very narrow strip

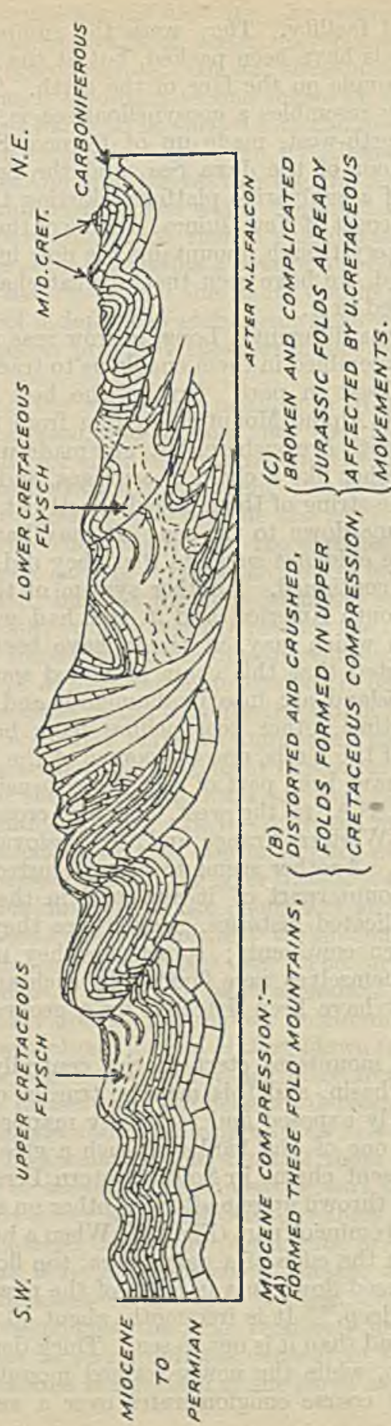


FIG. 2.

DIAGRAM OF THE S.W. PERSIAN MOUNTAIN STRUCTURE.

near the mountain foot, then comes a broader belt of grits, followed by a wide band where sands in narrow lenses interfinger with silts and muds in a very variable sequence. Sometimes there may be several 6-inch sands with only an inch or two of silt between them; sometimes many varying beds of silt and mud with a rare thin, sandy band only once in a 100 feet; and sometimes an almost regular alternation of sand and silt. Among the coarse deposits of near-shore type there are also narrow reefs of limestone. The whole packet was formed quickly, and is called "flysch," whether it was laid down 400 million years ago in the Palæozoic, or only 50 million years ago in the Kainozoic (Tertiary). Farther from land—say, from 40 to 60 miles from the foot of the coastal mountains—the flysch tends to grade into more homogeneous deposits, like silts, muds, or marls, and these may be dark with carbonaceous matter, perhaps oil, or potential oil, or a residue after oil, or only inert carbon, a kind of oil abortion. The flysch is very characteristic, sometimes near to great oilfields, sometimes not immediately connected with them. It is intimately associated with the Polish and Rumanian oil, and some occurs in the Caucasian, Persian, and Dutch East Indian oilfield provinces and features again in the Mexican oil-belt. Flysch constitutes a sedimentary type peculiar to the foot of steep ranges, and seems to be the emergency filling shot down by the weather to make good the hole which accompanies a wrinkling of the earth's crust which has been too vigorously pressed. Upon this "fill" as a foundation the deposits of a more leisurely type are then built up, and they, too, may be thick and likely to produce oil.

We take the view that oil is of sedimentary origin, but does not accumulate in workable quantities as a result of deposition alone. It is disseminated among other sediments. However, as a liquid it is mobile, but some force is required to set it moving before it can collect into the lusty lenses known as fields. Two types of force are available to do this work. The one is gravity, which acts everywhere as the materials settle down; the other is lateral pressure, produced, at least in part, by mountain building. The beds in any column of sediments differ in permeability from horizon to horizon. Some of the sheets are chosen by the fluids as desirable places of residence, some as channels of easy movement, and some of them as layers of no passage. Even if there be no plastic flow of the sediments during folding to act as a kind of hydraulic press when a packet of strata is folded, parts of the packet are lifted up and parts depressed, so that the fluid content has to move to restore its equilibrium, assuming, of course, that the permeable beds are not wholly waterlogged. The combined forces result in the most convenient strata filled up with fluids, and these in turn make gravity adjustments among themselves. This soon gives rise to the conventional pattern of oil and gas in the anticlines and water in the synclines. The conditions favouring this result may be found at any one time over a rather wide strip. Near the core of the mountain things may have been much too hectic if intrusions of eruptive rocks occurred or if strong plastic flow took place accompanied by fracturing. In this zone fluids are not preserved. They are boiled off or squeezed out. Then comes the flank, where things are cooler and quieter. Somewhere in it a strip is reached where the folds are entire without any faulting, consequently they may be suitable structures for easy fluid movement, but where the folding has been so vigorous that all the beds in the sequence have suffered jointing. In this case the layers which would normally canalize the movement between them, whilst prohibiting passage through them, may have so many gaping fissures across them that they permit disastrous leakage to take place. The zone is next found were folding is adequate and where, under the conditions of cover existing at the time of movement, the impermeable strata remained tight. Similar conditions may occur for a long distance away from the mountain system's axis, and so long as they do obtain, a belt of probable oilfield development continues. Still farther afield, although warping occurs which may be connected with the mountain building, the principal factor inducing accumulation becomes the movement produced as the beds settle down and their particles pack together during consolidation.

The three divisions of country produced during the folding of mountains, then, are :—

(i) the central core with too much heat and disturbance,

(ii) the flank where fields are simple and some of the folds at least not too tight to render all the impermeable beds concerned open-jointed, and

(iii) the outer zone where the suite of folds inaugurated by the pulses of compression has died out.

It is commonplace, though sometimes overlooked, that each case must be considered in the light of local conditions. One impermeable cover rock may be perfectly gas-tight, with curves on its surface the radius of which reaches 1000 feet, as, for instance, in a packet of thin-bedded gypseous marls with interbedded sheets of salt, gypsum, and anhydrite. Another may perform its conserving function satisfactorily only when its curves have radii never falling below 10,000 feet—as, for instance, may be the case in some splintery argillaceous limestones. Unless the impermeable bed is able to achieve plastic flow under the conditions obtaining, it has a critical radius of curvature below which it will joint and leak. In any fold, therefore, there is a limiting factor of flexure determining the capability of that fold to hold oil and gas. Examples of such significant difference of folding are provided by structures on the north-east and south-western sides of the Persian Gulf. The rather strong folding in the Persian oilfields thoroughly joints the limestone housing the oil, but leaves the Lower Fars saline series which folds easily impermeable. This traps the precious fluids securely, for even if its beds rupture or joint, the cracks seal off at once through plastic flow. On the Arabian side of the Gulf there is no saline series, but, because the folding is very much milder, shales and marly limestones, which are useless for the purpose in Persia, are satisfactory in the rôle of cap-rock in Arabia. It is not impossible that a failure to grasp the implications of radius of curvature may have had some part in determining the course of oil politics in this region.

As a sequence to our partition of the mountain ranges into good, bad, and indifferent oil-belts, we may glance along some of the chains with an eye to the future. Starting in Western Europe, we find the Alpine zone very much disturbed, but with some possibilities in Southern Spain, in the Pyrenees, and in Sardinia. The Rhone Valley, the Swiss Plains, and the foothill through Southern Germany to Vienna all lie in the interesting belt. The complications and burial of important zones by the sliding down of plastic sheets from off the High Alpine Core have been referred to above. Thus, it would not surprise the contemplative geologist if oil were found in one of the northern Swiss valleys. The Carpathians and the Caucasus have already yielded copiously, but there are unproductive gaps between the present fields. Some of these gaps may be shortened, or even filled in. Across the Caspian, fields are being opened up along the front of the Kopet Dagh and among the foothills in the Duab in Turkestan, and for a long distance along this southern edge of Central Asia, more fields are likely to accrue. On the south side of the Alpine folds the North African province has been tantalizing, but may yet make good. Italy is in the same category. The eastern shores of the Adriatic, where not too broken up by faults, have already given more than a promise and are far from being fully exploited. From Syria eastwards the southern folds have proved their worth not once, but many times, in Iraq, Persia, and Arabia. What happens to them east of the prong of the Oman peninsula is not clear. The Alpine chain does not seem to go through Baluchistan east of Bandar Abbas, and it does not make any convincing feature to the west across the Rub al Khali, so far as the described coastal sections show. Perhaps the range links up with the Carlsbad Ridge off Socotra, and the hiatus may be one akin to that in north-eastern Syria, where country exists in an almost unwrinkled state between the chains of Damascus and Palmyra, on the one hand, and those of Kurdestan and Persia on the other. If the Carlsbad Ridge be indeed a recrudescence of the Alpine type folds of Persia, it turns back upon itself, forming the Murray Ridge, much as the Apennines do when they deflect and swing on into the Dinaric Alps in the Balkans. In India, from Karachi to the Salt Range, on along the foothills of the Himalayas into Assam and then into Burma, the Alpine belt is clear. Here and there oilfields exist. More will be found, and probably some are hidden under the slumped or thrust-sheets along the Himalayan front, displaying a kind of kinship with the Albertan fields of Canada. The group developed further east in the Dutch East Indies is already partly proved.

The American backbone is dotted with fields from Canada to Mexico. Some of them, like those in Alberta, are proving extremely coy, but, given perseverance, they are eventually being won. More have yet to be discovered here, and further finds are particularly likely in Southern Mexico. If we ignore the Antilles because so much of their body is submerged, and proceed to scan the south and east of the Andes, we see that the most obvious prizes in the oil world as yet available are beginning to be collected. The Venezuelan Llanos has its fields, Colombia dangles the luring bait of the Meta River, with its seepages, before the noses of the Oil Fraternity and some one of them will surely be hooked. Peru, ahead of its time, has the audacious field of Aguas Negras, and, like the king with Banco's ghost, " carries in his hand a glass which shows me many more." The rest of the Andian foothills promise well, but their yield is delayed by physical, climatic, and political difficulties. The strip along the Andes from end to end is of high potential value, and exploitation in it is only just begun.

We have seen that mountains have had varied histories and many of them have been folded in several stages. In addition, most of them have experienced phases of vertical movement at a late date. To this we owe much of their present grandeur, because uplift and erosion go on together. In the Alps this movement impresses every tourist who thinks about the sculpture of scenery. The uplift has been well over a mile in amount, and if we go by the caricatures passing for sections of the mountains drawn by some visionaries it may have been much more. In Persia the drained lakes and deep-set gorges point to an uplift of not less than a mile. In the Himalayas the recent elevation is at least as much. In Venezuela, near Caracas, the uplift is more than half a mile, and in Peru not less than two miles in the Central Andes. Large blocks of country have been raised. Some of them remain nearly flat. Some of them have been tilted and some of them warped. The ruined plateaus produced are often bordered by large faults, and the detritus from the uplands sometimes accumulates in thick sheets on the flanking lowlands. The old mountains of 200 million years standing moved up in the past and were ground down, like their younger relatives to-day. The Appalachians, the Urals, ranges in Central Asia, and the Blue Mountains in Eastern Australia have all risen vertically again in rather late time. The result of these movements makes the mountain cores available for inspection in valley sections. The higher parts of the flanks suffer strong wear and tear until their anatomy, too, is freely displayed in gorges and gullies gashing the hills. The outer parts of the original band where there was comfortable folding, however, still lie blanketed with an adequate cover, and they may have had new deposits heaped upon them. In this case their outer folds are covered from view and may be detected only by inference from physical measurements.

On account of these differential vertical movements, samples of the structures still buried and the counterpart of the containers still holding accumulations of oil can often be inspected in the mountains' flanks. Not only are there structures laid bare which simulate those laboriously worked out by making contour plans or peg models from drilling records, but both in the Zagros Ranges and in the Andes the dissected corpses of oilfields can be seen, fields comparable in dimensions with large ones now in exploitation. Their permeable beds lie there, dark with the dregs of their hydrocarbon blood congealed, and their anatomy as stark as if on a dissecting table. No medical man can qualify until he has passed a gruelling course in practical anatomy. Is it not urgent that the oil-man, be he engineer or geologist, should have a sound knowledge of *practical* structure before he proceeds to practise or attempts to prophesy about structure which, because it is deeply buried, must be largely inferred?

We saw that the vertical movements result in fractures which bring lowland areas close to highlands. In these circumstances, oil already trapped and housed in folds may start to leak and flow along some of the fault-planes. This outflowing oil would soon be lost, but a boxed-in sump is well placed to receive and accumulate boulders, sand, and mud at uncommonly high speed. These deposits fulfil the double duty of plugging the leak and absorbing the discharge. In the course of consolidation and the later movements they may be fashioned into comfortable new quarters for the transferred oil. The adjoining regions in South America of Maracaibo and the Magdalena valley come to mind as type examples, whilst the Pacific coast fields in the U.S.A., as well as in Ecuador and Peru, have features in common with them. These are the only oilfields associated with the western part of the great mountain system of Western America, which differs essentially from the Alpine chain on account of the imposing array of immense granite masses incorporated with it. These are the largest known individual masses of eruptive rock, and they are strung out along the coast from Alaska to Patagonia, and their presence undoubtedly diminishes the prospects of the terrain as an oil one.

This review of mountains, their distribution, their origin, their constitution, and their destruction has shown us that they play a great part in the oil game. They stand in the belts where the greatest thickness of sediments has assembled, and the more sediment, the more the chance of oil. They are the welts where many gradations of folding occur, and hence they provide a great choice of structures, in some of which liquid oil can and does gather. They are the rain-makers, and, as such, they keep the pot of sedimentation boiling, and so have maintained conditions in which oil has been able to form from time to time, and can still do so. They form barriers in the oceans, and influence the course of deposition on the one hand, and the type of bottom conditions on the other. Some are suitable and some inimical to oil formation. They are singularly susceptible to uplift, which may ruin some fields whilst bringing others within the reach of the drill. With uplift may go collapse, after which oil is liable to move along fractures, though it may be caught again by hasty piling up of beds derived from the highlands around. Finally, they provide an ideal school for the budding oil-man. There he can see the rock column, the reservoir rock, the cover rock, and perhaps the mother rock itself. There he can see in three dimensions the actual structures, and the type and progress of the joints which cross them.

We live in an age when education is a popular subject for discussion and at a time when there has been a break in the continuity of training and recruitment of those who must carry on the technical side of oil production. Is it not an appropriate time to ginger up the artificial and theoretical curriculum with more than a laboratory to elaborate the lecturers' themes? Is it not a time to think of a course when the students shall work for a time in one of those favoured lands where oilfields exist and, more important still, where they have existed, but are now dissected, and where the mountain-sides hold their ruined bodies naked and unashamed? Men with such a training would be then well equipped for the task awaiting them in the near future, in the deserts and jungles of India, on the Canadian prairies, on the plains and in the swamps of Mexico, around the Atlas Mountains in Africa, and in that Eldorado which is waiting to be opened up in the forests at the head of the Orinoco, the Amazon, and the Paranà Rivers from Venezuela to the Argentine.

THE INSTITUTE OF PETROLEUM.

A MEETING of the Institute was held at Manson House, 26, Portland Place, London, W.1, on Tuesday, May 9th, 1944. The President, Professor F. H. Garner, occupied the Chair.

The following paper was presented by Dr. J. V. Harrison :—

"Mountains and Oil." [See pp. 243–253.]

DISCUSSION.

THE PRESIDENT, opening the discussion, said that Dr. Harrison had given a very stimulating talk, and that he could understand now why the series of lectures he gave to the students at Birmingham last session had been so much appreciated.

The reference to the plastic flow of the rock materials, when the tops of mountains slide down into the valleys, was of great interest. In the part that was sheared off, was there an actual flow ?

DR. HARRISON said that he had seen a sheet of limestone 1000 feet thick which had peeled off a mountain side and folded over on itself, producing a structure called a flap. The flap was 8 miles long and 3 miles wide, and had taken place without a break along the hinge line. This suggested plastic flow.

DR. G. M. LEES said that he found it very difficult to comment on Dr. Harrison's very interesting address, for he had taken them around the world such a number of times and had touched on so many aspects of his subject. They had made many journeys together ; he was, of course, the great mountain enthusiast *par excellence*, and it was a real delight to travel with him through the mountain country which he knew so well.

In the course of his address Dr. Harrison had given certain interpretations of some very complex mountain structures, and had mentioned the phenomenon of gravity sliding. Quite frankly, he admitted at first he had refused to believe it ; but after having been frog-marched around some of his mountain examples he had had no option but to believe it. He joined in the author's enthusiasm for the importance of gravity sliding in special cases, but he feared that he could not go all the way with him in extending the theory quite so widely as he had done. However, he had lagged behind him even in the initial conception of gravity sliding, and it might be that there was delayed action in his understanding !

In Dr. Harrison's survey of the world his emphasis had been all the time on mountains. It was perhaps unfair to criticize his address on the ground that it lacked reference to the great oilfields of the plains, as he had set out to deal with mountain zones only, and had indicated where some of the oilfields of the future might be found in those zones. But there were great areas of plains, in the intermediate zones between the mountains of the old shields. For example, on one of his maps there was a most significant extent of blank areas, the very extensive plains of European and Asiatic Russia. But they lay far out from the mountain areas, and were excluded from his survey.

However, he agreed with Dr. Harrison on the great importance of the mountain areas and the degree to which they had yielded oil, as well as the possibilities for the future. The great range of the Andes and the belt lying east of the Andes was probably one of the least known parts of the world so far as its oil-bearing possibilities were concerned. He even referred to the great sub-ocean ranges, up and down the Atlantic and backwards and forwards into the Pacific. Whilst one agreed that there might be many buried oilfields there, he was afraid that we should have to wait another 20 million years or so until they in their turn were uplifted ; it would then be for our remote descendants to deal with the anticlines.

In the high mountain countries there had been many oilfields which had been bled to death, so that one could see only their skeletons. He agreed entirely with Dr. Harrison that it should be part of the experience of every oil geologist to visit the mountain countries and to see the skeletons of the oilfields of the past. He supported fully his suggestion that students be given every opportunity to enlarge their experience of mountain geology.

He would like, in conclusion, to endorse the President's remarks that it had been a great pleasure to hear Dr. Harrison's address, and to see his sections and diagrams and particularly his mountain photographs.

Dr. Harrison thanked Dr. Lees for his remarks, but did not think they called for extended comment. He was aware that he had not discussed the potentialities of the intermediate areas between the mountain ranges, as they lay outside his terms of reference. So far as the interpretation of the Alpine structures was concerned, he was by no means leading the way, but was humbly trying to follow Dr. Harold Jeffreys. He had tried to draw a diagram which was more specific than the generalized ones Dr. Jeffreys had published in 1931. But he did think that Dr. Jeffreys and others were on the right scent when they brought to our notice the possibility that ridges on the earth's surface had somehow or other been humped up higher than they could bear, and that in order to acquire a position of repose there had been a sliding down of material. That was a subject for engineers as well as geologists to pursue. The strength of materials is such that they will stand only limited strain, and rocks in thin sheets will not stand indefinite pushing about. In his opinion a thin packet of rock might behave rather like a fluid, and slip and sag downhill. At all events, packets of rocks have assumed attitudes which recall those observed in slabs of wax which have suffered slow distortion by flowing.

Mr. E. Thornton said that the fascinating survey of world geography and geology seemed definitely to establish sound relation between mountains and the position of oil, and unless we assumed that all oil had migrated, some relation between conditions leading to the formation of oil and its location with regard to mountains seemed to be established. Had any similar theory been formed or any such correlation been established between the position of other products of sedimentation and decay and earth rock structure, *e.g.*, could we predict where to look for shales or coal by reference to mountains ?

Dr. Harrison replied that it seemed to him that oil shale, being a deposit which is fine in grain, was likely to occur at a considerable distance from a mountain range. It was a type of deposit which he would expect to find more abundantly in the intermediate areas of the land surface of the earth than in the mountain country, because whilst this was the region in which the deposits were the thickest, it was also the region in which the deposits tended to be coarse. He could think of no considerable oil shale deposit which occurred close to mountains, but he could think of many which occurred at some distance from mountains, in the more peaceful regions between the mountains and the bosses of the ancient shields.

On the motion of the President, a hearty vote of thanks was accorded Dr. Harrison for his address and illustrations.

SPECTRAL METHODS AND THEIR APPLICATION IN THE PETROLEUM INDUSTRY.

By W. H. Naylor, Ph.D.

Many of the modern advancements in the physical sciences have had their inception in spectral investigations. The knowledge of the light-emitting and absorbing properties of various materials has provided a means whereby both qualitative and quantitative determinations may be made. Among the early workers in the field were Bunsen and Kirchhoff, who in 1859 utilized flame spectra for analytical purposes. Since that time there has been extensive development in the use of emission spectra. The metallurgical industries, in particular, rely almost exclusively upon arc and spark spectrographic analysis for control. All branches of chemical industry use spectral methods, both for analysis and in investigative work. It is to be expected that as the petroleum industry turns more and more from a producer of raw materials to a chemical industry, it also will increasingly utilize methods of analysis.

X-Rays

Since the discovery forty-nine years ago by Röntgen of a type of radiation which he called X-rays, the development and utilization of these rays have become a full-fledged science. X-rays can find application in almost all industries and in many other fields. Many industries now use X-ray measurements for control and inspection, and it is probable that others will soon begin to realize the potentialities of their use. Many present-day industrial uses are given in the symposium presented in the May and July 1941 issues of the *Journal of Scientific Instruments*.[1] Equipment may be obtained which ranges in size from large installations for cancer and sub-atomic research to small portable instruments used to locate pipes and wiring in walls.

X-rays are produced when an electron fills a vacant space in an inner electronic shell of an atom. Thus in order to produce X-rays at will, one must have means at hand which will knock electrons out of various atomic electronic shells; the primary method generally used is a stream of electrons, accelerated in an electric field, striking a target consisting of a high-melting metal. The moving electrons or cathode rays remove electrons from various shells, even the innermost shell, if they are accelerated by sufficient potential. The electronic rearrangement which follows produces X-rays whose wave-length depends on the target element and on the energy difference between the initial and final position of the electron that shifted towards the atomic nucleus. The highest energy differential—*i.e.*, going from the outer shell to the innermost shell—produces X-rays of the shortest wave-lengths and highest frequencies. Secondary X-rays may be produced by irradiating a substance with X-rays, whereupon the substance radiates X-rays of longer wave-length. Each chemical element, when suitably activated, will emit X-rays of characteristic wave-length; this provides a valuable method of qualitative analysis.

There are two general fields of application of X-rays in industry: first, the macroscopic examination of materials to reveal the inner structure, and second, the diffraction of X-rays to reveal the atomic arrangement in materials. In the first field, photographing or fluoroscoping the casting or forging under illumination of X-rays will show internal faults, if such exist. The only method of testing a weld without destroying it is to use X-rays; furthermore, the strength of a weld may be well predicted from an X-ray photograph.

The use is not limited to metallic substances. The application to the petroleum industry is apparent, at least in construction work in inspection of welds, condition of refractories, etc. It is probable that it would prove useful in routine equipment inspection to predict where failure of tubes or plates is imminent, but before such failure occurs. Moving pictures by X-ray have been used for research in biological fields within recent years. Stroboscopic and ordinary moving pictures by X-ray would be useful in motor research.

The diffraction of X-rays by crystals was the first application of X-ray analysis. In 1912 von Laue and co-workers [2] developed and tested a theory involving interference of X-rays. A year later, W. H. and W. L. Bragg [3] found that crystals might be used as interference gratings for X-rays. Each crystalline solid gives a characteristic diffraction pattern, and may be identified thereby. The arrangement of the atoms in the crystals may also be deduced. Present applications include identification of substances on a purely empirical basis from the diffraction pattern, structure of alloys, allotropic changes in refractories, measurement of stresses in metals by measuring changes in crystal-lattice dimensions,[4] identification of intermediate products in chemical processes, and following changes in catalyst structure during operation. In the last example we find a particularly useful field of investigation in the petroleum chemical industry. Catalytic processes in this industry are becoming very prevalent, but our knowledge of the action of catalysts is still largely empirical. X-ray study in this field under actual operating conditions may give us catalysts of greater activity and longer life. Since the original material incorporated in a catalyst is often a mixture of oxides, it may be well to study the catalyst during and after operation, for the existence of some oxides as such is unlikely at the temperatures and conditions used. The gradual loss of activity may be due to a progressive reaction within the catalyst itself.

Ultra-violet and Visible

Those portions of the spectrum which are called the ultra-violet and the visible regions are considered to be the result of shifting of electrons to various energy levels in the valence or outer electron shell. The electrons are moved to higher energy levels away from their normal positions by absorption of energy from some source, and then, on returning to the normal position in certain fixed jumps, various specific wave-lengths are emitted. These wave-lengths are characteristic of the atom emitting the light although a particular wave-length of high energy may not appear if the activation energy is insufficient. Let us first consider the application of emission spectra in the visible and ultra-violet.

There are three general methods of producing emission spectra. The material under test is introduced into a flame, or an arc, or, third, into an electric spark. These three methods increase in activation energy in the order named. Flame spectra are generally used for qualitative identification of the alkali metals, although Lundegardh [5] has obtained satisfactory determinations for thirty-two elements using an acetylene flame. The electric arc is at present the most commonly used excitation method for spectrographic determinations. The spark source is used in cases where the sample is volatilized too rapidly by the arc or where activation energy is desirable. The arc and spark light sources may be observed visually after passing through a prism or grating spectrometer, but the more generally used equipment is a spectrograph, which gives a permanent record of a sample on a photographic plate. The actual measurement for quantitative determinations is then in terms of density on the plate of a characteristic line or lines. This is very widely used for qualitative and quantitative analysis of metals, and there is a voluminous literature in this field. By using a high-frequency, low-voltage spark under reduced pressure, most of the non-metals may also be detected.[6]

Emission spectra may be used in the petroleum industry in engine-wear studies, since iron may be detected down to 1 part in a million. Inorganic impurities in crude oil or its various products may be determined. Any metallic equipment, as well as clays, sludges, and catalysts, may be analysed by this means. Spectrographic analysis is of particular importance in the case of catalysts, since the presence of extremely small quantities of impurities may markedly change its efficiency. Emission spectra are used by some oil companies for analysis of cores, soil, and water in oil-fields. It is useful in correlating geological strata, and may have value in prospecting.

