It will be seen that the magnification of the original harmonic in the tuning-fork circuit is enormous; in fact, if we assume that the harmonic is only a few microwatts to start with, the magnification is of the order of magnitude 10^{11} (one hundred thousand million times). Obviously the screening of each circuit from the more powerful one succeeding it in the chain is of the utmost importance and must be carried out thoroughly.

At Rugby the fork has a frequency of 2000 per second and can be slightly adjusted by the inertia effects of small set screws in the prongs. When the temperature in the fork box alters by 1° C. the frequency of the final oscillations changes from 16,000 to 16,001·5, an amount imperceptible in the ordinary receiving apparatus of wireless telegraphy. The advantages of constant frequency are many; but the principal one is that exceedingly selective receiving apparatus can be employed, and all the refinements of accurate note tuning can be utilised, in order to prevent interference by other wireless stations working on nearly the same wave-length.

The design of the high-frequency circuits has presented many problems. These circuits comprise an inductance coil and condensers forming a closed circuit, which is connected on one hand to the anodes of the bank of fifty-four triodes, and on the other hand excites the antenna by means of mutual inductance.

The condensers must withstand a quarter million volts, must pass a thousand amperes at high frequency, and must not cause appreciable loss of energy. Condensers using thoroughly dry and clean oil would probably be best, as oil has a power factor less than one-twentieth of one per cent.; but, in order to save space, mica condensers were adopted, and these have a power factor less than a quarter of one per cent. They weigh more than ten tons. They are carried on a partial flooring about 20 feet above the ground floor on which the triodes stand.

The high-frequency coils in the closed circuit and in the antenna are made of stranded cable containing 6561 separately insulated copper wires of 36 gauge made up by twisting in threes. The coils are of various sizes; the antenna tuning coil, for example, consists of five flat spirals of eight turns each, the outer turn of each spiral being 15 feet 6 inches in diameter. The total weight of the coils is about 6 tons. They are carried on great beams of fir 20 feet above the level of the condensers, and are flanked by flying galleries along which men can pass for inspecting and adjusting the coils. This isolated position is chosen for the coils because the inductive effects of the large high-frequency currents they carry might lead to great energy losses and even to destructive rises of temperature, if any metallic masses were near. The roof trusses, the beams, the supporting framework of the coils, are all of selected wood. The most suitable wood for this purpose, that is to say, the wood with the smallest dielectric loss at high frequencies, is American white wood—a discovery made after long and close investigation in the Post Office laboratories.

The features above described are only a small selection of the numerous novel details with which the station abounds. But the space available permits of no further descriptions. There is just room for a few remarks upon the performance of the station as judged by observers who happened to be listening in at great distances during the tests of the past few months. For example, Newfoundland reported "signals thundering in"; New York said "signals readable through heavy atmospheric and jamming" and "copyable at 75 words per minute"; Cape Town reported "note good and steady"; in the Red Sea "Rugby effectively drowns all interference"; Java reported "key action excellent, frequency very constant"; Dutch East Indies said "Rugby splendidly received, far more distinct than any other European station." The Commander-in-Chief of the China station stated "all ships report note good, clear and steady." Among other Australian stations, Sydney reported "Rugby was only European station readable through atmospherics." These results, it should be noted, have been obtained with less than the full power available. For up to this date only eight of the twelve masts have been utilised on these telegraphic tests, owing to the other four masts being temporarily set aside for the trans-Atlantic telephony trials. The eight mast aerial will take only about 600 amperes without exceeding a voltage of 200,000, and at this rate only about two-thirds of the possible high-frequency power is being drawn from the triodes. But the complete equipment will doubtless be required to ensure communication at all hours of the twenty-four and under severe conditions.

The Stratigraphical Value of Micro-organisms in Petroleum Exploration.

By Henry B. Milner.

During the last decade of rapid development of technique of petroleum geology, problems of sub-surface stratigraphical correlation have forced themselves to the front, and have engaged the closest attention of geologists operating principally in late Cretaceous and Tertiary oil-fields all over the world. Formerly, and to some extent now, drillers' recognition and classification of rock-chips collected either from bailer or sample box served as a crude guide to underground conditions, though the limited vocabulary and superficial petrological knowledge of the average driller led to some quaint determinations and technically to still more fanciful structural interpretations. 'Gumbo' and 'shell,' for example, cover a multitude of geological shortcomings, while clay, shale, silt, and sand vary in diagnosis largely according to their degree of wetness when they arrive at the surface; anything productive of white powder to the bit is termed 'chalk,' and so on. Such casual nomenclature and equally casual sampling has been part of the long-established code of the oil-well driller, and sufficed until the advent of a more exacting petroleum geology signified the impending and much-to-be-desired change.

The closer study of productive rocks and sub-surface structures concerned with the preservation of petroleum pools has gradually led to the adoption of

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refined methods of differentiating and correlating strata, and of actual zoning within given formations deep down in the earth's crust; to this end the geologist has been thrown back on his first principles for the requisite desiderata and the aid both of palæontological and petrological data invoked. The frequent divorce between surface and sub-surface structures has to a large extent influenced this trend of field-technique, so that to-day no geologist worthy of the name would dream of interpreting his key-structures on the basis of mere lithological comparison and description, and certainly not in terms of drillers' evidence.

There are four principal methods now employed for studying sub-surface deposits from samples; three are direct, namely, micro-palæontological, microscopical (the examination of rock-cuttings under the microscope), and petrographical (correlation by means of 'heavy' mineral residues extracted from the sediments); the indirect method is that based on comparison of chemical analyses of subterranean (often connate) waters peculiar to certain porous formations. Of these methods, micro-palæontological investigations theoretically take precedence, though in practice this is not always substantiated if the necessary organisms are rare or wanting; the other methods, while capable of considerable precision and accuracy in competent hands, can only be regarded as local and confirmatory, though they are none the less valuable on that account. We dismiss them here, however, in favour of the much-debated problem of the value of micro-organisms as indexes not only of formations, but also of the more restricted developments such as oil-sands.

For obvious reasons, the macro-organic content of oil-well samples is seldom preserved, however prolific the rocks may actually be in molluscan or brachiopodan faunas, etc., though the recent introduction of the core-barrel, and particularly the use of the diamond drill, tend to heighten the possibility of whole shells reaching the surface. For the most part, however, samples from wells are obtained in a comminuted state, so that whatever fragile remains may be originally enclosed in the rocks drilled through, these soon succumb to the drastic action of the cutting bit. Therefore only the initially minute organic bodies stand a chance of escaping disintegration, and consequently their presence in any sample is of paramount stratigraphical importance. The micro-organisms which have received most attention in the course of exploratory work for petroleum are the Foraminifera, Bryozoa, Ostracoda, Radiolaria, Diatomacea, in that order of interest and importance; sponge spicules and echinoderm spines have occasionally proved useful 'indicators.'

It will be at once apparent that, quite apart from a special aptitude for palæontological investigation, the study of these micro-organisms constitutes the work of the specialist; accuracy in diagnosis, dependent on an intimate knowledge of the organisms as regards their morphology and variations, precision in assigning species or groups of species to particular stratigraphical horizons, and vision in detecting the subtler steps in the evolutionary chains involved: all these, among others, are the qualifications for this type of research. Specialisation is to-day the essence of progressive palæontology; the tendency to resort to 'species splitting' is a concrete result of this intensive study, of which there exists no finer example than contemporary work on Ammonoidea, an example fast being emulated by those engaged with micro-organisms, especially the Foraminifera. If, in view of much recent criticism, such technical procedure stands in need of