Absorption Spectra in the Ultra-violet and Visible

Some chemical compounds possess electronic configurations such that they absorb light in the ultra-violet or visible regions. The aromatic hydrocarbons, as well as many of their derivatives, have characteristic absorption bands in the ultra-violet. Fig. 1 gives the well-known absorption spectrum of benzene. The fact that the paraffins and naphthenes (*cyclo*alkanes) do not absorb in the ultra-violet makes identification and determination of the aromatics possible.

R. N. Jones [7] has recently given an excellent review of the field of absorption of ultra-violet light by aromatic hydrocarbons. The olefins [8, 9] and acetylenes absorb in what is called the far or vacuum ultra-violet. Experimental difficulties in the exact measurement of light intensities in this region limit this field at present to qualitative identifications, but it is to be confidently expected that photoelectric and electronic methods rather than photographic will soon overcome this limitation.

Compounds which absorb in the visible give evidence to the eye that they do so through their colour. That is, a solution of a red dye appears red because it transmits red light and largely absorbs other wave-lengths. The colours of various materials has given rise to innumerable colorimetric

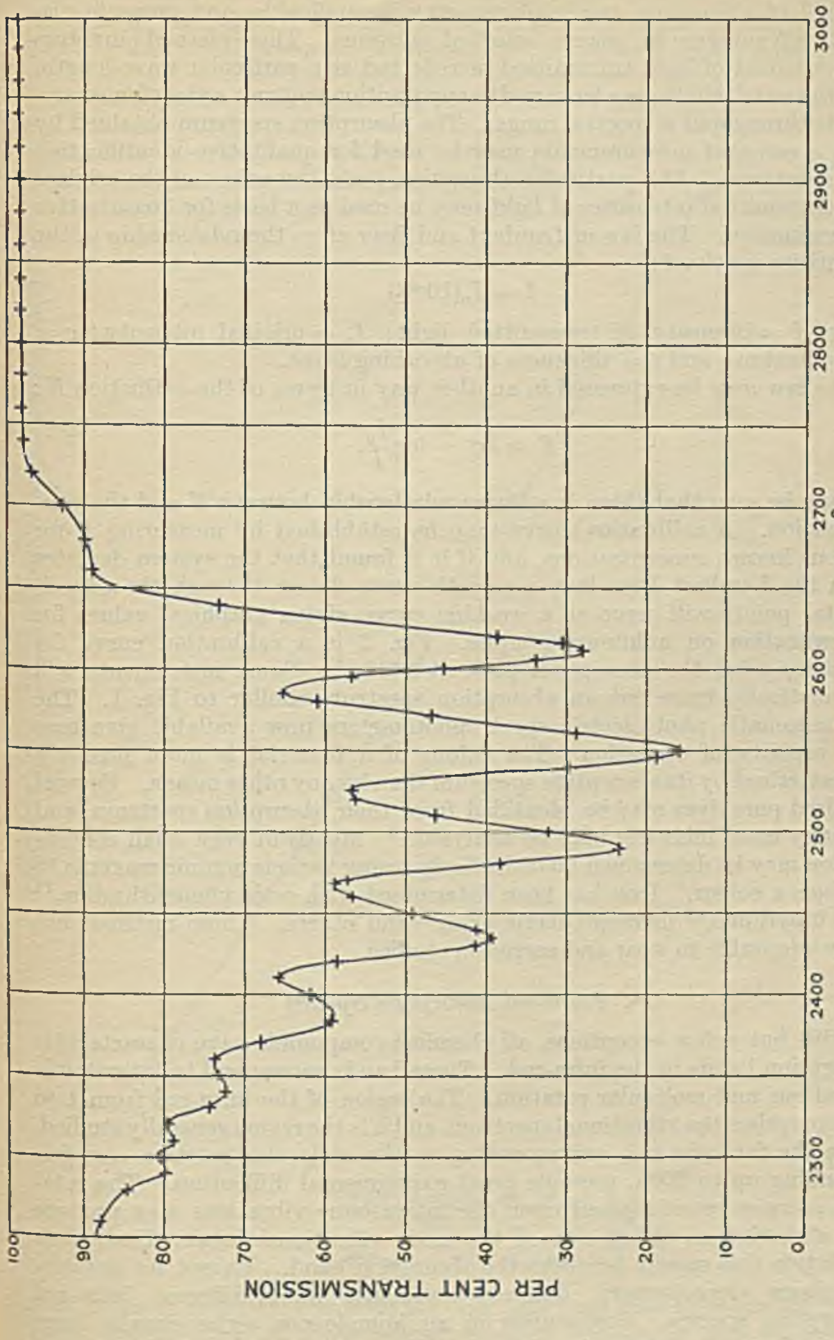


Fig. 1.

BENZENE 0·0045 MOLS./LITRE IN *iso*-OCTANE.

X

methods which are in use in all branches of science and industry. The method of absorption spectrophotometry is applicable, and presents distinct advantages in many coloured systems. This method involves measurement of light transmitted or reflected at a particular wave-length, and the wave-length may be varied to any position to give a series of measurements throughout a spectral range. The absorption spectrum obtained by such a series of measurements may be used for qualitative identification of a substance. At a particular absorption peak, the values of the original and transmitted intensities of light may be used as a basis for quantitative determination. The law of Lambert and Beer gives the relationship of the quantities involved :

$$I = I_0(10^{-kct})$$

where I = intensity of transmitted light; I_0 = original intensity; c = concentraton; and t = thickness of absorbing layer.

The law may be expressed in another way in terms of the extinction E :

$$E = kct = \log \frac{I_0}{I}.$$

It may be seen that there is a linear relationship between E and the concentration. A calibration curve may be established by measuring E for various known concentrations, and if it is found that the system deviates from the Lambert–Beer law, a smooth curve drawn through the experimental points will serve as a working curve giving graphical values for concentration on unknown samples. Fig. 2 is a calibration curve for benzene, using the absorption peak at 2548 Å. Some instruments will automatically trace out an absorption spectrum similar to Fig. 1. The non-automatic photoelectric spectrophotometers now available give ease and rapidity of operation. The colour of a material is more precisely characterized by its absorption spectrum than by any other means. Several hundred pure dyes may be identified from their absorption spectrum, and in many cases mixtures may be analysed.[10] Metals in very small concentration may be determined quantitatively, using various organic reagents to produce a colour. Iron has been determined with *ortho*-phenanthroline,[11] 2 : 2-bipyridine,[12] mercaptoacetic acid,[13] and others. These methods are quite adaptable to wear and corrosion studies.

Infra-red Absorption Spectra

With but a few exceptions, all chemical compounds have characteristic absorption bands in the infra-red. These bands correspond to interatomic vibrations and molecular rotation. The region of the infra-red from 1 to 23μ comprises the vibrational spectrum, and it is the region generally studied, since the far infra-red, corresponding to the molecular rotation energies, extending up to 200μ, presents great experimental difficulties. The rotation energies superimposed upon the interatomic vibrations may produce fine structure on either side of the main vibrational band. Under low resolution this merely broadens the absorption band. Except for enantiomorphous stereoisomers, different molecules have different infra-red absorption spectra. Compounds in an homologous series usually have certain bands in common, although they differ in intensity. *Cis* and *trans*,[14] as well as other types of isomerism, give different spectra. Various functional groups, as O—H, C═O, C═C, etc., have characteristic frequencies.[15] The C—H group has a different frequency in aromatic compounds

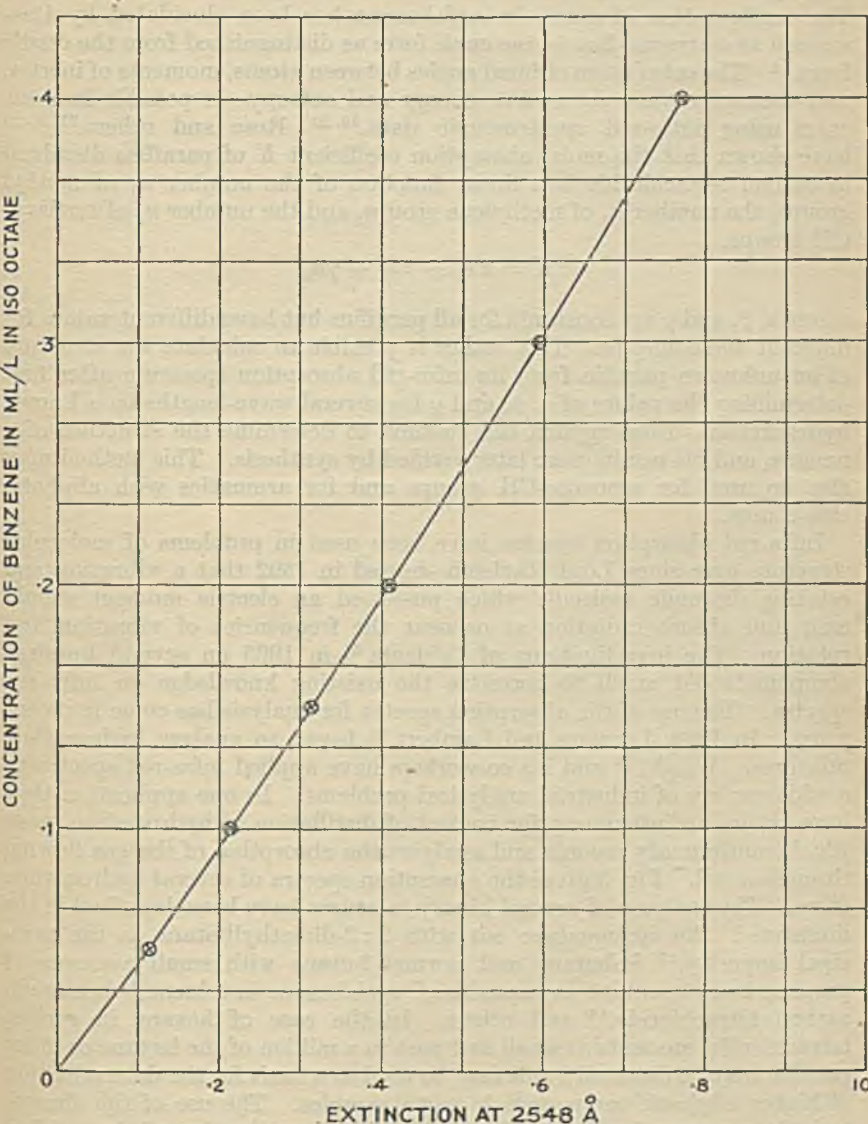


Fig. 2.

CALIBRATION FOR BENZENE.

than it has in aliphatic compounds; this difference may be made the basis for a determination of aliphatic and aromatic compounds in a mixture.[16] The characteristic frequencies of the various groups is valuable in determining molecular structure or the presence in a molecule of a particular group. For example, Gordy and Williams [17] were able to distinguish between normal and *iso*cyanides. Isomerization, association, chelation, polymerization, and keto-enol isomerization may likewise be detected. The configuration of atoms in *cyclo*hexane has been elucidated by Rasmussen as corresponding to the chair form as distinguished from the cradle form.[18] The calculation of bond angles between atoms, moments of inertia, and thermodynamic data—free energy and entropy—is possible in some cases using infra-red spectroscopic data.[19, 20] Rose and others,[21, 22, 23] have shown that the molal absorption coefficient K of paraffins dissolved in carbon tetrachloride is a linear function of the number n_1 of methyl groups, the number n_2 of methylene groups, and the number n_3 of tertiary-CH groups.

$$K = \alpha n_1 + \beta n_2 + \gamma n_3$$

where α, β, and γ are constants for all paraffins but have different values for different wave-lengths. This makes it possible to calculate the structure of an unknown paraffin from its infra-red absorption spectrum after first determining the values of α, β, and γ for several wave-lengths on a known hydrocarbon. Rose applied this method to determine the structure of a nonane, and his results were later verified by synthesis. This method may also be used for aromatic-CH groups and for aromatics with aliphatic side-chains.

Infra-red absorption spectra have been used in problems of molecular structure ever since Lord Rayleigh showed in 1892 that a vibrating and rotating diatomic molecule which possessed an electric moment should emit and absorb radiation at or near the frequencies of vibration and rotation. The investigations of Coblentz [24] in 1905 on several hundred compounds did much to correlate the existing knowledge on infra-red spectra. The use of the absorption spectra for analysis has come in recent years. In 1932, Lecomte and Lambert [25] began to analyse hydrocarbon mixtures. Wright [26] and his co-workers have applied infra-red spectra to a wide variety of industrial analytical problems. In one application they have set up an instrument for control of distillation of hydrocarbon gases which continuously records and analyses the absorption of the gas flowing through a cell. Fig. 3 gives the absorption spectra of several hydrocarbon gases. The analyses of several binary mixtures have been described in the literature: the *cyclo*pentane cut with 2 : 2-dimethylbutane as the principal impurity,[27] *iso*butane and normal butane with small amounts of propane and *iso*pentane as impurities,[28] *cyclo*hexane in toluene,[16] hexane in carbon tetrachloride,[16] and others. In the case of hexane in carbon tetrachloride, amounts as small as 1 part in a million of the hexane or other paraffin may be detected; this may be used as a basis for the determination of higher aliphatic compounds in earth samples. The use of the characteristic frequency bands gives a method for determination of the total of several members of an homologous series, as for example the olefins or acetylenes. It should be emphasized that these methods are very rapid as compared to conventional methods.

The analysis of multi-component mixtures from infra-red data is a field which has not yet received much attention in the literature. It is never-

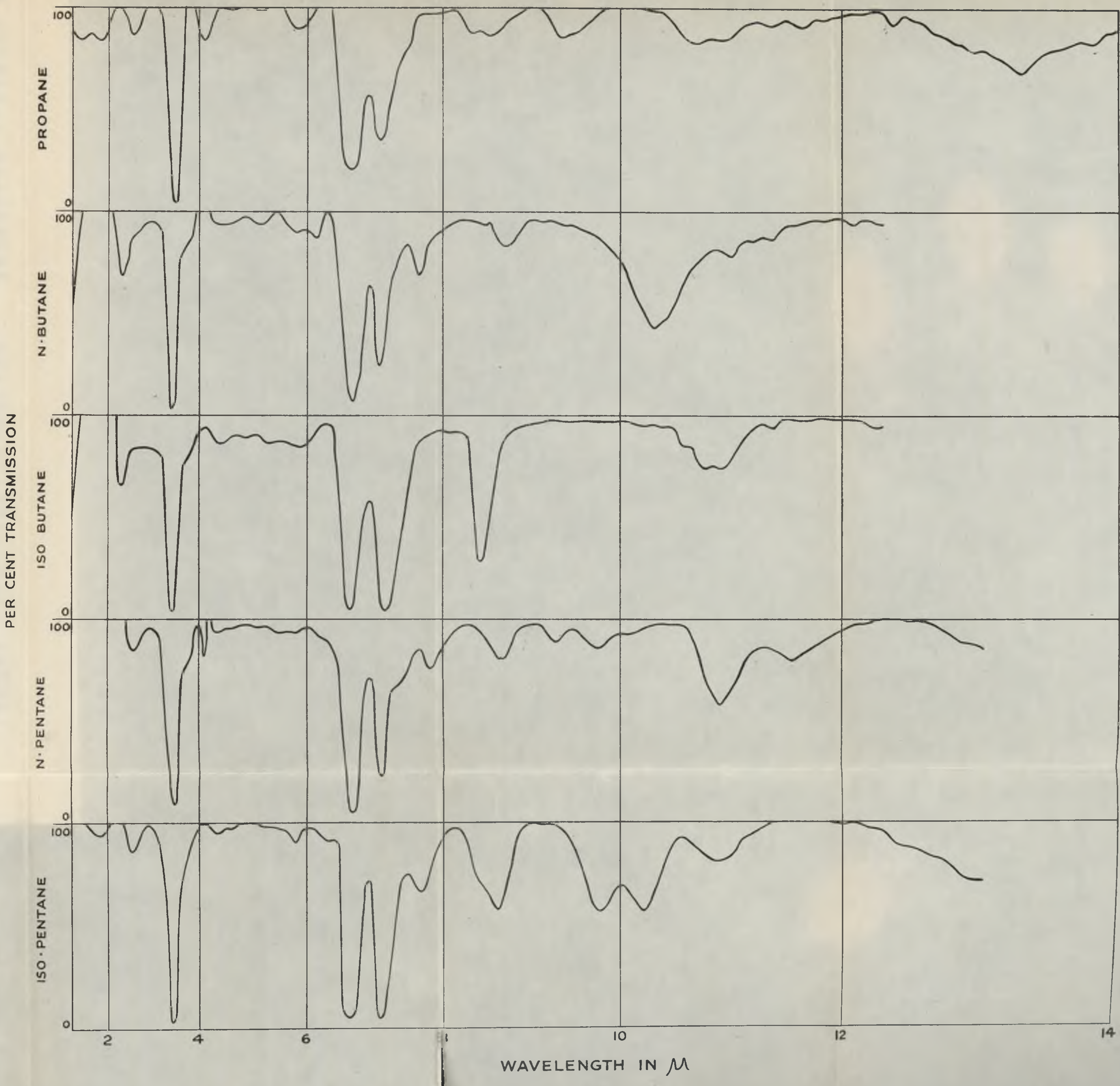


Fig. 3.
INFRA-RED ABSORPTION SPECTRA OF SOME HYDROCARBON GASES.

[*To face p.* 262.

theless being actively investigated in numerous laboratories, and in some cases well-defined methods are in use. The possibility of analysis of any mixture will depend on the number of components and the dissimilarity of their spectra. If, in a particular mixture, the absorption bands overlap too much, the use of a different concentration, or a lower temperature, or an instrument of higher dispersion may solve the difficulty. The data from another portion of the spectrum may help to make analytical interpretations. A description of the method of calculation for a multi-component mixture is given by Brattain.[29]

Many of the wide-range cuts from the distillation of petroleum are so complex, particularly in the higher-boiling ranges, that an analysis for components may be impossible by any spectral or by any other means. It is, however, possible to use the infra-red absorption on a purely empirical basis to control a process. When the influence of the variables in a process on the absorption, and the absorption of the desired product, are known, the measurement of this throughout the process may be used for control; indeed, for automatic control. Infra-red emission spectra may perhaps be brought into use here. Emission radiation in the infra-red appears to have received little attention to date.

Raman Spectra

In 1928, Raman discovered that when various substances, usually liquid, are illuminated by a monochromatic radiation in the visible or ultra-violet, the molecules will for the most part transmit the light unabsorbed. However, some of the light is absorbed by the molecules and then emitted at a frequency different from the original. The scattered light of changed frequency is usually on the long wave-length side of the original, although some light of higher energy per photon is obtained. The difference of frequency $\pm \Delta\nu$ multiplied by Planck's constant gives an energy corresponding to infra-red radiation. Apparently, then, the Raman spectra is in effect a measurement of an infra-red absorption spectrum, although the measurements are made with visible light. The small amount of scattered light of changed wave-length makes observations difficult, and a spectrometer of high dispersion is needed to separate the various Raman lines. The low light intensity of the Raman spectra has necessitated long-exposure photographic measurement; however, Rank [30] has succeeded in using a photoelectric technique with sensitivity which compares favourably with the photographic method. Work in the field of Raman spectra has the distinct advantage of being in the visible range, where the equipment is not so delicate and where there is a much greater backlog of experience and instrument development.

A number of workers have used Raman spectra for analytical purposes. Shorygin [31] has had considerable success in analysing gasoline components. Grosse and co-workers [32] have used Raman spectra for identification and semi-quantitative analysis of paraffins up to C_8. The alkylacetylenes and other hydrocarbons have been investigated by Cleveland.[33] Rank [34] has written on the qualitative and quantitative analysis of hydrocarbons.

Mass Spectroscopy

This paper would not be complete without a consideration of the mass spectrograph, even though it does not deal with a portion of the electromagnetic spectrum. Thompson[35] did the early work on the action of positive ions in electric and magnetic fields. Aston[36] was the first to build an instrument to analyse positive ions using the principles of the mass spectrograph as we know it to-day. He, by the use of an electric and a magnetic field, was able to spread a mixture of positive ions into a spectrum where all ions of the same ratio of charge to mass were brought to focus on a line on a photographic plate. With this instrument he measured the masses of many isotopes of the elements with an accuracy of 1 part in 10,000. The mass spectrometer can be constructed and operated in such a way as to measure the relative abundance of ions of a given mass. If a hydrocarbon mixture or other sample which is fully vaporized at 30–40 microns pressure be introduced in the ionizing chamber of a mass spectrometer and bombarded with electrons, some of the molecules will be ionized by the knocking out of one or more electrons. Other molecules will be broken up into ionized fragments. The particular fragments formed and their relative numbers are dependent on the original substance, and various hydrocarbons as well as other compounds have characteristic mass spectra. Interpretation of the spectra is complicated by the fact that a particular fragment is not specific for a compound, but may be formed from several compounds. It is only the relative amounts of several fragments which identify a compound. Hoover and Washburn[37] have had considerable success in interpreting the spectra and in using the mass spectrometer for qualitative and quantitative analysis. Instruments are available and are in use in the petroleum industry[38] as well as in other industries.[39]

Bibliography

1 *J. Sci. Instruments*, 1941, **18**, 69–102 and 126–158.
2 von Laue, M., et al., *Sitzb. kais. Akad. Wiss. Munchen*, 1912, 303–322.
3 Bragg, W. H. and W. L., *Proc. roy. Soc.*, (A)**88**, 428–438.
4 Thomas, D. E., *J. Sci. Instruments*, 1941, **18**, 135–138.
5 Lundegardh, H., "Die quantitative Spektralanalyse der Elements," G. Fischer, Jena, 2 volumes.
6 Pfeilsticker, K., *Zeit. Metallkunde*, 1941, **33**, 267–272.
7 Jones, R. N., *Chem. Rev.*, 1943, **32**, 1–46.
8 Price, W. C., and Walsh, A. D., *Proc. roy. Soc.*, 1941, (A)**179**, 201–214.
9 Carr, E. P., et al., *Rev. Modern Phys.*, 1942, **14**, 260–264.
10 Shurcliff, Wm. A., *J. Opt. Soc. Amer.*, 1942, **32**, 160–163.
11 Mehlig, J. P., and Hulett, H. R., *Industr. Engng Chem. Anal.*, 1942, **14**, 869–870.
12 Koenig, R. A., and Johnson, G. R., *J. Biol. Chem.*, 1942, **143**, 159–163.
13 Koenig, R. A., and Johnson, G. R., *ibid.*, 1942, **142**, 233–238.
14 Lecomte, J., *Compt. Rend.*, 1938, **206**, 1174–1176.
15 Gore, R. C., *J. Chem. Ed.*, 1943, **20**, 223–229.
16 Gore, R. C., and Patberg, J. B., *Industr. Engng Chem. Anal.*, 1941, **13**, 768–771.
17 Gordy and Williams, *J. Chem. Phys.*, 1936, **4**, 85–87.
18 Rasmussen, R. S., *ibid.*, 1943, **11**, 249–252.
19 Kassel, L. S., *Phys. Rev.*, 1933, **43**, 364–365; *Chem. Rev.*, 1936, **18**, 277.
20 Sutherland, *J. Chem. Phys.*, 1940, **8**, 161–164.
21 Rose, *Bur. Stand. J. Res. Wash.*, 1937, **19**, 143; 1938, **20**, 129.
22 Wulf and Liddel, *J. Amer. chem. Soc.*, 1935, **57**, 1464.
23 Fox and Martin, *Proc. roy. Soc.*, 1940, (A)**175**, 208.
24 Coblentz, W. W., Publication 35, Carnegie Institution of Washington, 1905
25 Lecomte, J., and Lambert, C. R., *Compt. Rend.*, 1932, **194**, 960; 1938, **206**, 1007; 1939, **208**, 1148.

[26] Wright, N., *Industr. Engng Chem. Anal.*, 1941, **13**, 1–8.
[27] Avery, W. H., *J. Opt. Soc. Amer.*, 1941, **31**, 633.
[28] Brattain, R. R., and Beeck, O., *Phys. Rev.*, 1941, **60**, 161; *J. Opt. Soc. Amer.*, 1942, **13**, 699.
[29] Brattain, R. R., *Petrol. World*, Feb. 1943, **40**, (2), 46.
[30] Rank, D. H., et al., *J. Opt. Soc. Amer.*, 1942, **32**, 390–396.
[31] Shorygin, P. P., et al., *J. Phys. Chem. U.S.S.R.*, 1939, **13**, 1512; 1941, **15**, 1072–1081.
[32] Grosse, A. V., et al., *Industr. Engng Chem. Anal.*, 1940, **12**, 191.
[33] Cleveland, F. F., *Phys. Rev.*, 1940, **59**, 924; *J. Chem. Phys.*, 1943, **11**, 1–6.
[34] Rank, D. H., et al., *Industr. Engng Chem. Anal.*, 1942, **14**, 816–819.
[35] Thompson, J. J., *Phil. Mag.*, 1907, **13**, 561; 1910, **20**, 752; 1911, **21**, 225; 1912, **24**, 209.
[36] Aston, *Proc. roy. Soc.*, 1927, **115**, 487.
[37] Hoover, H., Jr., and Washburn, H., *Calif. Oil World*, 1941, **34**, (22), 21–24.
[38] Roberts, O. L., *Petrol. Engr*, May 1943, **14** (8), 109.
[39] Hipple, J. A., *J. Appl. Physics*, 1942, **13**, 551–560.

PRELIMINARY LIST OF DEFINITIONS.

BY STANDARDIZATION SUB-COMMITTEE NO. 11—NOMENCLATURE.

Preface.

At a meeting of the Standardization Committee held on 1st October, 1943, it was decided to appoint a sub-committee whose task would be to prepare a glossary of common terms used in the Petroleum Industry. The terms of reference of the Sub-Committee were that the definitions should be couched in as simple language as possible, in order that the non-technical reader could consult the Glossary and derive, it is hoped, a real benefit from it.

So far it has only been possible to deal with terms covering petroleum products which, in the main, are widely distributed. In some instances terms used in well-known tests associated with these products have also been defined. It is hoped, later, to extend the work of the Sub-Committee to embrace refinery nomenclature and terms used in the search for and recovery of oil.

The definitions and descriptions of terms used in the Petroleum Industry which appear in this list represent the usual meanings ascribed to such terms inside the industry. It should be appreciated that the Institute of Petroleum does not consider itself, as a body, responsible for any legal interpretations which might be placed upon these definitions.

B.S. & W. "Bottom settlings and water," comprises the solids and aqueous solutions which may be present in an oil, and which are separable therefrom by means of gravity or the centrifuge.

Butane. A hydrocarbon gas used as a constituent of gasoline in order to confer improved volatility and anti-knock value. It is used also for heating purposes and as a starting material for certain synthetic processes. It can be stored under pressure as a liquid at atmospheric temperatures. By reason of its chemical composition it is classed as a C_4 hydrocarbon.

Carbon Black. A substantially pure form of finely divided carbon usually produced from gaseous hydrocarbons by controlled combustion with restricted air supply. It is used as a filler in the rubber industry, being specially valuable by virtue of the improved wearing quality which it imparts to tyre rubbers. Smaller quantities are used as pigment in printing inks and paints.

DERV Fuel. A term applied in the United Kingdom to types of gas oil suitable for use as a fuel for high-speed compression ignition engines. The term is an abbreviation of "*D*iesel *E*ngine *R*oad *V*ehicle."

Detergent Oil. A lubricating oil possessing special sludge-dispersing properties and used in some internal-combustion engines. These properties are usually conferred on the oil by the incorporation of special additives. A detergent oil has the ability to hold sludge particles in suspension as well as to promote engine cleanliness.

Diesel Fuel. A general term covering oils used as fuel in diesel and other compression ignition engines.

This term usually applies to fuels suitable for those engines of the industrial and marine type which have a low or medium rotational speed, and which are not so critical of fuel quality as are high-speed engines. Fuels for the latter need special descriptions—*e.g.*, High-Speed Diesel Fuel, Automotive Gas Oil, or DERV Fuel (*q.v.*).

Distillate. A product obtained by condensing the vapours evolved from boiling petroleum and collecting the condensate in a receiver which is separate from the boiling vessel.

Distillation Range. A single pure substance has one definite boiling point at a given pressure. A mixture of substances will, however, exhibit a range of temperatures over which boiling or distillation commences, proceeds, and finishes. This range of temperature, usually determined at atmospheric pressure by means of standard apparatus, is termed the distillation or boiling range.

Fuel Oil. A general term applied to an oil used for the production of power or heat. In a more restricted sense it is applied to any petroleum product that is burnt under boilers or in industrial furnaces. These oils are normally residues, but blends of distillates and residues are also used as fuel oil. The wider term " Liquid Fuel " is sometimes used, but the term " Fuel Oil " is preferred.

Gas Oil. A petroleum distillate having a viscosity and distillation range intermediate between those of kerosine and light lubricating oil. Its main uses are in the manufacture of gas for enriching (" carburetting ") water gas, as a wash oil in the extraction of benzol from coal gas, and as a burner fuel in certain heating installations. Suitable gas oils are also used as fuels for high-speed diesel engines. (See DERV Fuel.)

Gasoline. A refined petroleum distillate, normally boiling within the limits of 30–220° C., which, by its composition, is suitable for use as a fuel in spark ignition internal-combustion engines. Alternative terms still in general use are petrol, motor spirit, and benzine. Motor Spirit is legally defined in the U.K. in the following publications :

Finance (1909–10) Act, Section 84(7) and 84(8); S.R. & O. 1942, No. 2400, Section 68(*a*).

H.D. Oil. The letters H.D. denote Heavy Duty, and have reference to the fact that these lubricating oils were originally developed for use in certain types of high-speed diesel engines and spark ignition engines subject to high piston and crankcase temperatures. H.D. oils combine the properties of detergency, resistance to oxidation, and relative freedom from corrosive action on alloy type bearings. Normally H.D. oils contain special additives which confer those properties.

C_3 *Hydrocarbons.* Any of the hydrocarbons of which the molecule contains three carbon atoms.

C_4 *Hydrocarbons.* Any of the hydrocarbons of which the molecule contains four carbon atoms.

Inhibitor. A substance the presence of which in small amounts in a petroleum product prevents or retards undesirable changes taking place in the quality of the product, or in the condition of the equipment in which the product is used. In general, the essential function of inhibitors is to prevent or retard oxidation. Examples of uses include the delaying of gum formation in stored gasolines, and of colour change in lubricating oils; the prevention of corrosion is also included—*e.g.*, rust prevention by inhibitors in turbine oils.

Kerosine. A refined petroleum distillate intermediate in volatility between gasoline and gas oil. Its distillation range generally falls within the limits of 150° C. and 300° C. Its main uses are as an illuminant, for heating purposes, and as a fuel for certain types of internal-combustion engines. In the U.K. it is often incorrectly termed "paraffin" or "paraffin oil"; the spelling "kerosene" is now officially obsolete. (See "Power Kerosine and Vaporizing Oil.")

For legal definition see S.R & O. 1942, No. 2400, Section 59.

Light Distillate. A term lacking precise meaning, but commonly applied to distillates the final boiling point of which does not exceed 300° C.

Liquefied Gas. Light hydrocarbon material, gaseous at atmospheric temperature and pressure, held in the liquid state by pressure to facilitate storage, transport, and handling. Commercial liquefied gas consists essentially of either propane or butane.

Lubricating Grease. A semi-solid lubricant consisting essentially of a stabilized mixture of mineral oil and soap. The properties of the material depend on the type of soap employed (lime soda or other base) and the viscosity and other properties of the constituent mineral oil.

Lubricating Oil. Any oil which is employed for lubricating purposes. It may consist of either petroleum or fatty oils, or these two main type in admixture, either with or without additives.

Motor Oil. A refined lubricating oil suitable for use as a lubricant in internal-combustion engines. May be a distillate oil or a blend of distillate oil with a bright stock (*q.v.*).

Naphtha. This term is rarely used to describe petroleum fractions in the U.K., but under the designation petroleum naphtha in the U.S.A., and coal-tar naphtha in the U.K., the term implies a distillate material which boils in the gasoline range.

Naphthenates. The alkali and metal salts of naphthenic acids. Their uses include service as paint driers and as wood and textile preservatives.

Naphthenic Acids. Organic acids found in crude oils from certain sources. They have a characteristic unpleasant odour. Their main use is for the preparation of naphthenates (*q.v.*).

Natural Gas. Gas found in certain localities issuing from the earth under pressure and often produced in association with crude petroleum (*q.v.*), when it acts as an important factor in the recovery of the latter. Natural gas is usually classified as "wet" or "dry," depending on whether the proportions of gasoline constituents which it contains are large or small.

Natural gas is also referred to as "Casinghead Gas."

Natural Gasoline. A low-boiling liquid petroleum product extracted from natural gas. In its "wild" or unstabilized condition it contains fairly high proportions of propane and butanes. The propane and part of the butanes are removed by certain processes, yielding a stabilized gasoline suitable for blending with other gasoline.

Natural Gasoline is sometimes referred to as "Casinghead Gasoline."

Petroleum. A material occurring naturally in the earth, and consisting essentially of hydrocarbons, solid, liquid, and gaseous.

For legal definition see Petroleum (Consolidated) Act 1928, Section 23.

Petroleum Coke. Solid matter formed as a by-product of thermal cracking (*q.v.*) of petroleum. It consists mainly of carbon, and has an ash content very much smaller than that of coal cokes. Certain grades are suitable as raw material for the manufacture of electrodes, but its main use is as boiler fuel at the producing refineries.

Petroleum Ether. A special boiling-point spirit (*q.v.*) of high volatility and narrow distillation range—*e.g.* 40–60° C. or 60–80° C., used in the extraction of edible oils, etc., and for laboratory analytical work.

Propane. A hydrocarbon gas, useful for heating and metal cutting and flame welding purposes. It can be stored under pressure as a liquid at atmospheric temperatures, but is more volatile than butane, and high-pressures are required to keep it in liquid form. By reason of its chemical composition it is classed as a C_3 hydrocarbon (*q.v.*).

Residue (*Residuum*). The material remaining as unevaporated liquid or solid from a process involving distillation or cracking.

Sludge. Acid Sludge. Material of high specific gravity formed during the chemical refining treatment of oils by sulphuric acid, and usually separable by settling or centrifuging. Also known as Acid Tar.

Engine Sludge. The insoluble degradation product of lubricating oils and/or fuels, formed during their use in internal-combustion engines and deposited from the oil on to engine parts outside the combustion space. Water may or may not be present in such material.

Tank Sludge. Material which collects at the bottom of storage tanks containing crude oils, residues, or other petroleum products. Such sludge usually contains water. (See B.S. & W.)

Straight Run. Produced by distillation without appreciable cracking or alteration of the structure of the constituent hydrocarbons.

Topped Crude. Crude oil from which some of the lighter constituents have been removed by distillation.

Viscosity. That property of a liquid which is a measure of its internal resistance to motion, and which is manifested by its resistance to flow. The viscosity of a liquid changes with temperature decreasing as the temperature is increased.

Volatility. The degree to which a given substance or mixture of substances is volatile—*i.e.*, capable of vaporization. Applied to gasoline, for example, the lower the temperature at which a given amount of the material may be distilled, the greater its volatility.

White Oils. A term applied to oils substantially colourless and without bloom made from light lubricating oils by a drastic process of refining. They have various uses, such as for medicinal purposes and in the manufacture of toilet preparations.

White Products. A term applied to the more volatile petroleum products, such as gasoline, white spirit, kerosine (*q.v.*). It is not to be confused with the term "White Oils."

White Spirit. A refined distillate intermediate in distillation range between gasoline and kerosine (*i.e.*, with a distillation range of about 150–200° C.). It is used as a paint thinner and for dry cleaning, etc. The term " mineral turpentine " is sometimes used for white spirit, but is not recommended, owing to possible confusion with gum turpentine. In the U.S. the term " petroleum spirits " is used for white spirit.

ABSTRACTS.

AUTHOR INDEX.

The numbers refer to the Abstract Number.

The original papers referred to in the abstracts marked with an asterisk may be borrowed by Members from the Institute Library.

Geology and Development.

1034.* Structural Conditions of Oil and Gas Accumulation in Rocky Mountain Region, United States. C. E. Dobbin. *Bull. Amer. Ass. Petrol. Geol.*, April 1943, **27** (4), 417–478.—The geosyncline in and west of the present Rocky Mountains region dates from late pre-Cambrian until nearly the end of the Upper Cretaceous. There are thick pre-Cambrian shales in western Montana and thick sandy beds in north-east Utah and south-west Colorado. Lower Cambrian deposition was restricted mainly to the western border, but in Middle and Upper Cambrian time the sea covered most of the region. Lower and Middle Ordovician seas were shrunken, but the Upper Ordovician saw the laying down of thin, but wide-ranging, limestones. Only dolomite occurs in the Silurian. It and the succeeding Lower Devonian were periods of erosion. Important subsidence in the Middle Devonian permitted thick accumulation of limestone and dolomite in south-east Idaho, northern Utah, western Wyoming, and thinner deposition in central and western Montana. In the Upper Devonian, shales and limestone were deposited in all these areas and also over most of south-west Colorado and in parts of northern Arizona. Further regional subsidence is indicated by the widespread distribution of Madison limestone (Lower Mississippian), which is followed by the less extensive, lithologically more varied Big Snowy group (Upper Mississippian).

Heralding the world-wide Permo-Carboniferous orogeny, early Wichita mountain-building formed the north–south Colorado geanticline, which was the parent of the Front Range and Wet Mountains. Warping was also early initiated in the Sweetgrass Arch area of Montana, where subsequently pre-Upper Jurassic erosion produced many of the conditions responsible for oil-accumulation in the Madison limestone. Whether Madison was laid down in the Front Range area of Colorado or in northern New Mexico is debatable.

In Pennsylvanian time, contemporaneously with the Arbuckle orogeny, positive areas were uplifted and deformed, and evaporite inland basins and seas with alluvial clastics were both characteristic. At the end of the Pennsylvanian, the ancestral Rockies were of considerable altitude. In the Permian, continental red beds were derived from the land masses of central and south-west Colorado, and grade into transgressive marine strata like the limestone of central New Mexico, west Kansas, and west Nebraska. The last stage of the associated earth-movements is seen in the formation of the San Juan upland of Colorado in late Permian or Triassic time.

Following Lower Triassic planation, the sea invaded from the west, but in Upper Trias time southern Idaho and central Nevada began to rise and so cut off connection with the Pacific Ocean. Coarse sediments were washed eastwards in increasing amounts during the Jurassic and Cretaceous.

Crustal warping ensued upon early Jurassic æolian deposition to bring in marine conditions in the Upper Jurassic from central Utah far into Canada. In the west and south there were local orogenies, contemporaneous with the Nevadan; and the Jurassic closes with the continental Morrison formation. Flood-plain sediments introduce the Lower Cretaceous, followed by warping and marine invasion chiefly in eastern Colorado. The Upper Cretaceous is marked by a great interior sea and the beginning of the Laramide orogeny. In western Colorado, extrusive volcanicity (late Cretaceous-early Eocene) accompanies the climax of deformation in the Front Range and San Juan Mountains.

Even the strongest orogenetic phases were local. Some of the largest uplifts were completed in the early Eocene by the beginning of Wasatch time, while others were still forming. The Sweetwater anticline was involved in great folding and faulting at the close of Fort Union (early Eocene) deposition and again after the Wasatch. J. D. Love postulates eight pulsations of the Laramide orogeny in north-west Wyoming, the first at the end of Lance time, the eighth after deposition of 3000 ft. of Oligocene (?) pyroclastics and after intrusion of igneous plugs when the Kainozoic volcanism was waning. Otherwise the Oligocene and the Miocene were epochs of slow sedimentation and normal faulting. Vertical movements and regional arching, with intervals of erosion, are responsible for the present height and deep dissection of the mountains.

Practically all structures yielding oil and gas in the region are products of Laramide orogeny. In general, oil-fields are on minor anticlines—satellite structures—flanking the large folds. 58% of the fields are on anticlines not faulted at the surface; 26% are on anticlines and domes faulted at the surface, or on fault-blocks; 14% are on monoclines and terraces; 2% are on plunging noses. Forty-one out of 180 fields are important producers, and of these 19 are relatively unfaulted. Most of the oil is derived from beds, mainly of Cretaceous age, above which overthrusting has taken place. Showings of oil have been found in the Cambrian, Ordovician, and Devonian; but the oldest commercial oil is in the Madison. The greater part of the Pennsylvanian yield is from the Tensleep sandstone. In Utah, the Coconino sandstone (Permian) yields gas with 98·3% CO_2 at Farnham dome, and with 1·31% helium at Woodside dome. Black oil is obtained from the Chugwater (Permian-Triassic). Most Jurassic oil is from restricted areas in the upper part of the formation. Lower and Upper Cretaceous sandstones are the most widespread yielders. Apparently indigenous oil, in commercial amounts, occurs in the Wasatch—fluviatile Eocene—at Labarge, Wyoming, and Powder Wash and Hiawatha, Colorado, while in the old Douglas field and in the Shawnee area, eastern Wyoming, minor amounts of oil occupy sand lenses at or near the base of the White River formation (Oligocene).

The Labarge field produces from a low dome on an asymmetrical anticline, 2 ml. east of the Darby thrust. Other fields close to major thrusts are Dry Creek, Montana, and Canon City and Florence, Colorado. The shallow thrust-fault zone of Bearpaw Mountains, Montana, contains six known gas-structures; and F. Reeves suggests it is due to the slipping plainsward, in the Middle Tertiary, of strata in the upper half of the Colorado shale resulting in the compression and tangential travel of weak Upper Cretaceous and early Tertiary beds in the plains. North of the laccolitic Sweetgrass Hills, the Whitelash, Bear's Den, and Flat Coulee structures appear to be due to uprise of igneous plugs; so too with the Guinn dome of the laccolitic Little Rocky Mountains, and the Bowdoin dome where the geothermal gradient is no less than 50% greater than in the purely sedimentary, rejuvenated Carboniferous structure of the Kevin-Sunburst dome, Sweetgrass Arch, Montana.

The quality of Rocky Mountains oil is not readily related to the dynamic metamorphism which the region has undergone. Light oil of paraffin base is frequently obtained from fairly shallow Cretaceous anticlines and heavy, black "asphaltic" oil from Palæozoic beds. The lowest gravity commercial product is 11° oil from the Mississippian in the asymmetric sharp-folded anticline of Red Springs, Big Horn Basin Wyoming. Highest gravity is shown by the 70° oil from the Dakota (?) sandstone (Lower Cretaceous) of the Rattlesnake field, New Mexico, which on 24 hrs. exposure weathers to about 63° gravity.

In the Rocky Mountains region, the abnormally high carbon-ratios recorded for low-rank coals, some of which lie at shallow depths and have suffered incipient weathering, are largely a result of failure to recognize moisture as an essential constituent of the "volatile matter" of coal. Were the analyses on an as-received ash-free basis, the lignites and sub-bituminous coals would probably indicate the degree of metamorphism closely. Furthermore, it is believed that the carbon-ratios of the much restricted low-volatile bituminous and higher-rank coals indicate nearly the same degree of metamorphic intensity as that indicated by the carbon-ratios of the Palæozoic coals of the Appalachian region. A. L.

1035.* Geology of the Wasson Field, Yoakum and Gaines Counties, Texas. W. T. Schneider. *Bull. Amer. Ass. Petrol. Geol.*, April 1943, **27** (4), 279–523.—The Wasson field in the central part of the arid Staked Plains, near the New Mexico border, was discovered in 1935. 42,631,627 brl. had been recovered by 1943. The field covers about 86 sq. ml. and is roughly triangular, the longest side facing north-north-west, and the other sides south-west and east-south-east respectively. The reservoir rock is massive dolomite of the San Andres formation (Permian), with small pores of 0·5 mm. average diameter. Cavities after fossils have a shagreen surface of protruding dolomite rhombohedra, showing that crystallization was later than removal of the organisms. The other pores originated upon crystallization of the dolomite (*cf.* Van Tuyl, *Amer. Jour. Sci.*, 1916, vol. 42, and *Iowa Geol. Surv. Ann. Rept.*, 1914, vol. 25). Pores are sometimes filled by secondary anhydrite.

The Wasson reef may be compared with the Addu Atoll of the Maldive Islands, Indian Ocean. The lagoonal or atoll growth, typical of the San Andres, contrasts with the barrier type seen in El Capitan, New Mexico. Deposition appears to have been upon a structural "high" on the margin of an area of general subsidence. Clastics are sparsely represented, but increase in thickness basinwards.

Two major axes of folding, one trending N. 60° W., and the other N. 30° E., cross the reservoir. The combined effect is to give the "atoll" the contours of a terraced platform tilted north-east by post-Permian movement. There is, however, no direct relationship between present structural elevation and ability to produce oil.

The original maximum bottom-hole pressure was 1800 p.s.i. Pressure "lows" occur where effective porosity decreases. Where bottom water is not likely to be encountered, pressure can be increased by deepening the wells. There appears to be no lateral encroachment of ground water; but, since the lower part of the San Andres is very porous, that may provide entry for water-drive. Evidence of gas-drive is deficient.

Multi-stage-pressure acid-treatments have been used in this field. A typical treatment consists of a preliminary wash of 700 gal., and then pressure treatments with 1000, 2000, and 5000 gal. of acid, to which various chemicals have been added as inhibitors, demulsifiers, activators, etc. The largest treatments so far have employed 22,000 gal. In 164 wells nitroglycerine was exploded opposite productive zones in quantities of from 200 to 2100 quarts. The average time for sinking a well is 5 weeks; acid treatment, 6–14 days. Artificial gas-lift was being employed (March 1942) in 71 wells, or 6% of the total, mostly on the north and west edges of the field. A. L.

1036.* Evidence for Upper Jurassic Landmass in Eastern Mexico. R. W. Imlay. *Bull. Amer. Ass. Petrol. Geol.*, April 1943, **27** (4), 524–529.—Carlos Burckhardt (*Mem. Soc. Paléont. Suisse*, 1930, vol. 39) visualized an Upper Jurassic Sea in the interior of Mexico. This sea extended from north-west to south-east, and in the position of Vera Cruz it had a portal to the Gulf of Mexico. Schuchert (1935) thought it might also have had a southern strait leading to the Pacific Ocean.

Imlay now demonstrates that this sea was bounded on the east by a peninsula over

600 ml. long. The east coast of the peninsula is defined by means of a coastal facies, rich in bivalves, of the Upper Jurassic in the San Amrosio No. 1 Well, Nuevo Leon; in the Panuco Well No. 2, etc., west of Tampico; and in the Poza Rica Well No. 8, in Vera Cruz; while a deeper water facies, found in the Sierra de San Carlos of Tamaulipas, indicates the presence there of the same waters which covered part of Arkansas and adjoining States. A possible connection with the Pacific is suggested in wells like those of Santa Domingo Ixcatlan and Amolotepeac, in Oaxacaca.

This Mexican peninsula furnished sediments including conglomerates to the early Lower Cretaceous sea in the region of Galeana and Aramberi, Nuevo Leon (Böse and Cavins, *Univ. Texas Bull.* 2748, 1927); and in the Sierra Madre Oriental, early Lower Cretaceous beds rest directly on weathered pre-Upper Jurassic. In late Lower Cretaceous time, the peninsula was submerged but remained clearly marked by a rudistid-miliolid type of reef-limestone which contrasted with finer grained, deeper water limestones to east and west. At present it still asserts its presence in the abrupt eastern termination of the folds of the Sierra Madre Oriental, which have evidently been thrust against a stable mass. A. L.

1037.* Emblar Field, Andrews County, Texas. Taylor Cole. *Bull. Amer. Ass. Petrol. Geol.*, April 1943, 27 (4), 538.—The Emblar field, south-west Andrews County, is on the northern part of the Central Basin platform of Texas. The discovery well in May 1942 reached the "pay" at 7,770 ft. in Ellenburger dolomite (Lower Ordovician). The porosity is largely due to fracturing. In February 1943 there were 7 producer wells and 5 dry holes in the Ellenburger, but one of the latter made a hit on the "Tubb pay" of the Leonard (Permian).

The structure of the Ellenburger is an irregular dome, covering 640 acres and with approximately 500 ft. of closure, and this underlies a local closure on a large Permian structure.

The nearest productive Ordovician is in Crane County, 50 ml. to the south, but the present discovery suggests that Ordovician oil may be present under many northern Permian fields. A. L.

1038.* Stratigraphic Type Oil Fields and Proposed Classification of Reservoir Traps. C. W. Sanders. *Bull. Amer. Ass. Petrol. Geol.*, April 1943, 27 (4), 538–550.—The importance of structure should not be minimized. Faulting is a specially significant factor in the Edison and Kern Front fields, California, and anticlinal folding in the shoestring gas fields of Michigan. In criticism of *Stratigraphic Type Oil-Fields*, it is pointed out that in the Hitchcock field, Galveston, Texas, the easterly dip is greater than that to north or west. Wedgeout may occur, but it is not necessary to complete the trap; ". . . it simply restricts the areal extent of the structural accumulation."

The following classification is given :—

STRUCTURAL TRAP

Normal.—Purely tectonic including faulted closures, *e.g.* Conroe Sand Zone in Conroe field, Montgomery County, Texas; Langham Sand (Frio) in Amelia field, Jefferson County, Texas; Salt Creek field, Wyoming.

Stratigraphically modified.—1. "Bald-headed" structures with producing zone missing from the apical area of closure, *e.g.* Simpson Sand Zone, Billings field, Noble County, Oklahoma. 2. Producing zone or permeability missing on one or more sides of area of structural closure.

STRATIGRAPHICAL TRAP

True or simple.—1. Trap wholly due to areal development of a wedging permeable zone with no structural deformation other than regional tilt, *e.g.* Lopez Sand, Lopez field, Webb and Duval Counties, Texas. 2. Trap produced by vertical development, or upward or downward convexity, of permeable rock of irregular thickness, *e.g.* old sandbars where unfolded.

Complex.—Combination of stratigraphical features, but unfolded.

Structurally modified.—Permeable layer, bioherm etc., which in itself would constitute a stratigraphical trap, but which happens to coincide with structural nosing.

Within a structural trap.—Permeable zone within an area of structural closure, *e.g.* 4100- and 4300-ft. Sands, University (Baton Rouge) field, Louisiana.

COMBINATION STRUCTURAL-STRATIGRAPHICAL TRAP

Most so-called "stratigraphic traps."—Tectonic deformation by folding, or faulting, is combined with wedging out or convexity, *e.g.* Government Wells field, Duval County, Texas (folding, faulting, regional tilt, up-dig wedging); Woodbine Sand, East Texas (up-dip wedging, nosing, and large-scale anticlinal folding).

1039.* Traverse Rocks of Thunder Bay Region, Michigan. A. S. Warthin, Jr., and G. A. Cooper. *Bull. Amer. Ass. Petrol. Geol.*, May 1943, 27 (5), 571–595.—The Thunder Bay district, on the margin of Lake Huron, contains the complete 560 ft. outcrop section of the Traverse rocks (Middle and Upper Devonian), well known for perfect preservation of fossils in limestone and shale. The area is also excellent for study of *biostromes*—sheets of organic limestone of uniform thickness—and *bioherms*—knolls of organic limestone. The latter in the Alpena limestone reach a height of 55 ft. and have oval bases with maximum diameter of about 150 ft.

The Traverse group is taken as beginning from the bottom of the Bell shale, which rests with erosional unconformity on the Rogers City limestone, and extending upwards to the base of the Antrim black shale. Direct correlation with the New York Devonian is rendered difficult by lithological changes. Further study of the effect of lithology on fauna is required. Narrow body-space and fine costation are typical of brachiopods in clay beds, *e.g. Chonetes* cf. *coronatus* (Conrad) in green clays of the Ferron Point formation, and *C. emmettensis* Winchell in a 1-foot shale intercalated in the Alpena limestone.

Upon the Bell shale with *Prismatophyllum* remains and short-lived simple corals, follows the Rockport Quarry limestone containing *Favosites, Prismatophyllum,* and stromatoporoid species. It contains at its base an alum shale succeeded by pyritiferous and bituminous limestones which give place at their top to sub-lithographic grey limestone with yellow specks of calcite. This is followed by the Ferron Point calcareous shales and thin limestones with near the bottom, in clay with limestone lenses, vast numbers of *Prismatophyllum, Pentamerella, Stropheodonta, Cyrtina, Atrypa,* and *Athyris*—including many new species. The Ferron Point beds apparently have their continuation in the Silica shale of north-west Ohio.

The next strata in upward succession are the calcareous shales and limestones of the Glenshaw, with very large brachiopods. Two-thirds of the way towards the top of the Glenshaw, Killians black shales yield the calcareous alga *Trochiliscus,* and still higher there are small bioherms. Above these lies the crystalline Newton Creek limestone, brown with petroleum residues, in which at the Michigan Alkali Co. Quarry, fossil cephalopods and brachiopods preserve their colour patterns.

The Alpena limestone comes next with biostromes in its lower part and bioherms in the upper part. The knob-like forms of compound corals and stromatoporoids in the later Alpena, may have been due to an increasing rain of muddy detritus, which is more easily removed from a convex colonial organism. Sheet-like habit of growth usually indicates clear water. The Alpena bioherms show little trace of petroleum.

The succeeding Four Mile Dam formation is of brecciated biohermal limestone, or by lateral transition becomes the Dock Street clay which fills up spaces between late Alpena bioherm knobs and contains the crinoids *Magistocrinus* and *Dolatocrinus* and the blastoid *Nucleocrinus*—as well as *Spirifer venustus.* The Norway Point fossiliferous shale and limestone follow, resting on irregular late Four Mile Dam bioherms.

The Potter Bay alternating limestone and shale probably introduce the Upper Devonian, and are succeeded by a concealed section, above which lie the Thunder Bay limy shales with Bryozoa and Blastoidea, comparable in age with the higher part of the Cedar Valley limestone, Iowa. The Squaw Bay limestone comes next with undoubted Upper Devonian cephalopods of roughly low Portage (Genundewa) age in terms of the New York succession. The key fossils, first noted by A. W. Grabau, are *Tornoceras uniangulare* (Conrad), *Koenenites cooperi* Miller, and *Bactrites warthini* Miller. Numbers of *Styliolina fissurella* (Hall) with long axes all oriented in one direction—as also happens with *Bactrites* and sticks of fossil wood—make up entire layers.

From the " Saginaw Sand " of the Squaw Bay zone, oil is produced in several pools in the east and centre of the Michigan basin. A. L.

1040.* Subsurface Stratigraphy and Lithology of Tuscaloosa Formation in South-eastern Gulf Coastal Plain. A. C. Munyan. *Bull. Amer. Ass. Petrol. Geol.*, May 1943, **27** (5), 596–607.—The Tuscaloosa (Upper Cretaceous) as studied in deep wells in South Carolina, Georgia, Florida, and Alabama, has within it a transgressive marine zone. The observations by Stephenson and Monroe (*Bull. A.A.P.G.*, December 1938) of glauconite and the fossils *Modiolus* (indicating brackish water) and *Ostrea*, near the middle of the Tuscaloosa in Chilton County, Alabama, are confirmed.

At the beginning of Tuscaloosa time a shallow sea encroached upon a deeply weathered landmass, partly re-working the accumulated subaerial debris into a vari-coloured series of beds. Gradual deepening brought more typical marine environements northwards till marine organisms and well-sorted marine sediments prevailed. This phase was followed by retreat of the sea southwards (or uplift of the landmass) with rejuvenation of streams and further accumulation of vari-coloured continental deposits.

A second advance of the sea inaugurated the Eutaw.

Upper Cretaceous fossils recorded include *Inoceramus* and *Belemnitella* in one South Carolina test well which also penetrated Upper Trias (?) with diabase. In Alabama, *Hamulus* (?), Foraminifera, and Ostracoda have been found at different levels.

A. L.

1041.* Stratigraphy and Age of the Seguin Formation of Central Texas. M. W. Beckman and F. E. Turner. *Bull. Amer. Ass. Petrol. Geol.*, May 1943, **27** (5), 608–621.—From surface sections 65 ml. apart at Solomon's Creek and Moss Branch, and at Smiley's Bluff and Pearson's Branch, central Texas, it is found that the Seguin formation (Eocene) of near-shore marine and lagoonal deposits straddles the boundary between the Midway and Wilcox groups. There is a very constant disconformity in the Seguin marking the transition upwards from the Solomon Creek clays (= Wills Point formation) to the Caldwell Knob sands (= Rockdale formation), and this is taken by the authors as the local boundary between Midway Group below and Wilcox Group above.

The Solomon Creek member shows gradational change from the Wills Point foraminiferal clays and is characterized by an abundant and varied molluscan assemblage including *Fusus quercollis* Harris, *Pleurotoma ostrarupis* Harris, *Pseudolira ostrarupis* Harris *et var.*, *Turritella polystricha* Stenzel and Turner, *Levifusus* cf. *lithæ* Gardner, *Nuculana protexta* Conrad, *Ancilla mediavia* Harris, *Volutocorbis olsonni* Plumer.

Above the disconformity, cross-bedded sands with sporadic clay-pebble conglomerate pass up into silts and beds of *Ostrea multilirata* var. *duvali*—an oyster which in the basal Wilcox of Louisiana is associated with *O. thirsæ*, while an analogous form *O. arrosis* is found at a corresponding level in the Nanafalia formation, in Alabama.

Mechanical analyses of sands from above and below the disconformity show noticeable differences in the shape of the cumulative curves and in grain-size constants. The sorting constants are nearly equal. A. L.

1042.* Origin of Siliceous Dockum Conglomerates. R. Roth. *Bull. Amer. Ass. Petrol. Geol.*, May 1943, **27** (5), 622–631.—The Dockum (Upper Triassic) in Texas has two facies. From Motley County southwards, a siliceous conglomerate with minor metamorphic fragments is dominant, while northward a clay-ball conglomerate with earthy dolomite and limestone pebbles prevails. The source of the latter is uncertain, but fusulinids have been found in a chert shingle in the siliceous conglomerate. The " rosetta stone " containing these Foraminifera has an ochreous surface pitted where the fusulinids have been removed, but is light grey on a fresh surface. The species are *Schwagerina franklinensis*, *S.* cf. *huecoensis*, and an unidentified *S.* sp. Since *S. franklinensis* has been reported in Hueco limestone in the Franklin Mountains and in the upper third of the Wolfcamp of the Glass Mountains, these are possible places of origin, *i.e.* some 300 ml. south-west of Motley County.

Other Dockum cherts contain monactinellid sponge spicules and Radiolaria including possibly the genus *Staurolonche*. This seems to rule out Arkansas novaculites, which are not known to contain Radiolaria; and the likeliest source is in the Solitario uplift.

Jaspers are regarded as not from the New Mexican Sangre de Cristo Mountains, since uplift of the latter has tilted adjacent Dockum beds.

Quartz, quartzite, quartz-schist, and hornfels cannot so far be accurately localized, but the eroded massifs from which they may have come are all at least 200 or 300 ml. distant, and the most probable direction of derivation seems to be from south or south-west. A. L.

1043.* Upper Desmoinesian and Lower Missourian Rocks in North-eastern Oklahoma and South-eastern Kansas. M. C. Oakes and J. M. Jewett. *Bull. Amer. Ass. Petrol. Geol.*, May 1943, 27 (5), 632–640.—The four major divisions of the Pennsylvanian (Upper Carboniferous) are (1) Morrowman, (2) Desmoinesian, (3) Missourian, and (4) Virgilian. The Morrowman and lower part of the Desmoinesian are not known in Kansas. At the top of the Desmoinesian the Lenapah limestone, traced in both Oklahoma and Kansas, is succeeded by the Memorial shale containing the Desmoinesian brachiopod *Mesolobus.* In many places in Oklahoma, however, the break between Desmoinesian and Missourian lies at the top of the Lenapah, or the Lenapah may be removed by pre-Missourian erosion. This unconformity is associated with overlap from the south of Missourian strata, in which facies changes are pronounced.

The Seminole formation, in Tulsa County, Oklahoma, has three members (*a*) sandstone and silt, (*b*) shale and Dawson coal, (*c*) sandstone and silty shale. The last member extends northwards and in Kansas it is inferred to be represented by the Hepler sandstone and by shales below the Checkerboard limestone. The Checkerboard limestone is tentatively correlated with the De Nay limestone of east-central Oklahoma. The Checkerboard lies fairly low in the Bourbon group of Kansas. The Hertha limestone of the same State lies at the base of the succeeding Bronson group. The Hertha, and higher still the Swope limestone, are not continued into Oklahoma. At the summit of the Bronson group, the Dennis limestone of Kansas is synchronous with the Hogshooter formation of Oklahoma. A. L.

1044.* Tertiary Sediments North-east of Morgan Hill, California. C. M. Gilbert. *Bull. Amer. Ass. Petrol. Geol.*, May 1943, 27 (5), 640–646.—In the area 5 ml. wide north-east of the Morgan Hill section of the Santa Clara Valley, Upper Jurassic serpentines are in contact along the Hayward fault with a red and green series of silts, sands, and conglomerates correlated with the Plio-Pleistocene Santa Clara formation. The red and green beds dip north-east towards the Calaveras fault-zone in which Franciscan (Upper Jurassic) serpentine, glaucophane-schist, red chert, and shale are exposed. North-east of the fault-zone, an anticline measuring 2 ml. across is formed by Cretaceous shales, sandstones with flakes of biotite, and conglomerates containing probable pre-Franciscan porphyry, quartzite, gneiss, and granite, as well as Franciscan chert and Cretaceous limestone. This is followed on its north-east margin by a syncline 1 ml. wide of Middle (and ? Upper) Eocene shales and rudaceous lenses, at least 2300 ft. thick with *Turritella andersoni* var. *lawsoni* Merriam, *Cryptochordia californica* var. (Cooper), *Discocyclina* sp., small lamellibranchs, and fragments of carbonised wood along with chips of black shale in a basal sandstone. The latter, when it is followed westward, overlaps on progressively lower beds in the Cretaceous. This Eocene syncline has on its north-east side a Miocene syncline less than 1 ml. wide, the basal coarsely clastic rocks of which yield abundant *Mytilus midendorfi* Grewingk, *Pecten andersoni* Arnold, *P. propatulus* var. Conrad—indicating a Temblor (Middle Miocene) age. In higher strata, *Tivela gabbi* Clark, *T. diabloensis* Clark, *Chione panzana* Anderson and Martin, and *Pseudocardium pabloensis* Packard, represent uppermost Miocene rather than Pliocene. The relation between the Eocene and Miocene synclines is obscure, but probably involves both unconformity and faulting. A strip of Cretaceous separates the Miocene syncline from overthrust Franciscan which has travelled from the north-east. A. L.

1045.* Two Deep Wells for Water near Rapid City, South Dakota. J. P. Gries. *Bull., Amer. Ass. Petrol. Geol.*, May 1943, 27 (5), 646–650.—Two wells at Rapid City airport, close to the eastern edge of the Black Hills uplift, give useful comparisons with water wells in Rapid City 10 ml. to the south-west, and with the outcrops 10–16 ml. to the west.

At outcrop and in the city wells the Pahasapa limestone (Mississippian) is 300 ft. thick; at the airport it increases to 400 ft. The overlying Minnelusa sandstone with subordinate amounts of dolomite and red shale is 400–500 ft. at outcrop. In the city increasing thicknesses of dolomite and red shales, with anhydrite and gypsum intercalations, bring it up to 660 ft. At the airport dolomite largely takes the place of the sandstone, and red shale and anhydrite become more abundant. The Opeche red shale is 90–100 ft. at outcrop, 135 ft. in city wells, and 120–130 ft. at the airport. The Minnekahta limestone varies from 30–50 ft. in the Black Hills, but is consistently 50–60 ft. on their eastern fringe.

The Spearfish red beds in the uplift have been put at 695 ft., but this may include part of the Sundance to the top of the red " Entrada " zone. 348 ft. of red beds have been found at Well No. 5, Rapid City, the only boring to penetrate the entire Spearfish section, and 340 ft. in the wells at the airport.

At the airport, the Jurassic (Sundance, Unkpapa, and Morrison) is apparently at its thickest, *i.e.* 400 ft.

The Cretaceous beds show a marked Newcastle sand member in the Graneros shale, the upper shale division of which is 100 ft. thinner than was expected. The Carlile shale is 100–350 ft. thinner than was previously thought possible.

The Niobrara bentonitic and chalky shales are 200 ft. thick, and covered by the Pierre (Tertiary).

Folding is sharp in a restricted area on the eastern flank of the Black Hills, but the regional dip is very gentle. A. L.

1046.* Intensive Drilling is Projected in Venezuela. Anon. *Oil Gas J.*, 27.4.44, **42** (51), 32.—It has been predicted that during 1944 the demands for Venezuelan oil may exceed the potential capacity of the fields now in production. Accordingly, all the principal operators have undertaken an intensive drilling plan which has been approved by P.A.W. The resumption of large-scale exploration is also contemplated.

In 1943, the average output was 491,505 brl./day, 21% more than in 1941. 81% of the oil was from Maracaibo and Cumarebo.

Creole reported the discovery in 1943 of the Yopales field, south-west of Oficina.

The Venezuelan output rose from about 400,000 brl./day in January 1943 to 580,000 brl./day in December. G. D. H.

1047.* Geology and Development of the Norman Wells Oil Field. J. S. Stewart. *Oil Gas J.*, 27.4.44, **42** (51), 136.—The discovery well of the Norman Wells field was drilled in 1920, and found oil at a depth of 783 ft. Later the discovery well was deepened to 1025 ft. In 1921, 8 ml. upstream, a dry hole which reported shallow gas was drilled to 1512 ft. In 1924, a dry hole was drilled on the western tip of Bear Island, 3 ml. from the discovery well. A second oil well was completed in 1925 at a depth of 1602 ft., and only 150 ft. from the discovery well. The third and fourth producers were completed in 1940 at depths of 2702 ft. and 1330 ft., respectively. These four wells had outputs ranging 30 to 200 brl./day.

In 1942, the U.S. Army took over the project and drilled 16 wells, 2 of which were non-commercial. 14 additional wells were drilled in the first eleven months of 1943, 9 being commercial producers.

The productive area will probably exceed 5000 acres, about 3000 acres being under the Mackenzie River, with perhaps 1500 acres of this drainable by directionally-drilled wells.

The oil is apparently gas-saturated and is produced by natural flow. One of the best wells gave 1000 brl. in 23 hours on open flow. Some of the poorer wells give only 50 brl./day.

Production is from a coral reef limestone in the Fort Creek section of the Upper Devonian. This limestone is a bioherm, a few feet thick at the edges and over 425 ft. thick in the centre. An average thickness of 66 ft. may be oil-saturated. The reservoir pressure is abnormally high for the depth, suggesting water drive, although no appreciable amounts of water have been met in edge wells, and the lenticular nature of the reservoir rock militates against external water drive. An artificial gas drive is planned later.

The crude is of 38·4° A.P.I. gravity, with 0·55% of sulphur. Waxing occurs. The average reservoir rock porosity is estimated as 15%, with 20% of connate water. Flowing production may yield 20–25% of the oil; with repressuring the recovery may be 35–50%. Shrinkage amounts to 15%. The total recoverable oil, using a 40% recovery factor, is estimated as 83·5 million barrels, but the basic data used in the computation are rather uncertain. A more reasonable estimate of the ultimate yield may be 63 million barrels. G. D. H.

1048.* March Completions Increase 15 per cent. Anon. *Oil Gas J.*, 27.4.44, **42** (51), 152.—1748 wells were completed in U.S.A. in March 1944 compared with 1520 in February. 1057 produced oil and 179 gas.

A table analyses the completions by States and districts, giving the footage, numbers of wells in different depth ranges, and the numbers of oil, gas, and dry wells. G. D. H.

1049.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 27.4.44, **42** (51), 152.—In the week ended 22nd April, 1944, 59 wildcats were completed in U.S.A.; 9 found oil and 4 found gas.

A table gives by States and districts the numbers and types of wildcat completions in the week ended 22nd April, 1944, and also cumulative totals to that date. G. D. H.

1050.* Test Drilling in South Dakota. Anon. *World Petrol.*, May 1944, **15** (5), 110.—The drilling of at least 9 test wells in South Dakota is planned for the summer of 1944. One is to be near Gustav in Harding County, and will be drilled under a unit agreement.

During 1943, two major tests were drilled. One went to 8000 ft. in Harding County, and was abandoned as dry. It was near a 7980-ft. well drilled in 1940, which well found small shows of oil in the limestone formation and a considerable show in the Deadwood sandstone. The probable recovery of oil was not deemed to be sufficient for commercial operation. During 1943, a good natural gas well was brought in ½ ml. north of Ardmore in Fall River County. It is planned to drill additional wells nearby.

Although tests in the past three years have failed, interest has been maintained in this region, and several million acres are now under lease in North and South Dakota. A successful well in the Newcastle, Wyoming, area, a few miles from the South Dakota line, has stimulated interest in western South Dakota. This well is 3852 ft. deep, and is expected to produce at least 1000 brl. of oil/day. G. D. H.

1051. Canada's Second Deepest Wildcat Reaches Limestone for Test. Anon. *Oil Wkly*, 1.5.44, **113** (9), 54.—Royalite Oil Co.'s Wildcat Hills 1 reached the Madison at 11,078 ft., and stopped at 11,098 ft. It is Canada's second deepest wildcat. The limestone cuttings showed porosity. Shell-Norman 1, 20 ml. to the south, reached the Madison at a depth of 11,588 ft., and stopped at 12,056 ft. It was abandoned after showing some gas and sulphurous water in the limestone. Canada's deepest producer of water-free oil is Northend Petroleum's No. 1, 25 ml. south and east of Shell-Norman 1. This was completed at 9612 ft., and is on the " East Side Limestone."

The oil-water line on the west flank of Turner Valley is 4000–4600 ft. below sea-level. Oil producers have been completed at much greater sub-sea depths on the east side of the field.

A table compares the logs of Shell-Norman No. 1 and Royalite-Wildcat Hills 1. G. D. H.

1052. Drilling Getting More Active in Colombia. Anon. *Oil Wkly*, 1.5.44, **113** (9), 54.—On 15th April, Shell's San Angel 1 was under test, and in the Llanos San Martin 1 was drilling below 1600 ft. In the Casabe field, No. 18 was approaching 4000 ft., and No. 19 was drilling after setting surface pipe. A second well was spudded on the El Doce tract on 11th April.

In the mid-Magdalena Valley area Socony-Vacuum's Cantagallo 4 was awaiting equipment for testing. A derrick has been erected for a test on the Floresante tract on the Sinu river. 7 well locations are being prepared in the Socuavo field of the Barco concession, and 6 locations are being made in the Tres Bocas area. G. D. H.

1053. Wells Completed in the United States in Week Ended 29th April, 1944. Anon. *Oil Wkly*, 1.5.44, **113** (9), 55.—317 field wells and 95 wildcats were completed in U.S.A. during the week ended 29th April, 1944. 6 of the wildcats found oil and 3 found gas.

A table analyses by States and districts the completions made in the week ended 29th April, 1944. G. D. H.

1054.* Exploration Spreading in Mississippi Oil Prospects. W. C. Morse. *Oil Gas J.*, 4.5.44, **42** (52), 30.—In Mississippi, the first well searching for oil was drilled in 1903, and it was only in 1930 that the first gas-well was completed to open the Jackson gas-field, which had been preceded by three gas wells in the small Amory gas-field. The first commercial oil-well was completed on the Tinsley dome in 1939. Nearly 500 wells, some 200 in the Jackson area, were drilled before oil was found in Mississippi. Two years after its discovery the Tinsley field had 242 producing wells and a cumulative production of 11,536,393 brl. of oil, and the Pickens field had also been opened. A year later the Tinsley field had 339 producers and Pickens 6, while the Cary (Sharkey County) field had 2 producers. During the next year the Pickens field was expanded to 27 wells, with a cumulative production of 1,726,139 brl., and the Brookhaven field was discovered. In the five months ended January 1944 four new fields were found: Cranfield (Adams County), Eucutta (Wayne County), Flora (Madison County), and Heidelberg (Jasper County).

At Tinsley, 303 wells produce from the Selma, 31 from the Eutaw, 2 from both, and 1 from the Tuscaloosa; at Pickens 28 produce from the Eutaw; at Cary 2 produce from the Cretaceous (Jackson) " gas rock," and at Flora at least 1 produces from the same horizon. Brookhaven, Cranfield, Eucutta, and Heidelberg produce from the Massive sand of the basal Tuscaloosa. At Cranfield the over-all sand section is about 125 ft. thick, with 30 ft. or more known to be oil-saturated.

Development of the Eutaw sand has been pushed some 9–10 mi. into Alabama, and in this Gilbertown field at least 1 of the wells seems to be producing from broken chalk near the base of the Selma.

In many of these producing structures drilling has revealed faulting which is concealed by surface rocks. 16 salt domes have been located.

A map of Mississippi shows the positions of the oil- and gas-fields and of the salt domes. G. D. H.

1055.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 4.5.44. **42** (52), 106. —During the week ended 29th April, 1944, 77 wildcats were completed in U.S.A. 6 found oil and 5 found gas. A table summarizes by States and districts the results of wildcat completions during the week ended 29th April, 1944, and gives cumulative totals for 1944 to that date. G. D. H.

1056. Ecuador Production Greater in 1943. Anon. *Oil Wkly*, 8.5.44, **113** (10), 78.—During 1943, Ecuador produced 2,362,176 brl. of oil, 400,000 brl. more than in 1942. G. D. H.

1057.* Ram River Field, Alberta, Development in Prospect. Anon. *Oil Wkly*, 8.5.44, **113** (10), 78.—Ram River Oils, Ltd, No. 2, in the foothills west of Red Deer, Alberta, a 1⅝-in. test hole completed in June 1942, found a Devonian pay between 4250 and 4300 ft. The 40-gravity oil is under good gas pressure. Efforts are being made to bring the well into production, but trouble is being experienced in shutting off Upper Devonian water and in cleaning out the pay-zone. An offset, No. 3, is being drilled. G. D. H.

1058. Wells Completed in the United States in Week Ended May 6, 1944. Anon. *Oil Wkly*, 8.5.44, **113** (10), 81.—The U.S. field and wildcat completions in the week ended 6th May, 1944, are summarized by States and districts. There were 204 oil-wells and 32 gas-wells among the 301 field completions, and 9 oil-wells and 2 gas-wells among the 59 wildcat completions. G. D. H.

1059.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 11.5.44, **43** (1), 171. —81 wildcats were completed in U.S.A. during the week ended 6th May, 1944. 7 found oil and 1 found gas. The wildcat completions are summarized by States and districts for the above week, and cumulative totals are given for 1944. G. D. H.

1060. Drilling in United States 20 per cent. Ahead of First Four Months of 1943. Anon. *Oil Wkly*, 15.5.44, **113** (11), 50.—In the first four months of 1944 well completions in U.S.A. averaged 388 per week, about 20% more than the weekly average for the corresponding period of 1943. Even if this higher average continues throughout 1944, the year's completions will be only about two-thirds of the 33,000 wells drilled in 1941. In 1944, the activity in California has been 54% greater than in the same period of 1943, and in Montana, New Mexico, South Louisiana, Mississippi, Texas, West Virginia, and Kentucky, respectively, the increases were 38%, 53%, 41%, 33%, 43%, 47%, and 143%. Arkansas, Illinois, North Louisiana, Nebraska, Ohio, and the Texas Panhandle have shown less activity in 1944 than in the same period of 1943.

In the five weeks ended 29th April, 1944, completions averaged 401 per week, compared with 384 per week in March and 410 per week in February.

3266 rigs were active on 1st May, 1944, as compared with 2312 on 1st May, 1943.

G. D. H.

1061.* Weekly Average Completions 20·7% above Last Year for First Four Months. Anon. *Oil Wkly*, 15.5.44, **113** (11), 50.—A table gives by States and districts an analysis of the completions in U.S.A. in April 1944 and in the first four months of 1944. Comparative totals are given for March 1944 and April 1943, as well as the numbers and status of the rigs in operation on 1st May, 1944. G. D. H.

1062.* Wells Completed in the United States in Week Ended 13th May, 1944. Anon. *Oil Wkly*, 15.5.44, **113** (11), 53.—378 field wells and 89 wildcats were completed in U.S.A. in the week ended 13th May, 1944. 260 of the former found oil and 20 gas, while 17 of the latter found oil and 2 gas.

A table summarizes by States and districts the U.S. completions in the week ended 13th May, 1944, and gives cumulative totals for 1944 to that date, as well as some earlier totals for comparison. G. D. H.

1063.* Hungary Rising Rapidly as Petroleum Producer. Anon. *Oil Gas J.*, 18.5.44, **43** (2), 44.—In 1943, Hungary's crude oil production is reported to have been 7,433,000 brl., nearly twice as much as in 1941. It is likely that the fields are being overproduced.

In the south-west of Hungary the Budafapuzsta and Lovaszi fields yield high-quality light-gravity oil which gives little lubricating oil. The Bukkszek field in the north-east has only a small production, and does not appear promising.

On the left bank of the Danube a gas-producing area is to be exploited.

Before the war, the Hungarian refining capacity was 3,716,500 brl./year, and it is believed that much of the current production is being refined abroad. The peacetime oil consumption was about 2,229,900 brl./year. G. D. H.

1064.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 18.5.44, **43** (2), 115. —70 wildcats were completed in U.S.A. in the week ended 13th May, 1944. 3 found oil and 1 found gas.

The U.S. wildcatting results are tabulated by States and districts for the week ended 13th May, 1944, and cumulative totals for 1944 are also given. G. D. H.

1065.* Exploration Completions Continue at Active Rate. L. J. Logan. *Oil Wkly*, 22.5.44, **113** (12), 13.—During April 1944, 377 exploratory wells were completed in U.S.A. and 67 were productive, although none of the successes was outstanding. In the preceding months, several unusually promising discoveries had been made, notably in Mississippi and Alabama, and apparently important additions to reserves had been made in California, Wyoming, West Texas and the Texas-Louisiana Gulf Coast.

A large proportion of the April discoveries took the form of new pay-zones in established fields, and important extensions to old fields. Some of the new pays and extensions seemed more important than most of the new fields found. The Atlanta field, Arkansas, appears to have been extended 2 ml. west and ¼ ml. east, while an outpost well may have linked the Fullerton and Union fields of Andrews County, West Texas, which are 4½ ml. apart. The Tensleep has been proved productive on the large Garland structure of Big Horn County, Wyoming. 2 wells, 3½ ml. apart, have found oil in this formation.

An important find seems to have been made in Pratt County, Kansas, 15 ml. south-west of the Chitwood pool, and a new pay-zone has been opened in the Layton sand of the North-east Mehan field, Payne County, Oklahoma. The Carthage distillate field of Panola County, East Texas, has been extended 2¼ ml. A ½-ml. north-easterly extension has been made to the Rio Vista gas-field of Sacramento County, California, and the Skinner North-west gas-field of Barber County, Kansas, appears to be an important strike.

During the first four months of 1944, 1264 exploratory wells have been completed in U.S.A., 229 being productive; the corresponding figures for 1943 were 1006 and 170, respectively.

A list is given of the April, 1944, discoveries, together with pertinent data, and tables analyse the exploratory completions by States and districts for April and for the first four months of 1944, while giving some 1943 figures for comparison. G. D. H.

1066.* Major Oil Province Promised in South-eastern States. L. J. Logan. *Oil Wkly*, 22.5.44, **113** (12), 29.—Activity in the South-eastern States has been accelerated by the discovery of 4 oil-fields in Mississippi and 1 in southern Florida in 1943, and by the opening of the highly promising Heidelberg field of Jasper County, south-east Mississippi, and the Gilbertown field of Choctaw County, Alabama, in February 1944.

The Heidelberg strike is 12 ml. north-west of Eucutta. Its second well had 200 ft. of oil-pay in 12 sands in the Eutaw and 3 in the Upper Tuscaloosa within 500 ft. of section. Is is estimated that it may produce 50–100 million brl. of oil. The Eucutta field may yield 50,000,000 brl. from the Eutaw at about 5100 ft. and the Tuscaloosa at about 6700 ft. The Cranfield field of south-western Mississippi is estimated to be good for 100,000,000 brl. of oil. Its discovery well found oil in the Wilcox at 5900 ft., and light oil with much gas in the Lower Tuscaloosa at over 10,000 ft. The Tinsley field, discovered 4½ years ago, has produced nearly 70,000,000 brl. of oil. It covers about 10,500 acres and has several pay-zones in the Selma, Eutaw, and Upper Tuscaloosa.

16 gravity parties are operating in Mississippi, 8 in Alabama and 14 in Florida, while there are 33 reflection seismograph parties at work in Mississippi, 4 in Alabama and 2 each in Florida and Georgia. 20 wildcats, 18 of them dry, were completed in the South-eastern States in the first quarter of 1944. This same region had 78 dry wildcats and 5 discovery wells in 1943, the bulk of them being in Mississippi.

The Palæozoic produces gas in north-eastern Mississippi and in south-western Alabama. These beds dip southwards, and in the coastal region they are overlain by younger beds. The thickness of these younger beds increases towards the coast, where there are production possibilities in the Eocene, Upper Cretaceous, Lower Cretaceous, and Jurassic. Production has been found in the Selma, Eutaw, and Tuscaloosa in Mississippi, in the Selma in Alabama, and in the Glen Rose in southern Florida. These formations are a continuation of those which produce in Texas, Arkansas, and Louisiana. It is probable that many favourable structures exist in these sediments, but they are often masked by shallower beds, thus requiring detection geophysically or by subsurface geology. A number of major uplifts are known: Sharkey County Uplift, Hatchetigbee Anticline, and McHenry High. The first two are associated with igneous activity and all have oil possibilities. There is also a basin with salt domes and other local structures.

The coastal region of the South-eastern States now has 10 oil-fields and a gas-field, all except 2 being in the southern half of Mississippi. All have been found in the past 5 years.

A table gives a summary of the wildcatting in the South-eastern States currently and in recent years, while another lists salient data on the oil-fields of Alabama, Florida, and Mississippi. A generalized stratigraphic section is given for the South-eastern States, together with the fields producing from the different formations in these States, and from their equivalents in Louisiana, Texas, and Arkansas. G. D. H.

1067.* Wells Completed in the United States in Week Ended 20th May, 1944. Anon. *Oil Wkly*, 22.5.44, **113** (12), 51.—A table analyses by States and districts the results of field and wildcat completions in U.S.A. during the week ended 20th May, 1944. Cumulative totals are given for 1944. G. D. H.

1068.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 25.5.44, **43** (3), 145. —63 wildcats were completed in U.S.A. in the week ended 20th May, 1944. 4 found oil and 3 found gas. Up to that date 1304 wildcats had been completed in U.S.A. in 1944, 147 finding oil, 11 distillate, and 43 gas.

The wildcat completions are summarized by States and districts for the week ended 20th May, 1944, and cumulative totals for 1944 are given. G. D. H.

1069.* Summary of April Completions. Anon. *Oil Gas J.*, 25.5.44, **43** (3), 152.—1811 wells, including 160 service wells, were completed in U.S.A. in April 1944. 953 produced oil and 200 produced gas. The completions are tabulated by States and districts, and the footage and numbers of wells in different depth ranges are given. G. D. H.

1070. More Discoveries Indicated for Alabama-Mississippi. D. L. Carroll. *Oil Wkly*, 29.5.44, **113** (13), 44.—Gilbertown, Alabama's first commercial oil discovery, was found in February 1944. It is in Choctaw County, 9 ml. east of the Mississippi border, and 40 ml. east of the new Heidelberg field of Jasper County, Mississippi. Production is from the Selma chalk at a depth of 2800 ft., the well having been plugged back from the Tuscaloosa at 5380 ft. The latter horizon is productive at Tinsley, Eucutta, and Brookhaven, while the Selma produces at Tinsley, Cary, and Flora, all these fields being in Mississippi. The Eutaw and Wilcox also produce in this region.

Cranfield and Heidelberg are of major rank, and Eucutta may prove to be the same. Between these two areas exploratory work is being concentrated.

Recent work has shown that beds of Lower Cretaceous and Jurassic age are intercalated between the Tuscaloosa and the truncated Palæozoic formations which dip coastwards. A well near the east end of the Hatchetigbee anticline encountered the Eagle Mills below the Smackover, finding it to consist of interbedded shales and salt, thus suggesting that it is probably the source of the salt in the salt domes of this basin. Geophysical surveys indicate that the core of the anticline is a deeply buried salt ridge from which two salt domes rise.

A well in Lauderdale County, Mississippi, reached Palæozoic beds at a depth of 6060 ft., without passing through Jurassic beds, pointing to the presence of a high Palæozoic ridge or the edge of the salt basin being south of this point. Salt domes occur in the area around the Jackson Uplift. The Tinsley dome is regarded as a large salt uplift.

Travis Peak and Trinity (Lower Cretaceous Comanche) beds are shown to occur in Mississippi and Alabama by well-cuttings and cores. The top of the Palæozoic dips south-west in Mississippi and almost south in Alabama, but the regional slope is interrupted by faults, anticlines, salt intrusions, and igneous bodies that have uplifted the Mesozoic beds. The most prominent of these structures are the Jackson and Tinsley domes, Hatchetigbee, Lower Peach Tree, and Wiggins anticlines, the Sharkey uplift, Jackson and Forest faults, and some broad arches over ancient Palæozoic folds in Alabama. The Sharkey uplift appears to be a local expression, with igneous intrusions, of the Monroe anticline which crosses the Mississippi valley, running north-east towards the Sabine uplift.

Pinch-outs of Jurassic, and perhaps of younger beds, may be expected along the flanks of the buried ridges which are believed to exist in Alabama, and differential compaction may have arched overlying beds.

Most of the oil-fields found so far in this area are definitely known to be associated with salt intrusions, and 15 other salt domes are known. Few tests have been put down for salt-dome flank production.

The great thickness of Selma limestone prevents effective shooting in lower beds, so that gravity surveys are being preferred, especially for locating salt domes. Magnetic surveys will pick up the igneous intrusions.

The belt of overlap or truncation of the Lower Cretaceous and Jurassic rocks below the Upper Cretaceous is favourable for searching for stratigraphic traps.

It appears that the Heidelberg field of Mississippi may cover 7000 acres, and that the closure is 700 ft.

A map, hypothetical cross-section, and a proposed stratigraphical column for the Mississippi–Alabama basin are included. G. D. H.

1071. Huge Production Gains Seen in Post-War Period. Anon. *Oil Wkly*, 29.5.44, **113** (13), 57.—If present indications are realized, oil production outside U.S.A. may be a million or more barrels per day greater within a few years than before the war.

The Near East area is the largest potential source of production, although Venezuela is likely to make large gains earlier. The actual proved reserves of the Middle East are estimated as 16,000 million brl., with a further indicated reserve of 25,000 million brl. in fields not yet fully explored. The U.S. reserve is estimated as 20,000 million brl.

Economics demand that the proposed pipe-line from Saudi Arabia and Kuwait to the Mediterranean should be operated at capacity, calling for 300,000 brl./day, compared with an output of 15,000 brl./day before the war. Before the war Iran and Iraq produced 215,000 brl./day and 75,000 brl./day, respectively, and if they should seek parity with Saudi Arabia and Kuwait the total, including the production of Qatar and Bahrein will be 1,000,000 brl./day, about 700,000 brl./day more than before the war.

Last year P.A.W. announced a programme for increasing Venezuela's output to 1,000,000 brl./day by 1945, and this will be attained if materials are available. Before the war the output was 600,000 brl./day.

Russia produced 625,000 brl./day before the war. This country has vast potential oil-bearing regions from which additional production could be developed, and so 1,000,000 brl./day is possible in the post-war period.

Colombia and Trinidad are included in P.A.W.'s programme for foreign development, and the Norman Wells field has opened a vast area of Canada which may become a source of large oil production.

If the Near East produces 1,000,000 brl./day, it will be capable of meeting the pre-war requirements of Europe and Africa. Before the war Venezuela sent 300,000 brl./day to these areas, and U.S.A. sent a similar amount. Thus with its increased output Venezuela would want new markets for 700,000 brl./day.

After the war the U.S. output should drop to pre-war levels, and may drop even lower, but if the oil industry is not to be depressed, it cannot fall sufficiently to make room for the 1,000,000–1,500,000 brl./day of additional oil expected from countries outside U.S.A. after the war. G. D. H.

1072. Wells Completed in the United States in Week Ended 27th May, 1944. Anon. *Oil Wkly*, 29.5.44, **113** (13), 63.—72 wildcats and 320 field wells were completed in U.S.A. in the week ended 27th May, 1944. 16 of the former found oil and two gas, while 210 of the latter obtained oil and 32 gas. Both types of completions are analysed by States and districts, and cumulative totals are given for 1944 to the above date.

G. D. H.

1073.* Oil Search in Eastern Gulf Region. J. A. Kornfeld. *World Petrol.*, June 1944, **15** (6), 27.—The discovery of the Sunniland oil-pool of Collier County, southern Florida, in November 1943 opened a new sub-province of millions of acres to geological and geophysical exploration. This is nearly 600 ml. from the nearest producing area, Gilbertown, of Choctaw County, Alabama. In the intervening area, geophysical crews are searching on a large scale for local structures, mainly by means of the gravity meter. The Sunniland production is from a Lower Cretaceous wedge, some 2000 ft. thick there, and overlapped northwards towards the Ocala Uplift.

About 16,000,000 acres of land are now under lease in the Eastern Gulf province—Florida 8,000,000 acres, Mississippi 5,500,000 acres, Alabama 2,000,000 acres and Georgia 500,000 acres. During 1943 this area had 460,223 ft. of exploratory drilling, 72% of the drilling being in Mississippi. In both Alabama and Mississippi wells have exceeded 12,000 ft. in depth; 11,000 ft. has been reached in Florida and 7000 ft. in Georgia.

In 1939, a wildcat was abandoned at 10,006 ft. in Monroe County, Florida, 50 ml. west of Miami, having encountered oil-shows at various points throughout the Cretaceous penetrated. This well proved the existence of Lower Cretaceous beds, possibly as a regional stratigraphic wedge. Geological and geophysical work, and core-drilling followed in Collier, Dade, Hendry, and Monroe Counties, anticlinal structure being indicated, and finally the Sunniland discovery well was drilled 42 ml. north-west of the dry hole. Production was obtained in the Lower Cretaceous, the initial pumping production being 140 brl. of net oil plus 65% of salt water. A second well is now nearing the productive pay. Two other tests are under way in Dade County.

The main drilling objective in southern Mississippi is the "Massive sand" of the lower Tuscaloosa. Three fields have been found in this area, at depths of 6667 ft.

(Eucutta, Wayne County) to 10,282 ft. (Brookhaven, Lincoln County). The producing structures have been located by gravity meter and reflection seismograph. Of the three "Massive sand" discoveries Cranfield, Adams Country, seems to be the most important. The Eucutta discovery well had an oil-show in the Eutaw. Cranfield gives 40° high-gravity oil, while Eucutta and Brookhaven give low-gravity oil.

The Heidelberg pool of Jasper County, east-central Mississippi, has three wells producing from the Upper Cretaceous Eutaw. The ultimate producing area is estimated as 8000–10,000 acres. The structure has at least one major fault and a number of cross-faults.

The Tinsley pool of west-central Mississippi was opened in 1939, and its cumulative production is over 65,000,000 brl. The peak output was 28,177,484 brl. in 1942. This field covers 9,840 acres, and is a dome with numerous cross-faults. There are seven producing sands, averaging 30 ft. in pay thickness, from the Selma, Eutaw, and Tuscaloosa, all of Upper Cretaceous age.

The Gilbertown pool of Choctaw County is Alabama's first commercial oil discovery. The "Massive sand" proved barren in the discovery well, and oil was obtained from the Selma Chalk. Another well showed oil saturation in the Eutaw. The Selma porosity is erratic. Small gas-pools have been developed at Fayette and Huntsville in the Palæozoic province of the north-western part of the State.

Nine unsuccessful Cretaceous tests have been drilled on the Hatchetigbee anticline of south-west Alabama.

Several maps are included, and tables give data on drilling and on geophysical activity in the Eastern Gulf region, and there are details of the various discovery wells.
G. D. H.

1074. Deeper Pay Discovered in Jusepin. Anon. *Oil Gas J.*, 3.6.44, **43** (4), 30.—A new producing horizon at depths of 5500–6000 ft. has been opened at Jusepin. Five wells are now producing from this horizon, which consists of sand, and is believed to hold important reserves.

The Creole Petroleum Corporation has surrendered about 1,500,000 acres of concessions since their prospective value did not justify payment of the conversion tax and annual rental of 80 and 65 cents/acre, respectively.

During the first four months of 1944, Venezuela's production averaged about 580,000 brl./day, Creole supplying about 333,000 brl./day, 277,000 brl. of it coming from western Venezuela.

At the instance of P.A.W., Creole has undertaken an intensive drilling programme, with a view to raising the production potential of the company to 572,000 brl./day by 1st January, 1945. This calls for nearly 250 new wells in proven fields. G. D. H.

1075.* Socony-Vacuum to Join List of Venezuelan Shipping Companies. Anon. *Oil Gas J.*, 3.6.44, **43** (4), 30.—Socony-Vacuum now has a small oil production in Venezuela, and hopes to start shipping about 3000 brl./day in the summer of 1944. The west Guara field has been extended to a Socony-Vacuum concession.

Socony-Vacuum has six concessions from the Colombian Government, aggregating 507,162 acres, and applications covering 2,820,592 acres; leases on private lands total 505,107 acres. In the middle Magdalena valley, the company has completed two producing wells which are 90 ml. from the Barco pipe-line. Preparations have been made to drill a joint well with Tropical in the coastal region of Colombia. Up to the beginning of 1944, about 11,000,000 brl. of oil had been shipped from the Barco concession held jointly with the Texas Company, and after curtailment due to lack of transport the production has again reached 11,000 brl./day.

In Venezuela, Socony-Vacuum now holds about 350,000 acres of concessions, and has drilled 25 exploratory wells, in addition to making geological and geophysical studies. G. D. H.

1076.* Peruvian Production. Anon. *Oil Gas J.*, 3.6.44, **43** (4), 40.—In 1943 Peru produced 14,653,748 brl. of oil, 1,025,170 brl. more than in 1942. G. D. H.

1077.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 3.6.44, **43** (4), 95.—In the week ended 27th May, 1944, 68 wildcats were completed in U.S.A., 8 finding oil, 1 distillate, and 2 gas. The 1944 totals to that date were 1372 wildcats, 155 yielding oil, 12 distillate, and 45 gas.

The wildcat completions in the week ended 27th May, 1944, are summarized by States and districts, and cumulative totals to that date are given for 1944. G. D. H.

1078. Future Gas Supply Twice Known Reserves. L. F. Terry, *Oil Wkly*, 5.6.44, **114** (1), 65.—The known reserves of natural gas in U.S.A. are estimated to be 110 trillion cubic feet. During 1943, the record volume of about 4 trillion cubic feet was produced, 3·3 trillion cubic feet being marketed.

The total past discoveries of gas in U.S.A. have been about 200 trillion cubic feet. During the period 1926–1934 the rate of discovery and development of new gas reserves averaged 6·82 trillion cubic feet per year, or about 2¾ times the rate of withdrawal. During the period 1935–1943 additions to reserves averaged 6·28 trillion cubic feet per year, or about twice the rate of production.

Deeper drilling may be expected to reveal increasing proportions of solution gas per barrel of new oil reserves discovered in the future, and the continued improvement in methods of conserving gas in oil-field operations should also add to the supply of natural gas available from this source. There is evidence that with deeper exploration the proportion of natural gas to crude oil discovered has been increasing. In the Gulf coastal area the proportion of gas and condensate discoveries has increased from 7% in 1933 and 24% in 1934 to 52% in 1943.

51·4 trillion cubic feet of gas has been produced and delivered to customers from 1906 to the end of 1943. Probably the total volume of gas marketed in U.S.A. to the end of 1943 was 57 trillion cubic feet. Making allowances for the reported gas losses and waste, as well as for that blown into the air before conservation was practised, the total volume of gas produced in the U.S.A. to the end of 1943 is at least 90 trillion cubic feet.

Various studies have indicated that future oil discoveries in U.S.A. will at least be equal to the total past discoveries, and since in general gas discoveries have run parallel with those of oil, it appears likely that future gas discoveries will at least equal and possibly exceed the 200 trillion cubic feet discovered to date. Thus the total potential gas reserves of U.S.A. may be some 300 trillion cubic feet or more. G. D. H.

1079.* Wells Completed in the United States in Week Ended 3rd June, 1944. Anon. *Oil Wkly*, 5.6.44, **114** (1), 73.—389 field wells and 83 wildcats were completed in U.S.A. in the week ended 3rd June, 1944. 249 of the former found oil and 39 gas, while nine of the latter found oil and one gas.

The wildcat and field completions are summarized by States and districts for the above week. G. D. H.

1080.* Jusepin Constitutes Eastern Venezuela's Largest Reserve. Anon. *Oil Gas J.*, 10.6.44, **43** (5), 50.—The aggregate daily potential of the greater Jusepin area is now about 90,000 brl. 33°-gravity oil is obtained from depths of 5000–6500 ft., and the reserve is the largest known in Eastern Venezuela. Production is obtained along a 30-ml. north-east–south-west trend, but it is not yet established that all the producing areas will join into a common structure, although the oil types and structural conditions are similar.

The discovery well was drilled near the town of Jusepin. Immediately to the south-west is the Mulata concession, and adjoining this on the south-west is the Santa Barbara concession. Both these concessions have much proven but undrilled area. North of Mulata is the Muri strip. South-west of Santa Barbara is the Travieso concession on which line-offset producers to those of Santa Barbara are being drilled. It is reported that Creole has found deeper productive horizons than those producing currently in Jusepin, in an area to the east of the field proper.

The present primary spacing outside competitive zones is about one well to 90 acres.

Twenty different saturated sands have been logged in the Miocene section, starting at 3900 ft. in the north-east. All the beds dip gradually south-west. Where possible in Jusepin proper dual completions are made in the zones 3900–4200 ft., and 4400–4500 ft. To the south-west in Mulata and Santa Barbara an intermediate producing zone appears, but it is now being cased off.

Considerable gas is being produced with the oil throughout the field. Probably some form of gasoline recovery, crude-oil stabilization, and pressure maintenance will be carried on after the war, when materials are available. Pipe-lines to Puerto la Cruz and Caripito serve this area, and a new 16-in. line is being constructed from Mulata to Puerto la Cruz. G. D. H.

1081.* Analysis Shows Abundant Reserves Still in Gulf, Mid-Continent Areas. F. B. Taylor. *Oil Gas J.*, 10.6.44, **43** (5), 52.—The Gulf and Mid-Continent areas of U.S.A. include various geological conditions, depths, and distributions, as regards oil, rendering them more nearly comparable to areas yet to be developed than any other producing sector, and so they may be used as a yard-stick. Oklahoma has a similar relation to the Gulf and Mid-Continent areas as these areas have to U.S.A. Hence its past production as compared with future possibilities is essentially the same as for the entire Gulf Coast and Mid-Continent area.

Production in Oklahoma began at the beginning of this century in shallow Pennsylvanian sands. The production was 52,000,000 brl. in 1910, 106,000,000 brl. in 1920, 277,775,000 brl. in 1927 (the peak year), 216,000,000 brl. in 1930, and 156,000,000 brl. in 1940. The decline since 1927 has been irregular, due to the depression and to discoveries. U.S.A. as a whole continues to show a rising production trend, and while Oklahoma's output is falling, its demand has been constantly rising. It appears that Oklahoma has progressed farther along its production curve than has U.S.A. Within the State the discovery of reserves has not kept pace with the development of producing areas already known, and the same condition is becoming apparent nationally. In 1943, Oklahoma produced 123,000,000 brl. of oil, while discoveries were 88,860,000 brl. The State's reserves have fallen from 1,202,000,000 brl. in 1938 to 935,000,000 brl. on 1st January, 1944.

It appears that under present economic conditions Oklahoma can produce 275,000,000 brl. of crude by secondary methods, while with price increases this might be raised to 625,000,000 brl.

The future reserves of Oklahoma may be about 5,000,000,000 brl., 1,000,000,000 brl. being primary reserves and 3,000,000,000 brl. being potential reserves in undiscovered fields. To date the production has been 5,300,000,000 brl. G. D. H.

1082.* Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 10.6.44, **43** (5), 119. —82 wildcats were completed in U.S.A. in the week ended 3rd June, 1944; 9 of them found oil, 1 distillate, and 3 gas. The wildcatting results in this week are tabulated by States and districts, and cumulative 1944 totals to the above date are given. G. D. H.

1083. Interest Revived in Wyoming and Montana. D. L. Carroll. *Oil Wkly*, 12.6.44, **114** (2), 18.—The exploration and development of the oil resources of Wyoming and Montana have been retarded by several factors which include: (*a*) the majority of the fields have yielded heavy black oil which has had only a limited market; (*b*) some large, ideal, surface-evident structures have failed to produce oil. However, crude oil shortages, improvements in refining methods, the discovery of higher-gravity crudes, and the fact that the less prominent and smaller structures may be productive have led to a change in outlook.

In the north-western Great Plains region there are isolated, and grouped anticlines of varying closures, domes produced by laccolites or other causes, structures which are much faulted, others which are relatively free from faults, terraces and fault zones. The formations range from Cambrian to Pliocene in age, except possibly for the Silurian and Miocene. Most of the structures that have been drilled in Wyoming and Montana have large closures and steep dips, and drilling has been slow and costly. Recently it has been shown that structures of comparatively small closure may also bear oil, and that the theory that only those structures with large closures have been able to hold oil against the flushing action of water entering the mountain outcrops is not necessarily valid. The favourable small structures lie some distance in from the margins of the Tertiary basins.

Two wells in the Gebo Dome field, near the south end of the Big Horn basin, have found big oil reserves in the Embar, and the Tensleep and Madison also hold production possibilities. After nearly 30 years, a deep test has been drilled on the faulted anticline of the Elk Basin field which produces from a shallow Frontier pay, and the deep test has found good production in the Tensleep, the producing area of which is more extensive than that of the Frontier.

The Garland field in the northern part of the Big Horn basin was opened in 1906, and gave most production from the Madison, with a little oil in the Frontier, Cloverly, Embar, and Tensleep. The Tensleep had a strong flow of gas which was cased off, but recently this has proved to be the gas cap of an oil-bearing horizon. Winkleman, Steamboat Butte, and the Gage Dome fields are on moderately-sized structures, known for many years, but for one reason or another not drilled until now. The Gage Dome field is in an area where some 70 wildcats have been drilled on other domes, finding fresh water only, thus suggesting that water circulation had flushed out any oil which might have accumulated in the area north and north-west of the Bull Mountain syncline, except in the Devils Basin structure. However, the Gage Dome structure seems to have been protected from flushing, and the same may be true of the West Gage dome.

North and east from the strongly folded and faulted area of central Montana Palæozoic beds gradually thicken, and they are truncated below the Mesozoic. These beds are involved in a number of prominent structures, some of them due to laccolitic intrusions, and some of the beds are productive in Canada, Wyoming and parts of Montana. Hence they may hold promise in eastern Montana. Few wells have reached the Madison in this area. In places the Ordovician may be accessible.

In Wyoming, the development of oil and gas has been more or less confined to the edges of the structural basins, and little is known about the deeper parts of the basins. It is likely that some of the structures plunging down under the edges of the basins continue below the Tertiary, and these buried structures may carry oil. A combined geological and geophysical attack will be required to find them.

The U.S. Geological Survey is making regional studies of areas in Wyoming and Montana from the point of view of oil possibilities.

A map and stratigraphical column are included. G. D. H.

1084. Completions First Five Months One-Fourth Ahead of 1943 Period. Anon. *Oil Wkly*, 12.6.44, **114** (2), 66.—More wells were completed in U.S.A. in May than in any of the earlier months of 1944. During the first five months of 1944, 8819 wells were completed, compared with 7102 wells in the same period of 1943. The following States had increases in 1944 relative to 1943, which increases exceeded the country's average of 24·2%: California (55%), Kentucky (128%), South Louisiana (42%), Mississippi (34%), Montana (65%), New Mexico (57%), Texas (45%), Pennsylvania (25%). There were decreases in drilling in Arkansas (25%), Illinois (11%), North Louisiana (9%), Nebraska (65%), and Ohio (2%), as compared with 1943.

Completions in May 1944 averaged 441 per week, against 322 per week in May 1943.

The well completions are analysed by States and districts, data being given for May 1944, January to May 1944, and some comparative totals for April 1944, May 1943, and January to May 1943, as well as footage and other figures. G. D. H.

1085. Wells Completed in the United States in Week Ended 10 June, 1944. Anon. *Oil Wkly*, 12.6.44, **114** (2), 67.—332 field wells and 68 wildcats were completed in U.S.A. in the week ended 10th June, 1944. The field wells included 217 oil-wells, 34 gas-wells, and 26 input and salt-water disposal wells; the wildcats included 16 oil-wells and 2 gas wells.

A table summarizes by States and districts the results of wildcat and field completions in U.S.A. in the week ended 10th June, 1944. G. D. H.

1086.* Colombian Production at 26-month High. Anon. *Oil Gas. J.*, 17.6.44, **43** (6), 77.—In December 1943 the daily output in Colombia was 59,677 brl. of oil, but the average in January 1944 was only 40,836 brl. The February, March, and April figures were respectively 57,472 brl./day, 62,084 brl./day, and 65, 862 brl./day, the last figure being the highest rate since February 1942. During the first four months of 1944 the production was 6,833,198 brl., compared with 1,384,766 brl. in the corresponding period of 1943. G. D. H.

1087.* Multiple Pays Create Complex Problems in San Joaquin Area. Anon. *Oil Gas J.*, 17.6.44, **43** (6), 84.—The oil-fields of the greater San Joaquin area of Eastern Venezuela have South America's deepest producing wells, and possess innumerable sands throughout a section over 7000 ft. thick, from which gas, condensate, or oil are produced, making completion problems difficult. High pressures and temperatures are encountered, and an unusual crude with a high wax content is met. There is also one of the world's largest gas-condensate reserves awaiting exploitation. Production is obtained along a 40-ml. north-east–south-west trend of steep domes, and the probable productive area on proven structures totals about 50,000 acres. The El Roble dome lies just north of the main San Joaquin structure. Its sands average 9650 ft. in depth, and have high permeability and low pressure. Ten wells have been completed, and to date they have produced 6,500,000 brl. of oil. It is possible that production may be obtained in the synclinal area between El Roble and San Joaquin. North-east of El Roble Anaco 1 found production mainly below 8500 ft., but the gas/oil ratio was 4000 to 1. The San Joaquin trend includes, from north-east to south-west, the Santa Rosa dome, Guario dome, central San Joaquin dome, western San Joaquin dome, and the Santa Ana dome. It seems possible that some of these domes will connect and produce throughout the synclinal areas at deeper levels. The Miocene Oficina section of this series of domes ranges 4500–6000 ft. in thickness, and in it 30 different producing sands have been logged. In these sands the net saturated thickness ranges 5–50 ft. The upper zones, at an average depth of 5774 ft., have temperatures up to 250° F., and bottom-hole pressures of 3200–4000 lb./in.^{2}. Three wells have penetrated the unconformable Oligocene section to the Eocene gas-condensate horizon. The condensate varies with structural position from 40 brl./million cu. ft. of gas to 1000 brl./million cu. ft. of gas.

Economic studies are now being made of the greater San Joaquin gas reserve, and a gas-cycling programme is being considered. In the gas caps a typical well may give 350–400 brl. of oil/day, with gas/oil ratios of about 5000 to 1.

The Mene Grande pipe-line from Oficina crosses the San Joaquin trend just north of proven production. G. D. H.

1088. Wildcat Completions and Discoveries. Anon. *Oil Gas J.*, 17.6.44, **43** (6), 163.—73 wildcats were completed in U.S.A. in the week ended 10th June, 1944, 9 finding oil, 1 distillate, and 5 gas. The wildcat completions in this week are tabulated by States and districts, and cumulative totals to this date are given for 1944. G. D. H.

1089. Geology Promises More Oil Fields in Turner Valley Area. G. S. Hume. *Oil Wkly*, 26.6.44, **114** (4), 32.—Turner Valley is on the eastern edge of the foothills. It has a pronounced surface anticline with flank dips of 50–70° or more, and plunging ends. Strike faults are numerous. The Palæozoic limestone at depth generally has moderate dips. A major thrust-fault cuts off the surface structure at depth, and the Mississippian appears as a westward-dipping limestone block, cut off by faults on both edges, and somewhat drag-folded on the east. This limestone plunges north and south. Some of the surface faults pass into bedding planes at depth and do not cut the Mississippian. Thus the Mesozoic beds have been rotated to possess steep dips. The Mississippian has few faults except in the north. Two porous reservoir horizons occur in the upper 350 ft. of the Mississippian, and they seem to die out westwards. Gas occurs east of the oil. The maximum closure for the oil- and gas-zones is 5000 ft. East of the main Palæozoic limestone mass, at the north end of Turner Valley, there is a fault-block with oil at a much lower level than elsewhere. To the west the Highwood uplift may have local oil and gas accumulations, and is separated from Turner Valley by the Outwest fault.

Turner Valley has given 66,780,000 brl. of oil and distillate, with large volumes of gas. It seems likely that the oil came from the east, for the oldest mountains are in the west of the Cordilleran area. The eastern fault-block at the north end of Turner Valley was probably separated after oil accumulation, thus carrying the oil down. Originally the Palæozoic beds must have dipped east, and the oil accumulated when they were in this state, perhaps in an anticline which arose before the main period of deformation. To the east the porous horizons of the Mississippian come to the surface of that formation due to bevelling, and so must be in contact with Jurassic shales. The oil could have originated in the Mississippian limestones, but the Jurassic shales may have been a prolific source of oil, so that the contact of the Jurassic shales with the porous Mississippian horizons may be significant, for the porous horizons would be favourably situated for receiving oil squeezed out of the shales. Thus, structures in front of Turner Valley would receive oil first as it migrated westwards, and hence if they exist they merit prospecting. Scattered holes east of Turner Valley have had oil-shows, though not of commercial size.

There are indications of a Palæozoic limestone anticline under the Turner Valley fault at the Sterling Pacific No. 1 location, according to well data, but the position of the anticlinal crest is uncertain.

Drilling on the Highwood uplift has shown water in the Palæozoic limestone about 6000 ft. higher than the Turner Valley oil–water contact. The crest of this uplift is at Pekisko Hills, where the limestone is only about 1000 ft. deep, and has low-pressure gas. Shows of oil were found in a well some distance down the northerly plunge of the structure. No well on this structure has been drilled to the Devonian. Some oil has been found in the Devonian at Moose Mountain, a Palæozoic outlier 30 ml. west of Calgary, but the porosity was low. At Pekisko Hills the Devonian might be 3000–4000 ft. deep.

The Dyson Mountain fault separates the Sullivan Creek anticline from the Highwood uplift to the east. As in other areas the surface Mesozoic beds show complicated structures, but the Palæozoic may be simpler. In a small porous zone a well found gas. Like the Highwood uplift, the Sullivan Creek structure is some 20 ml. long ; the latter has a long eastern limb, thus differing from the other structures of this region. No satisfactory test has been drilled on the Sullivan Creek structure. There are believed to be good prospects of its bearing light oil, and both the Mississippian and the Devonian merit testing, for the latter is known to contain porous zones. G. D. H.

1090. New Pays and Fields Many But Not Spectacular. L. J. Logan. *Oil Wkly*, 26.6.44, **114** (4), 41.—During May, exploration revealed a comparatively large number of new oil-fields, new pays, and extensions, but few of the discoveries appeared to be of outstanding importance. Important oil production was established in Oklahoma at a record depth. In Wyoming, a new oil-field was opened, and Tensleep sand production was extended at Elk Basin. A 1¾-ml. north-west extension of Clear Fork limestone production was made in the Sand Hills field, Crane County, West Texas.

The Oklahoma discovery is in McClain County, on the west side of the Nemaha Ridge. Production is obtained from the Wilcox at a depth of 10,625–10,645 ft. The structure is a faulted anticline.

Strawn limestone production was found at 4248–4255 ft. in Hardeman County, North Texas. Cooper Cove, Wyoming's new field, obtained oil from the Dakota at 4834–4912 ft. The Douglass field, Stephens County, West-Central Texas, has been revived by the discovery of flowing production in the Mississippi limestone at 4343–4362 ft. This strike is on a local high revealed by logs of old wells.

In Stafford County, western Kansas, Viola limestone production has been found at 3783–3787 ft., and this may connect with the Zenith and West Zenith fields to the east. The North McCallum field of Colorado has been extended, and a gas-field has been found in Pondera County, Montana.

Tables summarize by States and districts the results of exploratory drilling in U.S.A. in May and during the first five months of 1944. The new discoveries in May are listed with pertinent details. G. D. H.

Geophysics.

1091. The Future of Geophysics. W. T. Born. *Geophys.*, 6 (3), 213–220.—The greatest advances in the art of exploration in the near future will come through the more effective application of existing methods, and it is necessary that the geologist and the geophysicist complement each other's activities to a degree now only being approached.

Seismic activity in the U.S.A. will continue at the present level of 150–200 crews in the field for at least 5 years. The re-survey of old areas for minor structures will be continued. A considerable part of the Gulf Coast area will be surveyed once again to map deeper horizons, a task which requires only minor modifications of present technique. Much future work will be concerned with the location of stratigraphic traps. Improvement in technique in those cases in which the method is relatively unsuccessful has considerable possibilities.

Gravimetric surveys will continue to be an important reconnaissance method, but the amount of work done can be expected to decrease since, with proper use, re-surveying is unnecessary. The method could be used for locating the piercement type domes undoubtedly existing off-shore in the Gulf of Mexico.

Little change in the status of electrical methods of exploration is expected. They should be used only in areas where information concerning surface features is required or where there are extremely simple structures of a few particular types.

More time and money should be spent in the future on research on fundamental problems for, although instrumentation and technique are now very advanced, understanding of many of the phenomena encountered is still very imperfect. No proven method at present exists for the direct location of oil. The logical development of such a method requires the preliminary solution of the problems of origin and accumulation.

S. E. C.

1092. Seismic Receptors. H. R. Prescott. *Geophys.*, 1941, **6** (3), 221–244.—The equations defining the theoretical steady state characteristics and the dynamic response features of seismic receptors are developed. These are illustrated by a large number of curves in which are plotted, (1) steady state displacement response and displacement phase against the ratio of impressed frequency to natural frequency for the moving mass of a receptor having various degrees of damping; (2) steady state displacement response and displacement lag against impressed frequency for the moving mass system of a receptor for natural frequencies of 20, 50, and 100 cycles per second and various degrees of damping; (3) dynamic displacement response against time for receptors having natural frequencies of 20 and 50 cycles per second and various degrees of damping, upon receiving impressed motions of 20 and 60 cycles per second; (4) as in (3) above, but with the impressed motion followed by a second motion of the same amplitude and frequency but 0°, 45°, 90°, and 135° out of phase with the first.

The design and characteristics of a shaking table suitable for testing receptors are also discussed.

S. E. C.

1092A. A Refraction Theory Adaptable to Seismic Weathering Problems. H. E. Banta. *Geophys.*, 1941, **6** (3), 245–253.—It is often not possible, when using a curved path theory, to suggest a particular depth for the weathered layer, but some previously assigned depth, sufficient to include all low-velocity material, may be used and the vertical time from the surface to that depth calculated. An expression, $V_y = C(y + A)^{1/n}$, is suggested here for the relationship between velocity and depth, C, A, and n being constants for a given area, and from this expression equations are developed to enable such a calculation to be made.

S. E. C.

1093. A Note on the Determination of the Viscosity of Shale from the Measurement of Wavelet Breadth. N. Ricker. *Geophys.*, 1941, **6** (3), 254–258.—It has been demonstrated previously that the earth has an absorption spectrum for elastic waves and that a sharp seismic pulse is, by virtue of this, largely robbed of its high-frequency components, thereby being converted into a travelling wavelet of characteristic shape depending on the nature of this spectrum. Furthermore, it has been shown that, in the case of such plastic formations as clays and shales, the absorption agrees with the effect of viscosity on compressional waves at low frequencies. On developing the theoretical basis of this phenomenon, it is found that the wavelets generated widen with increasing travel time, the breadth being proportional to the square root of the travel time and the viscosity. It is thus possible to determine the viscosity of the medium. This was done for the Pierre Shale of E. Colorado, a formation several thousand feet thick. Two extreme values were calculated, $2{\cdot}7 \times 10^7$ gms. per cm. per sec. from near surface studies and $4{\cdot}9 \times 10^7$ gms. per cm. per sec. from deep studies, the average being $3{\cdot}8 \times 10^7$ gms. per cm. per sec.

S. E. C.

1094. Deep Correlation Reflections near Hoskins Mound Salt Dome. F. F. Campbell. *Geophys.*, **6** (3), 259–263.—In anticipation of reflections from steeply dipping beds on profiles as far as a mile north of the dome, charges were loaded to give energy to a time of 3·5 sec. The records in fact showed an indication of a reflection at 4·4 sec. and the profile therefore was shot with a charge increased from 6 lb. to 30 lb. of gelatin dynamite. With these new records the deep reflection is of sufficient character to be outstanding and favour direct correlation, although there are considerable time changes and some character changes. These are interpreted as indications of a fault and a major unconformity. S. E. C.

1095. Gravity Meter Survey of the Wellington Field, Larimer County, Colorado. J. H. Wilson. *Geophys.*, 1941, **6** (3), 264–269.—At the start of a survey of the Denver Basin in 1940, the Wellington Field, situated on an anticline with approximately 800 ft. closure, was selected as a typical mountain fold on which to run an experimental survey. It proved to be a case where a strong anomaly due to local structure is almost obscured by regional gradients. To the south there is a large regional maximum, believed to be due to density difference in the basement rocks, and it is obvious that the Wellington area lies on its north flank. The regional effect was calculated by making observations at equally spaced stations on a north-south, east-west grid, averaging the values and plotting them in profile form. Straight line approximations of the resulting curves gave the north-south and east-west componenets of the anomaly. The gravity meter used was designed by F. M. Kannenstine and his associates and was adjusted to a sensitivity of 0·025 milligal per scale unit. S. E. C.

1096. Relation of Gravity to Structure in the Northern Appalachian Area. L. L. Nettleton. *Geophys.*, 1941, **6** (3), 270–286.—Field tests of a new gravimeter were so arranged that a series of gravity stations at 1 mile intervals was established across the Appalachian Mts. from Pittsburgh to Gettysburgh. The network was tied into the primary U.S. Coast and Geodetic Survey gravity station at Washington, D. C., and Government field stations in the vicinity of Washington. The profile lines drawn across the area were chosen to include seismic refraction and magnetic survey traverses across the coastal plain. The maps and profiles make it plain that the larger gravity features are continuous and parallel to the mountain folding, and are thus closely related to the regional tectonics. Smaller, less continuous features are probably due to more local structural or lithologic units. It seems probable that the major gravity features are due more to density contrasts deep within the earth's crust rather than to density contrasts between sediments or between sediments and basement of the type exposed in the Piedmont. S. E. C.

1097. Geochemical Well Logging. W. R. Ransome. *Geophys.*, 1941, **6** (3), 287–293. —The geochemical well log indicates the hydrocarbon content of formations drilled through and is made from results of direct chemical analysis of cores and cuttings obtained during routine drilling. The analyses are made either in a portable laboratory at the well or at headquarters. The items commonly determined are hydrogen and the paraffins from methane to dodecane. When plotted in log form-depth-concentration patterns are frequently obtained. The log of a well located near the centre of an oil-pool shows high hydrocarbon values a short distance above it, whereas wells located near the edge may show high values many hundreds of feet above the oil. The depth-concentration patterns for hydrogen are different. High values indicate that the well is over or near the accumulation; low values mean that the well is either remote from the accumulation or over its centre. S. E. C.

1098.* A Direct Reading Phase Shift Meter. J. D. Eisler. *Geophys.*, 1941, **6** (4), 311–317.—Because of the limitations of the various devices for measuring phase shift, a new type of instrument was designed. It is a portable, direct reading meter which is capable of measuring phase shift to within 1° in the frequency range 10–1000 and its calibration is independent of the supply voltage. The design of this instrument is based on an application of the law of cosines. If two sinusoidal voltages, each equal in magnitude, have a phase difference, θ, then it can be shown that,

$$V_{\text{diff.}} = 2V_0 \sin \tfrac{1}{2}\theta \text{ and } V_{\text{sum}} = 2V_0 \cos \tfrac{1}{2}\theta$$

From this it can be seen that, by a proper choice of the magnitude of Vo, the meter can be calibrated directly in degrees phase difference.

The two vector voltages are fed to two identical automatic volume control circuits which compensate for initial variations in magnitude of the two voltages. One of the equalized voltages is then fed direct to a mixed amplifier unit, and from thence to a rectifier unit and a D.C. microammeter. A switch is provided with the other equalized voltage so that it can be passed through an inverter stage, if required, before going to the mixed amplifier unit, rectifier unit, and microammeter. In this manner V_{diff} as well as V_{sum} can be indicated. S. E. C.

1099.* The Relation Between Depth, Lithology, and Seismic Wave Velocity in Tertiary Sandstones and Shales. N. A. Haskell. *Geophys.*, 1941, 6 (4), 318–326.—A knowledge of the extent to which the average increase of velocity with depth is due purely to the mechanical effect of pressure exerted by the overburden, and of how much is due to the intrinsic character of the beds themselves, would enable one to calculate the effect of structural relief on velocity distribution. Also, if one knew how far the velocity log could be related to the lithology, then the accurate measurement of velocity over small intervals might become significant.

Experimental work on the effect of pressure on velocity which is applicable to this problem is lacking, and the principal evidence is obtained from well velocity determinations obtained at 62 wells in the S. San Joaquim Valley, California. The interval velocities for 1000 ft. intervals, determined from the well survey data, were tabulated with the depth below weathering of the mid-point of the interval. All velocities and mid-point depths for intervals over approximately the same depth range in the same zone were then averaged and plotted. It was found that the sandier formations (Middle and Lower Miocene and Eocene) show greater rates of increase of velocity with depth than the shales (Upper Miocene and Kreyenhagen), the figures being 0·428 and 0·581 ft./sec./foot and 0·240 and 0·231 ft./sec./foot, respectively. However, the velocity/depth curves for a typical shale and a typical sandstone may intersect at almost any depth and so the problem of deducing lithology from such measurements remains unsolved.

Comparison of these results with similar studies made by other investigators, indicates that the roughly linear increase in velocity with depth cannot be extrapolated very far beyond 14,000 ft. Below this depth the gradient probably begins to diminish toward an asymptotic value of 0·02–0·03 ft./sec./foot. S. E. C.

1100.* Seismic Velocities in the South-eastern San Joaquim Valley of California. E. J. Stulken. *Geophys.*, 1941, 6 (4), 327–355.—It is general practice to compute seismic data on the basis of a simple time-depth relationship based on velocity profiles or on seismic well-survey records. Discontinuities and irregularities across an area are smoothed out. Such records are the only means of attack where wells or velocity profiles are scarce, but in certain other areas more abundant records and data show that serious errors can arise. This is exemplified by the present study made in the Kern Co. part of the San Joaquim Valley, a portion of the valley floor, about 25 miles wide and 35 miles long, in the neighbourhood of Bakersfield. Data, largely in the form of maps showing velocity variations for different depths and for different time intervals are given for more than 35 wells. The magnitude of these variations in average velocity is indicated by the fact that in the area concerned there are differences of 1700 ft./sec. for a constant depth and horizontal velocity gradients which average more than 100 ft./sec./mile. The correction of data by direct computation is difficult because of the number of variables involved. It is suggested, therefore, that the easiest way to make such corrections is to construct maps giving them in feet for depth readings to key horizons. Examples of these are given for the marker horizon above the Stevens Sand, for the Oleese Sand and for the Rio Bravo Sand.

The possibility of establishing a relationship between velocity and stratigraphy is considered but no solution of the problem is obtained. Failure in this matter may be due to the coarseness of well velocity data, but it is more probably caused by lateral variations in lithology. S. E. C.

1101.* The Probable Errors of Delta-T Velocities. F. Romberg. *Geophys.*, 1941, 6 (4), 356–369.—The average velocity of a reflected seismic impulse can be found by observing the lag in its arrival time as the distance between the shot point and the recording point increases. The necessary accuracy may be obtained by using either the velocity profile method—an unusually large spread and only a few readings—or the *delta t* method—reading time lags from routine reflection records and compensating for small spread by the large number of observations. The accuracy of the velocities obtained from *delta t* data varies. The origin of these errors is discussed, their order of magnitude being illustrated by detailed examination of actual examples. It is concluded that *delta t* data from routine seismograph records will give velocities with probable errors of the order of 1% at depths down to 8–10,000 ft. Systematic errors are probably small so that the probable errors for the velocities can be computed by means of the average deviations of the observed *delta t's*. S. E. C.

1102.* Comparison of Well Survey and Reflection "Time-Delta Time" Velocities W. E. Steele. *Geophys.*, 1941, **6** (4), 370–377.—Although the most accurate method commonly used to determine average velocity is to make direct measurements with a geophone in a well, in many cases it is determined indirectly from *t-delta t* data. Data from both methods were obtained for five different areas in the Texas and Louisiana Gulf Coast and the velocities were compared. In all cases the *t-delta t* velocities were lower than the well survey velocities by 3–9%. In seeking the reason for this the effect of neglecting curvature of the path is dismissed as negligible; whilst picking the reflection travel time from the strongest cycle following the phase change has some effect, the principal cause undoubtedly lies in multiple reflections. S. E. C.

1103.* Notes on Refraction Prospecting. C. H. Dix. *Geophys.*, 1941, **6** (4), 378–396.—Various factors in the refraction method are discussed. A method is given for dealing with unreversed refraction profiles so that the first stages of the calculation refer only to known data. By this method, which involves a simple construction of a parabola to which all possible plane interfaces must be tangent in order to fit the data, old and incomplete surveys can be utilized.

There is next considered the case where an upper layer, in which there is a constant increase in velocity with depth, overlies a high-velocity layer. The method employed is based on circular rays and spherical wave-fronts, and is especially suitable for the case of an overburden of Tertiary sands and shales above the high velocity layer. It is shown that the accuracy of the depth determination decreases as the velocity contrast at the interface decreases.

An improved procedure is given for the construction of tables which give a series of depths in terms of a series of times. Finally, reflection on the ground surface is discussed. S. E. C.

1104.* Current Penetration in Direct Current Prospecting. M. Muskat and H. H. Evinger. *Geophys.*, 1941, **6** (4), 397–427.—In D.C. prospecting the potential between two electrodes is measured and then multiplied by an appropriate factor to give the apparent resistivity of the ground. Interpretation is essentially a comparison of this data with ideal resistivity curves for various conditions. Because the surface measurements represent the resultant effect of all the conducting layers below, the tendency will be for the surface data to be smooth and continuous. Any sharpness in variations in the surface data will depend on such factors as geological structure and geometrical arrangement of electrodes. The extent to which a specific conducting medium will affect the surface resistivity data will depend directly on the fraction of the total current which will flow through it; the surface electrodes must therefore be arranged so as to make this fraction as high as possible. This condition has not been analysed in detail previously, except for the case of a homogeneous earth. In the present paper the case of a stratified earth is considered, and the fraction of the total current which passes through each of the several strata is calculated as a function of electrode spacing and of the conductivities of the strata. The 2-layer and 3-layer cases are considered, and numerical values are obtained from which curves are drawn showing the magnitude of the fraction of current flowing in a stratum plotted against electrode spacing and conductivity. These curves are given for the following cases: 2-layer earth with complete conductivity range; 3-layer earths in which top and bottom layers are of the same material and the middle layer has a thickness, (1) equal to, and (2) twice that of the top layer; 3-layer earths in which the bottom layer has, (1) infinite conductivity, and (2) infinite resistance, and in which the middle layer is (1) equal to, (2) twice, and (3) three times as thick as the top layer. S. E. C.

1105.* Prospecting Effectiveness. E. E. Rosaire. *Geophys.*, 1941, **6** (4), 428–448.—The overall prospecting effectiveness of a method is determined by four factors—

operating, technical, resolving, and finding effectiveness—and it is established by the lowest effectiveness of any one of these factors. Operating effectiveness refers to the cost of getting data under the varying conditions prevailing throughout the potential theatre of operations. The technical effectiveness of a method refers to the quality of the data obtained. Resolving effectiveness is the extent to which the data obtained can be translated into terms of economic significance. The finding effectiveness is the ratio at any given time of the magnitude of anomalies of economic interest which it is possible to find to the magnitude of the current observational errors.

The various prospecting methods are examined in the light of the above ideas. It is concluded that, of the indirect (structural) methods which have been used successfully, only one, the drill, now has any appreciable finding effectiveness, and that is limited by its low operating effectiveness. The other structure-finding methods have found a multitude of anomalies but these cannot be translated into terms of economic significance. The methods therefore lack resolving effectiveness. In the case of the potentially direct geochemical methods, the free soil gas method showed a negligible prospecting effectiveness until later work, which led to the analysis of soils rather than free soil gases, made a major improvement in the resolving effectiveness of the method. Similar increases in the prospecting effectiveness of the indirect methods might well result from increased resolving effectiveness. It is predicted that the major advance in petroleum prospecting will follow a change in objectives from geological structure to the direct geological, geophysical and geochemical manifestations of petroleum itself.

S. E. C.

1106.* Considerations on the Vertical Migration of Gases. R. G. Nisle. *Geophys.*, 1941, 6 (4), 449–454.—A perfect gas, saturated with water vapour, is assumed to escape at a slow, uniform rate to the surface from a reservoir 5000 ft. deep. The pressure gradient is assumed to be 0·5 lb./sq. in./foot of depth and the temperature gradient is taken as the average of that in 15 wells scattered over Texas, viz. 0·021° F. per foot of depth. The rate of escape is slow enough for the gas at all times to be in thermal equilibrium with its surroundings. On this basis it is shown that the total weight of water vapour in the expanded gas decreases continuously as the gas rises from 5000 to 1000 ft. For the last 1000 ft. to the surface, however, the total weight increases, indicating a withdrawal of moisture from the strata through which the gas passes. Furthermore, it is concluded that the gas does not directly evaporate water by supplying heat from its internal energy but acts merely as a carrier for the water vapour. The effect of this on geothermal anomalies is discussed. It is suggested that further studies be carried out on temperature gradients at various depths, actual rates of gas leakage, and correlation of this information with hydrocarbon surface patterns and mineralization. S. E. C.

1107. Use of Gamma-Ray Logs in Measurement Problems. G. F. Shepherd. *Oil Wkly*, 8.5.44, **113** (10), 40.—The present trend towards development of relatively thin reservoir rocks at greater and greater depths has drawn more attention to the problem of obtaining correct depth measurements. Gamma-ray logs, being obtainable through casing, permit any given point to be located relative to a new or plugged-back bottom. Where a discrepancy exists between electrical log measurements in open hole and those of a gamma-ray log made through casing, the use of the latter may lessen the danger of testing a sand at the wrong depth, by reducing the measurement requirements to a minimum, which is the distance above the well bottom as shown by the gamma-ray log. The problem is to find the position of the object sand on the gamma-ray log, and then to determine its distance above the gamma-ray total depth.

The curves of drilling logs, electrical logs and gamma-ray logs generally have similar characteristics, but the radioactive and electrical potential properties do not always coincide. Opinions differ as to the exact points of the logs at which contact planes occur. At times peaks are correlated, but they do not always coincide exactly in depth, even in re-runs of electrical surveys. Thin shale breaks in a thick sandstone body are the most reliable points to measure in gamma-ray logs, but they are relatively rare and may be absent. Thin, sharply-defined sandstone peaks are generally reliable where positive identification is made with the electrical log. Tops of sandstones should be measured at one half the distance between the minimum " sand kick " and the maximum "shale kick," in the absence of a definite break in the line. The tops of shales are poor for use in measuring from gamma-ray data. The length of the detector causes appreciable uncertainty in the positions of contacts.

Measurements of the interval between two apparent correlative points on the electrical and gamma-ray logs tend to weed out unreliable data. Agreement of the intervals suggests, but does not prove, correctness, and multiple readings will lend further support if they agree. In multiple readings, all apparent correlation points are picked on this basis, and the readings are tabulated to give the apparent discrepancies between the two logs. The correction factor is selected by predominance of discrepancy values, and it has been found that these should be kept within a limit of 1 ft. from the selected factor. Discrepancies outside this limit may be due to non-coincidence of electrical and gamma-ray characteristics. Correction factors may change in different zones.

The position of the object sand is identified on the gamma-ray log by applying the correction factor when the position cannot be established directly by correlation. Finally the distance above the datum zero on the gamma-ray log to the completion depth in the object sand is computed by simple arithmetic in order to give the completion point in terms of distance above this established zero point. G. D. H.

Drilling.

1108.* World's Deepest Well. E. H. Short, Jr. *Oil Gas J.*, 27.4.44, **42** (51), 100.—A long article describes the drilling of the deepest well, giving details of equipment, mud, difficulties met, etc. The following table summarizes the chief characteristics of the well.

Total depth, ft.	15,255
Approximate months to reach total depth	21
Number bits used	460
Casing settings :	
20-in. (ft.)	507
13⅜-in (ft.)	1940
8⅝-in. (ft.)	6901
Bottom-hole remperature, °F.	248
Open hole, ft.	8354
Maximum mud weight used, lb.	12·6
Type of rig	Diesel-Mech.

Mud details are as follows :

Bentonite	250,400 lb.
Native clays	54,600 lb.
High-yield clays	213,000 lb.
Weighting Materials	1,038,300 lb.
Mud-treating chemicals	15,431 lb.
Fibrous materials	2050 lb.

Total mud cost—not including drayage	25,302·15 dollars
Total mud cost—including drayage	31,492·15 dollars
Mud cost per foot of hole drilled (less drayage)	1·71 dollars

A. H. N.

1109.* Perseverance Displayed in Drilling Phillips Well to New Depth Record. Anon. *Oil Gas J.*, 27.4.44, **42**, (51) 121.—A descriptive paper detailing some of the troubles encountered in drilling Phillips Petroleum Company's No. 1. Price well, which reached a total depth of 15,255 ft. at date of writing. A. H. N.

1110. Drilling Fluid for Completion of Shallow Oil Wells. W. H. Farrand and W. A. Clark. *Oil Wkly*, 1.5.44, **113** (9), 24.—*Paper Presented before American Petroleum Institute.*—Water base and oil-base drilling fluids are discussed. The effect of water or shales is detailed. Besides ordinary water-base mud and various types of oil-base drilling fluid, two other drilling fluids can be mentioned. Some operators prefer to drill in or freshly wallscrape low-pressure zones with drilling fluid made from bentonite. This fluid makes a very light-weight mud, which reduces the hydrostatic pressure against the zone and is believed to form a soft, easily removed cake. However, some laboratory experiments have shown that a bentonite gel cake on sands of high permeability may be inadequate to prevent actual penetration of the gel into the zone. Whether or not this is detrimental, is not known.

A second completion fluid recently tried consists of water-base mud of a high alkaline value treated with hydrolysed starch. This combination is said to have the effect of greatly lowering the water loss and forming a thin cake, thus both decreasing the seepage into the sands of drilling water and eliminating any harmful effect due to presence of a thick, tough cake. It may have promise, especially if salt water is used as the mixing medium. Considerable data indicate that presence of water, particularly fresh water, is detrimental to the effective permeability to oil of many sands, especially those of low values. This condition, of course, would seriously impair production from low-pressure zones. Consequently, it would seem logical that such zones should be drilled with some fluid other than water-base muds. Wells drilled with these other drilling fluids should therefore show improvement in production over those drilled with water-base mud. It is, however, extremely difficult to prove this in the field. In most fields in California, and particularly in the San Joaquin Valley, the low-pressure zones vary greatly in sand content, permeability, and saturation over short distances. Moreover, in the operator's desire to obtain best possible completion at the cheapest cost, it is difficult to impress him with the example; if a good completion is obtained with bentonitic gel, or with oil-base, or with crude oil, or with plain mud, then there is no reason in the operator's opinion to change to some other mud for any later well, for which he cannot be blamed. Despite these difficulties of control, there are some field data that offer a comparison of the effect of different fluids on production.

Oil-base completions, crude-oil completions, and completions using special fluids are studied. It is concluded that (1) There is definite proof of seepage of water from the ordinary drilling mud into the sand bodies encountered in the hole. (2) Seepage of fresh water into the producing sands should be kept at a minimum or eliminated entirely to ensure maximum productivity. There is definite evidence that use of oil-base drilling fluid provides greater initial and settled production. (3) Use of oil in areas where shales are present that are apt to slough on contact with oil should be avoided, as it may be harmful for the maintenance of sustained production. Sloughing, started by drilling oil, may be continuously aggravated by formation oil. (4) Favourable results of fluids other than water-base muds are indicated by many examples of good well completions, but the final evaluation must be deferred for further study. A. H. N.

1111.* South Arkansas Operators Employ Innovations In Drilling Procedures. P. Reed. *Oil Gas J.*, 4.5.44, **42** (52), 48.—The practices of J. C. Mayfield, drilling contractor, are described. The most conspicuous of these is his practice of placing the boilers on the same side of the derrick as the "V," instead of behind the engine operating the draw-works. In this unique plan the boilers are located at a sufficient distance for safety and to allow ample space for the pipe-rack. With the boilers in this position they are constantly within sight of the driller, who can observe any inattention of the fireman which may result in costly and dangerous trouble. Mud pits are laid out in such a manner that the mud pumps may be located as close to the boiler as practicable, instead of at the side of and close to the derrick. The purpose of this is to operate with short steam lines, which are regarded as more desirable than short mudlines. When the terrain does not permit placing the boilers on the "V" side of the derrick, boilers are located in the customary manner, behind the draw-works, and mud pumps are placed near the boilers.

Two factors are credited by Mayfield with effecting savings in time amounting to a total of 8 days in the drilling of a 9000-ft. hole. One of these is his practice of giving special attention to spudding-in and drilling the first 30 ft., which he supervises personally at each of his wells, for he has found that a deflection too slight to be detected by an instrument may result in unnecessary consumption of time in handling slips, in the course of drilling the well. Such loss of time may total as much as 5 days on a typical well of the area. Straightness is insured for drilling the first 30 ft. by unusual care in levelling of the crown block and rotary table and in centering the kelly, without the kelly joint, over the centre of hole. A saving of 3 days has been estimated to result from the use of a "mouse hole" close to the rotary table for "rat-hole make-up," which has been widely used by drilling organizations in recent years.

Much trouble, formerly attributed falsely to key-seating, is said to have been eliminated by low-water-loss mud with a thin filter cake, since there is less chance of sticking the tools. It is also claimed that with it better results have been obtained in getting side-wall samples. With low-water-loss mud, conditions are reported to be more favourable for cementing. A. H. N.

Production.

1112.* Air Repressuring for War-time Needs of the Ohio Oil Co. P. Reed. *Oil Gas J.*, 6.4.44, 42 (48), 39–41.—This is an account of air injection applied to stripped properties in the old fields of Illinois for the purpose of improving earning capacity. Costs of converting properties from vacuum operation to this type of secondary recovery are given, as well as results obtained, practices employed, and production policies followed in the programme. The policy of the company is the outcome of 15 years' steady application of secondary-recovery engineering principles. Starting in 1929 with experiments conducted primarily for salvaging marginal properties, repressuring of the company eventually entered the phase where it is now applied for preserving the profitable continuation of stripper production. This function of repressuring becomes vital in solving current problems connected with rising costs and frozen crude-oil prices.

Air is used altogether in most of the company's repressuring. In the summer, an air–gas mixture is injected into some projects. So little trouble has been encountered in the use of air that the additional expense for gas for the repressuring programme does not seem to be warranted. There has been some plugging of the sand pores, due to slight oxidation of oil resulting from contact with injected gas, but such plugging has not been sufficient to be serious. There have been no explosions of air–gas mixtures. Emulsion problems are not prevalent. A. H. N.

1113.* Deep Production Emphasizes Value of Rodless Pumping. J. Zaba. *Oil Gas J.*, 6.4.44. 42 (48), 52.—The hydraulic pumping system consists essentially of three parts: the surface power unit, the subsurface production unit, and the system of small-diameter pipe conducting the power oil from the power unit to the production unit. The power unit consists of a triplex pump designed to provide the smooth and continuous flow of fluid under high pressure. The pump may be driven by direct or indirect drive by a gas engine or an electric motor. The volume delivered by the pump is controlled by the speed of the prime mover and the size of plungers and liners used. The power oil is conducted from the pump through small-diameter pipe to the well-head, and from this point through small-diameter tubing to the subsurface production unit located at the pumping depth of the well. The production unit consists of two parts, the hydraulic engine and the pump. The hydraulic engine is of double-acting, reciprocating type. The power oil is conducted to both ends of the engine piston by passage controlled by a valve. The reciprocating motion of the engine is secured by subjecting first one and then the other end of the piston of the engine to the pressure of the power oil. An important factor controlling satisfactory operation of the unit is proper design of the action of the valve. This action is such that the power fluid is not throttled during any appreciable interval of the cycle. Cutting off and admission of the fluid take place at such a rate that smooth action is produced both at the beginning and end of the stroke. The power oil is exhausted, after use, into the production stream.

The pump forms the lower part of the production unit. The piston of the pump is driven by a rod connecting to the piston of the hydraulic engine. The pump is a double-acting, reciprocating piston pump. Both intake and exhaust valves are located at each end of the pump, which results in pumping action at each stroke of the piston. The pumped fluid is discharged into the annular system between the production unit and production tubing. The rod-and-piston system is drilled in such a manner as to provide the lubrication by the high-pressure, clean power oil.

Certain features of the design, operating characteristics, and problems of hydraulic pumping are discussed. A. H. N.

1114.* Paraffin Important Problem in Hydraulic Pumping. J. Zaba. *Oil Gas J.*, 13.4.44, **42** (49), 271.—Removing paraffin by heating the power oil may remove it from part of the tubing and deposit it in another. A very efficient method of cleaning the paraffin from the high-pressure part of the system is the use of oil-soluble plugs. A soluble plug of proper size is inserted at the discharge of the power unit and is pumped through the surface line and down the power tubing to the bottom. The plug becomes soluble at the bottom-hole temperatures. For cleaning paraffin out of lead lines, a unique method is used in some Illinois installations. A rubber ball $\frac{1}{2}$–$\frac{3}{4}$ in. larger than the diameter of the pipe is inserted back of the manifold of the power unit. The ball is then forced through to the wellhead connection, where it is retrieved. Some of these leases are flooded during certain seasons of the year. To make possible removal of paraffin, without special difficulties, during this part of the year plug receivers consisting of 7-ft. sections of 7-in. casing are installed in the power lines. The rubber balls are caught in these receivers, and can be removed later during the dry season. Of the several methods of actually removing paraffin from the production tubing, two are particularly effective. One is that of rotating the power-oil tubing. This causes scraping action inside the production tubing, and loosens the paraffin, so that the pumped oil will force it out of the production tubing. By installation of high-pressure swivels in power-oil tubing below the paraffin zone and above the well-head connection, this turning of power tubing can be accomplished while the well is pumping. Another method consists of installation of a tubing crossover below the paraffin zone, which allows the reversal of flow through the paraffin zone, of power oil and of produced fluid. Paraffin may be caused to be deposited inside the power tubing in the troublesome zone, from where it can be quite readily removed. The crossover may also be used for pumping paraffin solvents or heated power oil into the paraffin zone.

Characteristics of the pump and their dependance on piston area ratios are discussed in some detail. A. H. N.

1115.* Pure Oil Co. Operates Closed-Type Salt-water-Disposal System at Pauls Valley. N. Williams. *Oil Gas J.*, 20.4.44, **42** (50), 43.—Open-type systems function to precipitate the solids from the water and remove them by settling and filtering before the water is injected into the disposal wells. Closed systems, on the other hand, are designed to hold the solids in solution and inject them with the water into the disposal formation.

In a completely closed system, tanks or pits, filters and flow lines are all air-tight, and the water does not come in contact with the atmosphere. Without the oxygen chemical reaction, most of the iron compounds are retained in solution in the water in the same ferrous state in which they existed in the reservoir from which produced. In this way they can be injected with the water into the disposal formation without much danger of clogging the sand-face of the disposal well. Some operators have developed semi-closed systems, which represent modifications of the principle of the closed system and embrace features of both general types. Instead of sealed tanks to exclude air, such systems usually have open-top pits, but provide for the maintenance of a heavy scum of oil on the surface of the water to prevent contact of the water with the atmosphere. Tanks and pits are usually roofed, but this serves largely to prevent contamination and disturbance of the oil-scum. This practice precludes use of aerating towers or sprays, and is applicable only in the simplest of disposal systems.

The paper deals with one of the more recent closed-type systems installed. Production of all the company's wells in the field is processed through a continuous-flow heat treater located at the central separator, and stock-tank battery where the water is separated without contact with the atmosphere. Location of the disposal plant and well is at the lowest surface point in the field, permitting gravity flow of the water from the treater to the plant. The main line to the plant consists of approximately 1000 ft. of 8-in. cement-lined pipe. At the receiving tank the 8-in. pipe is provided with an 8-in. balanced valve. All tanks, filters, and lines at the plant are vapour-tight, so that the entire field system from the producing wells to the input well is completely closed.

A. H. N.

1116.* Deepest Sucker-Rod Pumping East of Rockies is in Buckner Pool, Arkansas. P. Reed. *Oil Gas J.*, 27.4.44, **42** (51), 41–42.—Pumping from the unusual depth of approximately 7200 ft. in the Buckner pool of southern Arkansas attracts attention because it represents the deepest sucker-rod operations in the United States east of the Rocky Mountains. The few pumping wells of this field lifting oil from low depths are equipped with standard equipment which has functioned with surprisingly little trouble, giving evidence that such equipment is capable of pumping from considerably greater depths. Geological, lithological, and hydrodynamical, characteristics of the Buckner pool, are given and the pumping equipment is described in some detail. Echometer and dynamometer tests have been conducted at a few wells, and from these tests and from pumping characteristics, such as may be determined by raising and lowering the pumps, it has been indicated that the fluid levels are relatively close to the bottom. The well on which dynamometer test data are presented here has top producing depth of 7264 ft., pump depth of 7183 ft., echometer depth of fluid 7016 ft. Fluid production consisted of 153 brl. daily of which 70% was water. A. H. N.

1117.* A Study of Corrosion in Gas and Condensate Wells in Katy Field, Texas. F. W. Jessen. *Oil Gas J.*, 4.5.44, **42** (52), 53. *Paper Presented before National Association of Corrosion Engineers.*—An examination of data, considered to be representative, available from a well in the Katy field, Waller County, Texas, indicates the corrosion of steel may be correlated with the rate of flow of gas, which in turn is believed to contribute largely to the rate of absorption of carbon dioxide. Evidence is presented to show that the rate of reaction of dissolved carbon dioxide with steel at the pressures and temperatures encountered in the operation of gas and condensate wells seems dependent on the rate of absorption of carbon dioxide and the length of time the fluid film is in contact with the metal. The continuity of a fluid film is questionable at higher rates of flow. It is believed that the ratio of condensed water to hydrocarbon condensate is also of considerable importance in the corrosion of steel by high-pressure gas. It is felt that invaluable information may be gained by a laboratory study of the problem of corrosion occurring in high-pressure gas and condensate wells. An essential part of any programme of laboratory research of the problem should be a consideration of the factors of rate of flow of gas, absorption of carbon dioxide by fluid films, rate of reaction of dissolved carbon dioxide on steel at prevailing temperatures and pressures, fluid-film behaviour at high flow rates, and the effect of water-hydrocarbon condensate ratio. A. H. N.

1118.* Factors Affecting Design of Hydraulic Pumping Systems. J. Zaba. *Oil Gas J.*, 4.5.44, **42** (52), 67.—The amount of fluid which has to be handled would be the starting point of the design of the installation. From the manufacturer's specifications, size and type of the pump can be selected with displacement corresponding to the expected production. Tubing already in the well may satisfactorily serve the purpose, although the selected size of pump will, of course, have a bearing on the size of tubing. As far as power tubing is concerned, this is usually selected in certain specified combinations with the corresponding size of production tubing. These combinations have been shown in a chart in the preceding instalment of the series. The size of the surface power lines will depend on the type of installation selected. In some installations each of the pumped wells has its individual power line leading directly to the central power plant. In other cases a line of larger size conducts the power oil from the central plant through the lease with laterals of small size delivering power oil to the individual wells. Selection of one of these two alternatives will depend on shape and size of property, spacing of wells and ideas, and preferences of the operator. In either case the size of the lines will be governed by the amount of fluid to be handled.

The paper details these steps giving formulæ for calculating horse-power and pressures required. A. H. N.

Gas.

1119.* Natural Coal Gas in West Virginia. P. H. Price and A. J. W. Headle. *Bull. Amer. Ass. Petrol. Geol.*, April 1943, **27** (4), 529–537.—Large quantities of gas—over 90% methane—are released from the coal seams of West Virginia. To prevent explosions in the more gassy mines, over 20 tons of air for every ton of coal produced are required for ventilation. The volume of methane emitted from coal is fully equal to the rest of West Virginia's output of natural gas. At present, moreover, considerable quantities of methane are being produced in mine waters. For the most part, methane is sorbed in the coal. Whether it is adsorbed or absorbed is not clearly known; but at a pressure of 10 atmospheres many coals sorb 10 volumes of methane per gram of coal, so that there is as much gas present as could exist in the same space if the coal were absent. For the Pocahontas No. 4 Coal, the heat of sorption reaches a constant value of 5200 calories per mol after 1·55 ml. per gram is adsorbed on the coal.

The release of gas from the coal is a desorption process, and for this closer drilling than in natural gas fields, as well as shooting of wells and possible horizontal drilling, will be necessary. In pipes from the system a vacuum will also have to be created to hasten the flow of gas.

European attempts to bleed off gas from virgin coal have been unsuccessful owing to the wide range of permeabilities and variation in gas release (*cf.* J. I. Graham, *Trans. Inst. Min. Engrs*, 1916–19 and 1926–27). A. L.

Cracking.

1120. Properties of Typical Products Refined by Houdry Cracking Process. E. A. Smith and R. E. Bland. *Oil Gas J.*, 13.4.44, **42** (49), 209.—Data are given on the properties of typical motor gasolines, aviation gasolines, gasoils and furnace oil cuts produced by Houdry fixed bed catalytic cracking of a variety of naphthenic, mixed base and paraffinic stocks. Naphthenic type oils are regarded as superior catalytic charge stocks for producing aviation and motor gasolines, and paraffinic type stocks for producing diesel fuels of high cetane number, but the process is capable of great flexibility. Motor gasolines from the cracking of light gas-oil do not require any further treatment and have O.N. of 77–80, the addition of 3 c.c. T.E.L. raising this to 88–89. Those from heavy gas-oil are about one O.N. higher, but have lower lead susceptibilities and may require treating. Aviation gasolines from coastal heavy naphthas, light and heavy gasoils, after addition of 4 c.c. T.E.L. have O.N. (A.F.D.—I.C.) of 98 and 99, while that from the more paraffinic East Texas heavy naphtha is 96.

Cracked gas-oils have lower cetane numbers than the base stock, this decreasing with severity of cracking, while in gravity and hence calorific value increases. From highly paraffinic stocks, gasoils of cetane value over 50 can be obtained. (Data are given on the properties of cracked gasoils from various stocks and on the effect of severity of cracking conditions.) While lighting kerosine is best prepared direct from the crude, power kerosine produced by catalytic cracking should be of high value.
C. L. G.

Refining and Refinery Plant.

1121. Liquid Hydrocarbon Treating with Aqueous Amine Solutions. J. D. Gordon. *Oil Gas J.*, 13.4.44, **42** (49), 202.—The Girbotol process for the removal of H_2S from gases has been extended to the treatment of liquid hydrocarbons, *e.g.* propane and butane cuts. The ethanolamine solutions are only slightly soluble in petroleum hydrocarbons, while the latter have a negligible solubility in the amine solution. A water wash or the usual caustic wash to remove mercaptans will extract any dissolved amines. Several commercial plant operations have confirmed the efficiency and economy of the process. Towers packed with stoneware Raschig rings have been found the most suitable, the solution being maintained in the continuous phase.

Heat for the regeneration of the solution is provided by a closed reboiler or, in the case of combination units, where caustic soda, etc., is used to remove mercaptans, the steam from the mercaptan plant reactivator is used as direct stripping steam in the Girbotol reactivator. A simplified flow diagram of a typical liquid hydrocarbon treating unit is reproduced. C. L. G.

1122.* Corrosion in Petroleum Refineries. B. B. Morton. *Petrol. Engr*, May 1944, **15** (8), 186–192.—Few general rules seem to apply to the complex problem of corrosion, but it has been established that the character changes with the presence or absence of liquid water. Thus, results presented show that sulphur corrosion resistance of steel at high temperature is markedly improved by small additions of chromium and that the improvement is progressive up to 20% chromium. The resistance is further improved by addition of nickel to certain types. However, in the lower temperature regions, where liquid water can exist, chromium alloys lose some of their importance and non-ferrous alloys such as nickel, monel, brass, bronze and certain special alloys, which are listed, are indicated. The recent use in refineries of many reagents corrosive to carbon steel, etc., has introduced new problems, and results of tests and observation on the corrosion resistance of materials, which in some cases are not yet to be regarded as final, are provided.

Sulphur in the form of H_2S is dealt with above; in the form of SO_2 in water solution it is resisted well by type 316 stainless steel. For resisting sulphuric acid at high temperatures and concentrations, Hastelloy A, B, and D are used. The adverse effect of copper introduced with steam is mentioned. For fuming acid, chrome–nickel alloys are more resistant than mild steel, Hastelloy C is used in refinery service and other alloys with high resistance to oxidizing media would probably be as satisfactory. The most resistant metallic materials are high silicon cast irons, but these necessitate special design features on account of brittleness.

Naphthenic acids are corrosive at high temperatures. Monel metal is shown to be resistant, but above 500° F. is liable to sulphur corrosion. For such temperatures Inconel and 18–8–3 alloy are shown to be highly resistant, but 18–8 stainless steel shows poor resistance. Hydrochloric acid corrosion can be combated by the use of Hastelloy B and Inconel, nickel and monel metal are also used, monel again being subject to temperatures of below 500° F. In many cases the use of liners is adequate and for pumps, valve parts, etc., Ni-resist cast iron is widely used. Hydrofluoric acid corrosion is still being intensively studied but results to date indicate (*a*) silver is probably the most resistant metal, but effects of sulphur, etc., upon the metal remain to be evaluated; (*b*) monel metal appears the most satisfactory commercial alloy for aqueous and anhydrous H.F. provided oxygen is absent; (*c*) copper is resistant to aqueous, but is vigorously attacked by anhydrous H.F.; (*d*) steel is vigorously attacked at temperatures over 150° F.; (*e*) 70/30 copper–nickel alloy shows good resistance in laboratory tests.

In caustic regeneration, by boiling, the chief attack appears to take place on tubes of the heating unit. Monel metal has been successfully used, but 5% nickel steel tubes show erratic results.

Phosphoric acid corrosion due to condensation of steam used in blow back operation is successfully combated by monel metal liners. Hastelloy C and 18–8–3 alloy also possess good resistance to phosphoric acid in concentrations up to 35% at high temperatures. Where chlorinated solvents are used, monel metal is employed. Monel is also resistant to the phenol group of solvents and furfural. 18–8 steel is used for liners and tubes to contact phenolic compounds and hydrocarbons at temperatures of over 500° F. R. A. E.

1123.* Shell's Wood River Plant Exemplifies Progress in 100 Octane Manufacture. J. P. O'Donnell. *Oil Gas J.*, 4.5.44, 42 (52), 33–107.—Before the war, Wood River was one of the few refineries in the U.S. producing 100 octane fuel components. During the last five years, the capacity has been raised from 45,000 to 85,000 brl. a day, the main objective being to increase production of war products. Three new topping units and an alkylation unit having a capacity of 1500 brl. a day of alkylate were added in 1939. The second programme, completed in 1942, included fractionation equipment to recover 1500 brl. a day of *iso*pentane, the necessary equipment to produce 700 brl. a day of toluene synthetically and an Edeleanu extraction plant for production of special naphthas.

The third programme is now in the completion stage, and includes expansion of topping capacity, extension of alkylate capacity to 5000 brl. a day and addition of two fluid catalytic cracking units having a combined charging capacity of 31,000 brl. a day, the necessary treating facilities for the gasoline produced, and an isomerization plant designed to produce 1200 brl. a day of *iso*butane for the extended alkylation plants. Suitable extension of auxiliary equipment was also included in the programme, utilizing as far as possible existing equipment. Brief descriptions are given of the various sections of the enlarged plant, methods employed in the preparation of feed stocks for the various units and the operation of these units. Mention is also made of the manufacture of cumene by alkylation of propylene and benzene at Wood River. This required but minor modification of existing equipment, and was responsible for a large increase in U.S. output of 100 octane fuel at a critical period of the war. It is estimated that with the equipment now installed the Wood River refinery will be able to produce in the neighbourhood of 25% by volume of 100 octane aviation gasoline based on the crude intake. R. A. E.

Chemistry and Physics of Hydrocarbons.

1124. The Effect of Thixotropy on Plasticity Measurements. H. Green and R. N. Weltmann. *J. Appl. Phys.*, May 1944, **15** (5), 414–420.—The apparatus and procedure adopted by the authors in measuring plasticity and thixotropy, the results of which have already been reported in previous papers, are described in detail. The subject of handling a thixotropic material on testing is a very difficult one to standardize. The authors describe a method which proved successful in giving consistent results when six operators used six different viscometers and tested samples of the same material on the same day. A. H. N.

1125. Thermal and Electrical Conductivity of Graphite and Carbon at Low Temperatures. R. A. Buerschaper. *J. Appl. Phys.*, May 1944, **15** (5), 452–454.—Thermal and electrical conductivities of graphite and carbon were measured at various temperatures in the range between −191° C. and 100° C. Thermal conductivity of graphite was found to increase at an increasing rate as the temperature was lowered, and two values were always found for Acheson graphite, a longitudinal and transverse conductivity, the latter being about ½ the former. This effect has not been reported for artificial graphite although Wooster reported an anisotropy in natural graphite with respect to thermal conductivity, the values along the axis being about four times that at right angles. X-ray patterns give no evidence of crystalline alignment in Acheson graphite and the explanation of this anisotropy has not been found. The electrical conductivity of graphite increases with rise of temperature as contrasted with the decrease of thermal conductivity with temperature rise. Thus the Wiedmann-Franz law does not hold, nor is the Lorentz number a constant. Carbon shows no anisotropy. The thermal and electrical conductivities both increase with temperature rise, the thermal conductivity linear, in the temperature range −191° to 100° C. A. H. N.

1126. The Formation of Bubbles. R. B. Dean. *J. Appl. Phys.*, May 1944, **15** (5), 446–451. Extreme values for the negative pressures and the degrees of superheat which water will withstand without forming bubbles are contrasted with the case of forming bubbles by vibration or by the turbulent flow of liquids. The subject of bubble nuclei is briefly reviewed, and it is pointed out that such nuclei usually function by virtue of sorbed or trapped air which can be removed, rendering the nuclei ineffective. Technique for avoiding extraneous bubble nuclei is presented, with some experiments on the formation of bubbles by mechanical action. It is pointed out that free vortices in liquids produce sufficient tension to rupture the liquid, and it is suggested that mechanical disturbance produces bubbles only in such vortices and not by general pressure lowering in sound waves.

Very simple and interesting experiments are described to substantiate the hypothesis. A. H. N.

Lubricants and Lubrication.

1127. Heavy Duty Oils for Internal Combustion Engines. W. J. Backoff and N. D. Williams. *Petrol. Engr*, May 1944, **15** (8), 138–149.—The use of detergent type additives in lubricating oils to enable satisfactory operation of engines under higher conditions of speed, temperature and load is a comparatively recent development commercially. Such severe operating conditions occur almost exclusively in trucks and buses and, to a limited extent, in certain heavily loaded stationary engines.

Under these severe conditions of operation, the oil undergoes oxidation, as evidenced by the development of organic acidity, oil-insoluble sludge, and oil-soluble sludge to a degree which depends on conditions, type of oil used, and the method and degree of refining. The development of these oxidation products gives rise to corrosion of bearings, clogging of oil filters, and unsatisfactory engine operation, and in severe cases may lead to engine failure or breakdown. As a result, antioxidants were developed which, on addition to lubricating oils, fulfil one or both of the following functions: (1) Arrest the natural ability of the oil to absorb oxygen; (2) deactivate hot metal surfaces of engine parts thus rendering them inactive as oxidation catalysts. Such materials have promoted better operation of engines, but even the most stable of lubricants may show signs of deterioration due to (1) tendency to absorb excess oxygen in blowby gases; (2) high ring-belt temperatures of the newer high output engines; (3) contaminating influence of unburnt fuel residues (soot). Detergent-type additives were developed to mitigate these effects and are usually metallo-organic salts. Metals commonly used are zinc, tin, nickel, calcium, lithium, barium, aluminium, and potassium. The acidic organic radical most often contains sulphur and/or phosphorus to promote oil solubility and confer metal deactivating effects described under antioxidants. The detergent type additive should provide (*a*) prevention, by cleansing action, of oxidation products from adhering to engine parts, (*b*) sludge dispersion or prevention of any contaminant described under (*a*) from physically separating from the main body of the crankcase lubricant and later depositing throughout the engine. The cleansing action of a detergent-type additive is shown by numerous illustrations of engine parts after service on oils with and without detergent additives.

A good heavy duty motor oil, in addition to normal requirements of a well-refined oil, must possess the characteristics of oxidation resistance, detergency, dispersion, and corrosion resistance. The testing equipment used for evaluation of these properties involves (1) laboratory testing, (2) tests in single cylinder engines especially to evaluate lacquer formation, bearing corrosion and ring sticking tendency, (3) full-scale engine tests in diesel engines of the industrial type to provide the final evaluation of the expected service performance of the oil under examination. The engines used for (2) and (3) are illustrated, and the various conditions of operation employed for evaluating specific oil properties are detailed. It is stressed that in the present state of knowledge, no one engine or set of operating conditions will give an accurate prediction of the service performance of an oil, but a careful evaluation of results of the various engine tests described is essential for this purpose. R. A. E.

BOOKS RECEIVED.

B.S. No. 1171 : 1944. High Duty Studs and Tapped Holes in Light Alloys. Pp. 16. British Standards Institution, 28, Victoria Street, London, S.W.1. Price 2*s*. net.

Some Recent Advances in Chemistry in Relation to Medicine. D. H. Hey. Pp. 24. Royal Institute of Chemistry, 30, Russell Square, W.C.1.

Coke Oven Managers' Association. Year Book. 1944. Pp. 234. Benn Brothers Ltd., "The Gas World" Offices, Bouverie House, 154, Fleet Street, London, E.C.4.

Recent Developments in Fuel Supply and Demand. Arno C. Fieldner. U.S. Bureau of Mines Information Circular No. 7261. Pp. 27.

Industrial Insulation with Mineral Products. Oliver Bowles. Pp. 17. U.S. Bureau of Mines Information Circular No. 7263.

History of Water Flooding of Oil Sands in Oklahoma. D. B. Taliaferro and David M. Logan. Pp. 182. U.S. Bureau of Mines Report of Investigation No. 3728.

National Motor-Gasoline Survey, Summer 1943. A. J. Kraemer and O. C. Blade. Pp. 28. U.S. Bureau of Mines Report of Investigations No. 3735.

INSTITUTE NOTES.

SEPTEMBER, 1944.

NEW MEMBERS.

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

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

As Members.

ASCHER, Richard.
CLUER, Abraham.
KENNEDY, Thomas.

As Associate Members.

ELLIOTT, John Lanyon.
GILL, Thomas Edmund.
NEWMAN, Jocelyn Eric.
SMITH, James Alfred.
HANCHETT-STAMFORD, Derek.
THOMSON, Alan John.

APPLICATIONS FOR MEMBERSHIP OR TRANSFER.

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

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

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

Membership.

FARBER, Louis Nathan, Engineering Chemist, S.A. Railways and Harbours.

HOBLYN, Edward H. T., Chemical Engineer, and Secretary, B.C.P.M.A. (*Norman C. Fraser ; E. A. Evans*).

JOYCE, George Thomas, Dep. Managing Director, A. Duckham, Ltd. (*J. S. S. Brame ; A. Duckham.*)

ROSE, Gerald Gershon, Chemist, Shell Refining & Marketing Co., Ltd. (*D. Morten ; J. Parrish.*)

WATSON, Noel Edward, Chief Chemist, Bahrein Petroleum Co., Ltd. (*N. L. Anfilogoff ; R. F. Hurt.*)

Transfers.

NEPPE, Solly Louis (Associate Member), Chemist. (*A. P. Faickney ; W. J. Jarrett.*)

SCHIFFMAN, Eric Charles (Associate Member), Plant Superintendent. (*A. P. Faickney ; W. J. Jarrett.*)

"TABLES FOR MEASUREMENT OF OIL."

Panel VI of Standardization Sub-Committee No. 1 (Measurement & Sampling) is preparing a new I.P. publication, "Tables for

Measurement of Oil." This will be a comprehensive book (approx. 320 pages) comprising 15 detailed tables covering reduction of specific gravities and volumes to standard temperature (60° F.), interrelation of units of measurement and computations of weights and volumes of bulk petroleum products. The book will be the official British counterpart of the well-known American (Bureau of Standards) publication "National Standard Petroleum Oil Tables —Circular C. 410," but it will be more extended in scope.

The book is expected to be available early in 1945 at the price of 25*s*. per copy.

STANDARDIZATION COMMITTEE.

Sub-Committee No. 5 (Engine Tests) of the Standardization Committee wish to draw attention to the revision of Method I.P. 44/44(T) distributed with the July issue of the *Journal* and the correction slip for Method I.P. 43/42(T) enclosed in the current issue. In both cases the corrections are necessitated as a result of the removal of the throttle plate from the apparatus used for the knock rating of motor fuels. In I.P. 44/44(T) Revised, the guide tables have been corrected to allow for this change, and in I.P. 43/42(T) the apparatus specified is corrected to the original Motor Method engine incorporating the throttle plate.

PERSONAL NOTES.

Mr. E. A. Evans, F.Inst.Pet. (Member of Council) has been elected Chairman of the Automobile Research Committee of the Institution of Automobile Engineers.

Mr. G. C. F. Greant has recently left Ecuador to take up new duties in Egypt.

BIOGRAPHY OF LORD CADMAN.

The biography of the late Lord Cadman is to be written by Mr. Ivor B. N. Evans, who states that he would be glad of any letters, papers, and other material of interest that readers might care to lend to him. These should be addressed to him c/o Mr. James Cadman, Walton Hall, Eccleshall, Staffordshire.

INSTITUTE OF FUEL.

Dr. E. W. Smith, C.B.E., the present President of the Institute of Fuel, has consented to continue in office for a further period of twelve months until October 1945.

The Council of the Institute has decided to award the Melchett Medal for 1944 to Dr. J. G. King, O.B.E., Director of the Gas Research Board, in recognition of the outstanding work he has done in recent years during his connection with the Fuel Research Station at Greenwich.

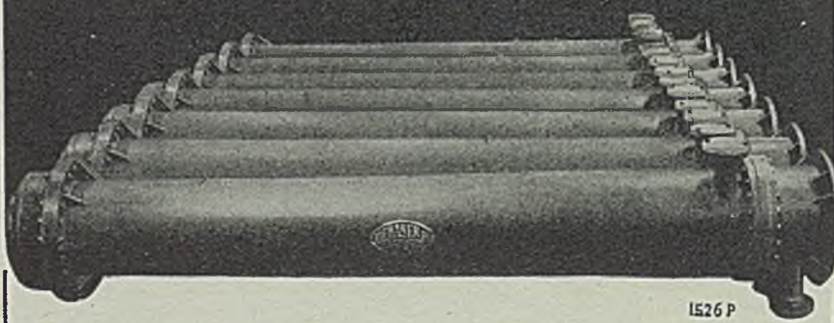
The Council have also announced that Mr. H. L. Pirie, one of the Honorary Secretaries of the Institute of Fuel since its inception, has been made an Honorary Member.

SOCIETY FOR VISITING SCIENTISTS.

The Society for Visiting Scientists has been formed to serve as a focus for scientists from overseas visiting Britain, and to provide an information centre and hospitality.

The President of the Society is Professor F. G. Donnan, C.B.E., F.R.S., and the Secretary is Mr. J. G. Crowther.

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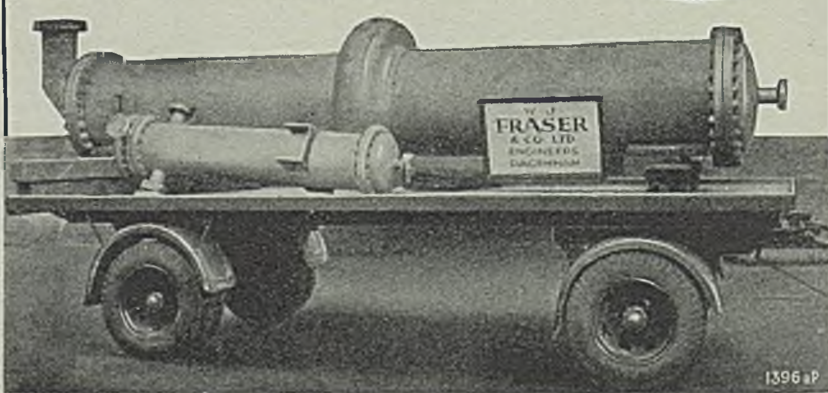
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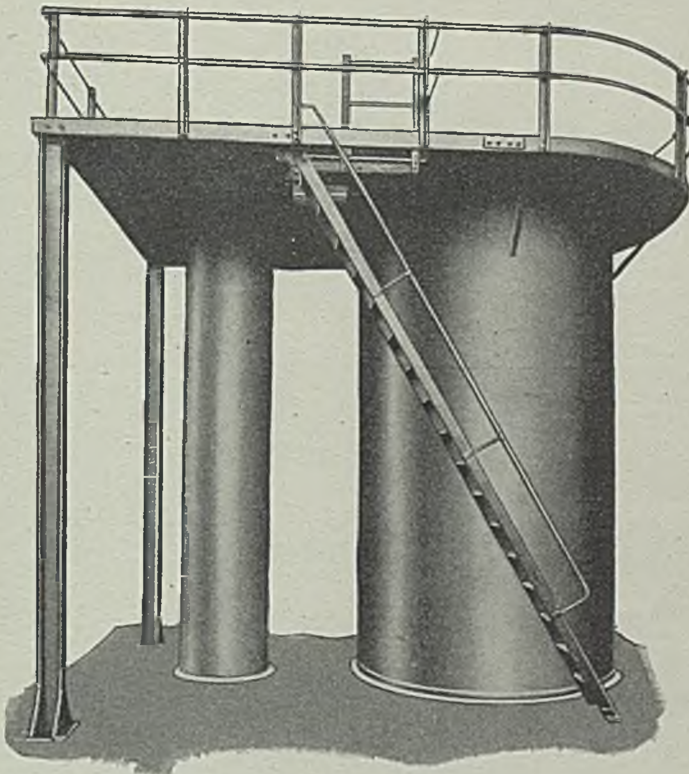

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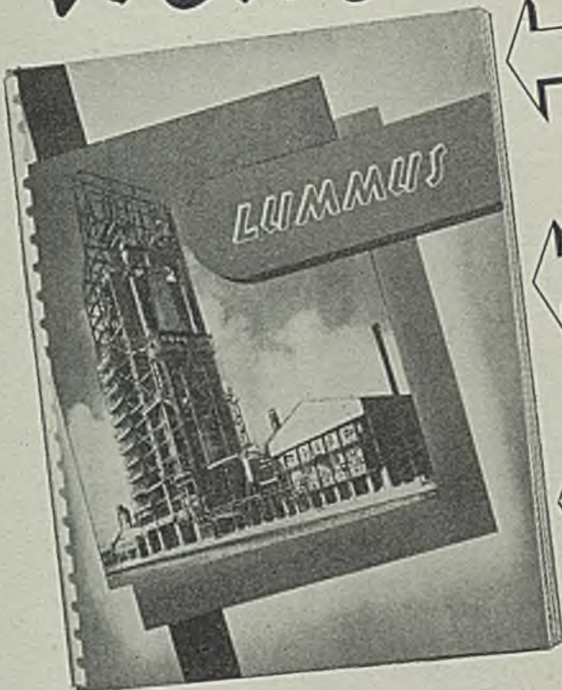

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"Petroleum Refining Processes," Bulletin R-8

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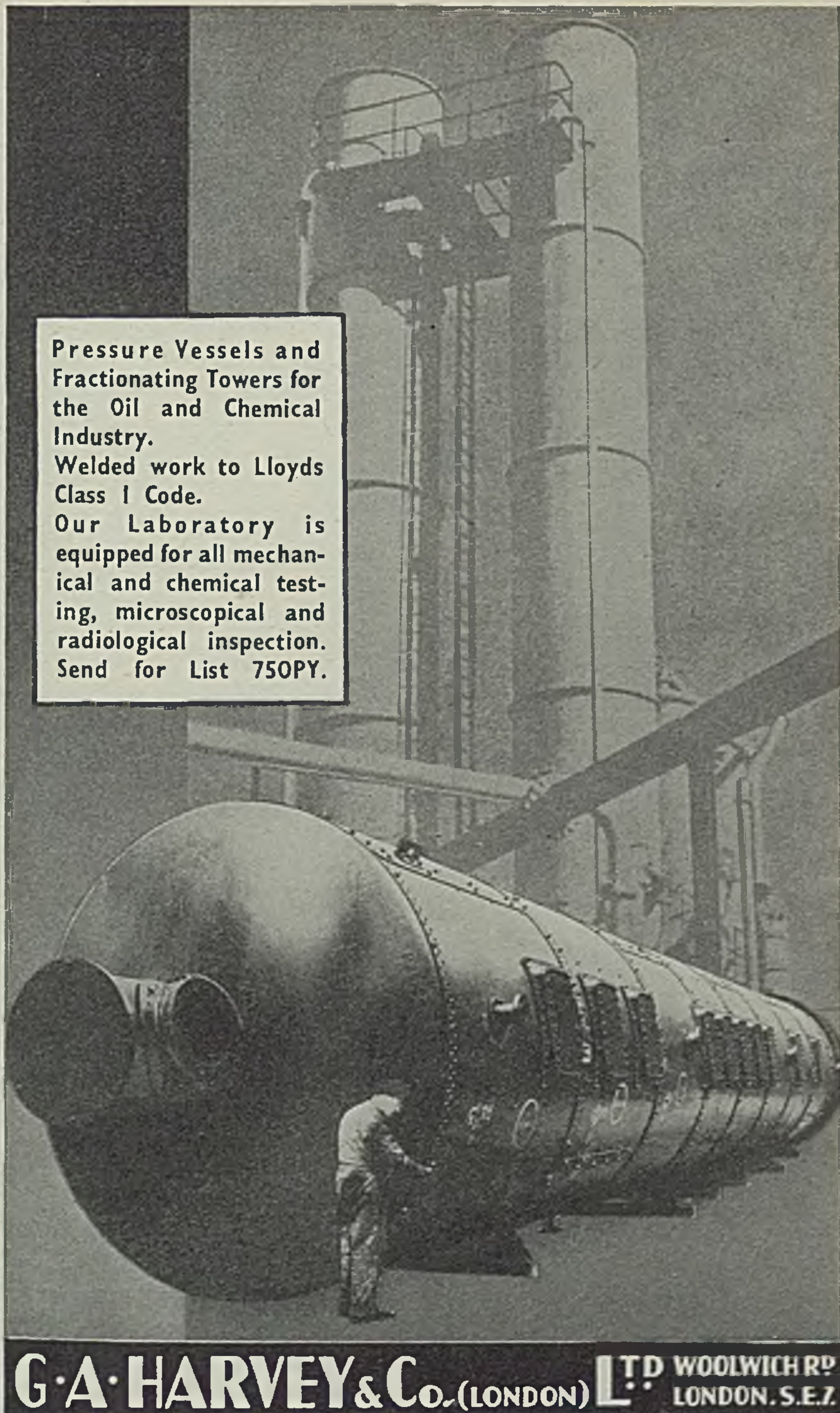
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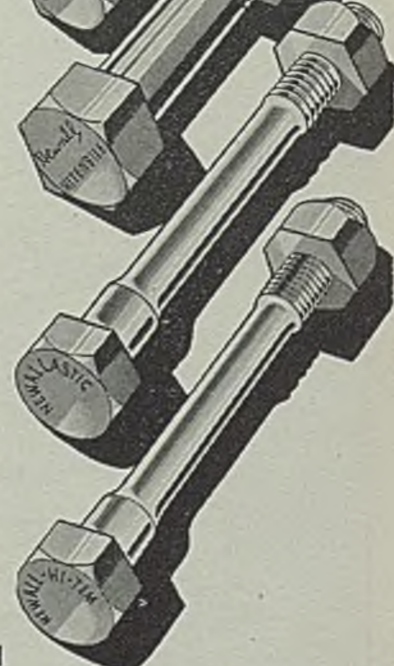
One of the leading Research Engineers had stated in the course of a paper, that there had been no basic changes in steel for twenty-five years and that he sees no immediate prospect of any such changes. He goes on, however, to say that by adapting certain well-known processes, immense improvements can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

The introduction of 'Newalloy' which followed after a long interval of experiment and research, carried the strength of bolts to the highest point which they have yet reached. It is to be noted, however, that 'Newallastic' bolts and studs, which came later, are much more resistant to fatigue than are normal types. 'Newall Hi-tem' are, more or less, the same as 'Newallastic' with the essential difference that they are made in steel possessing non-creep qualities.

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



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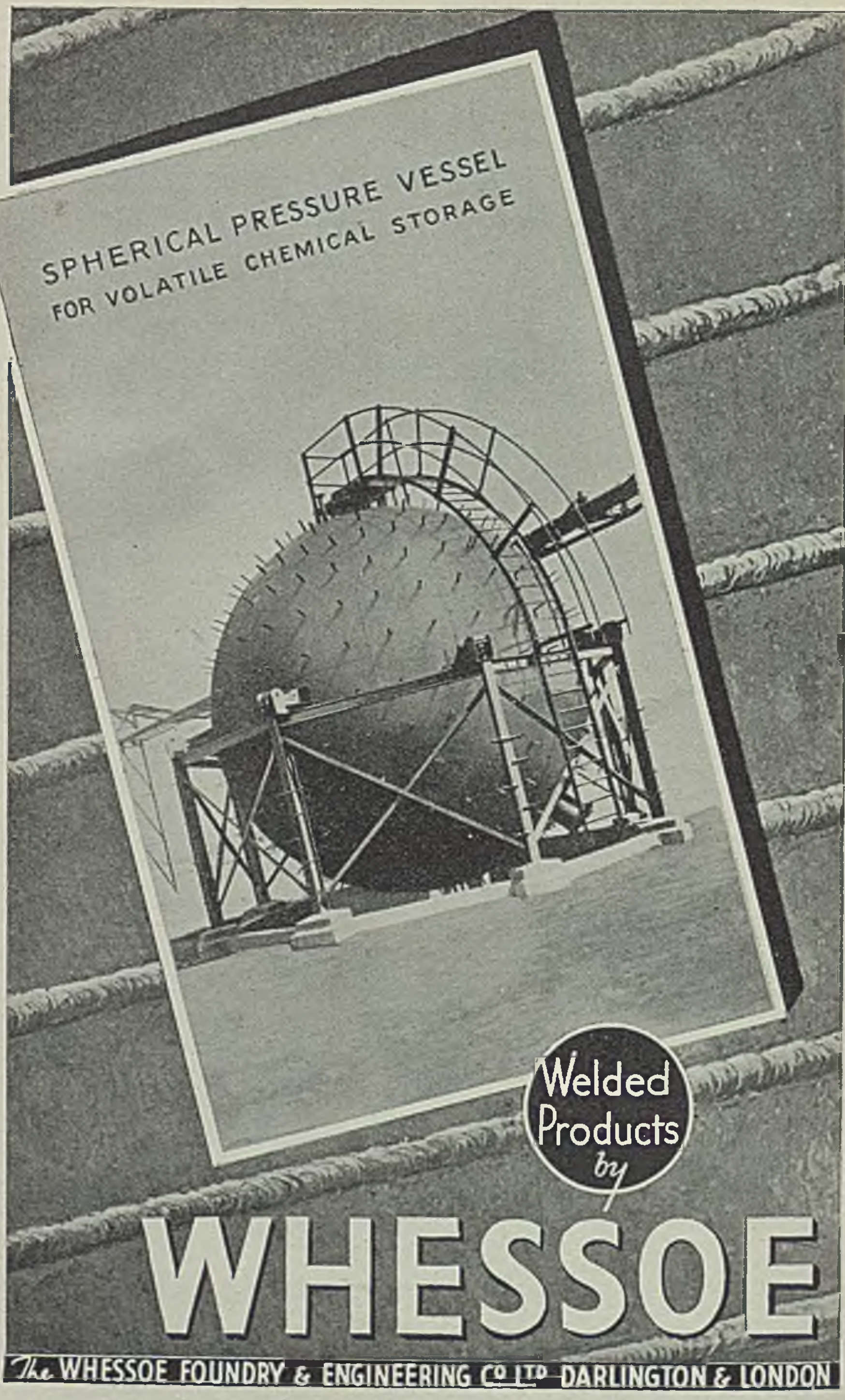
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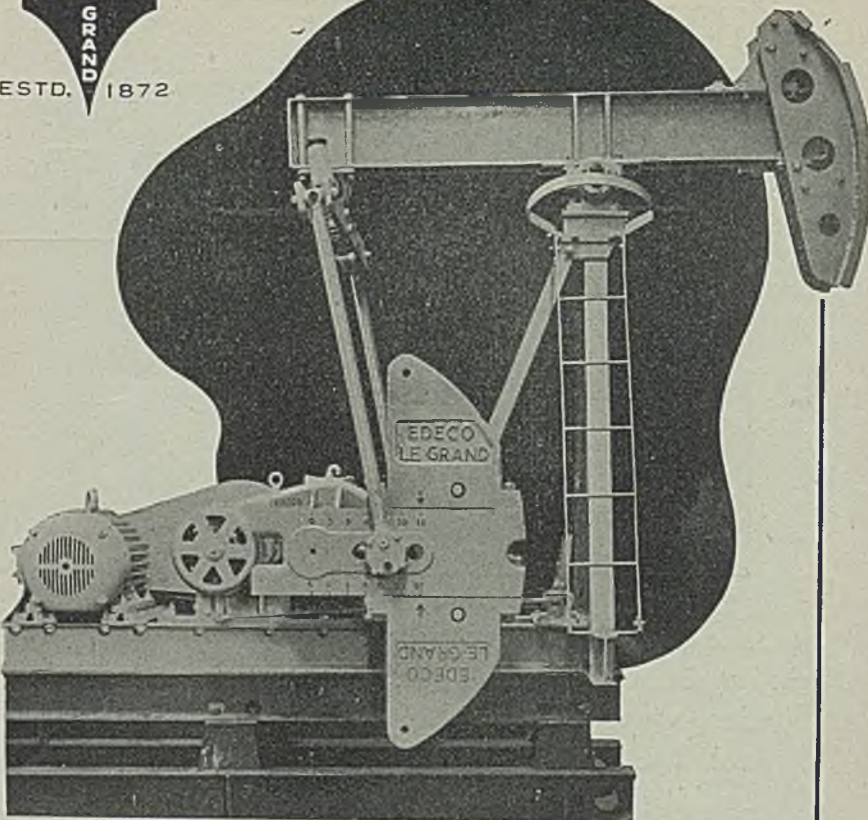

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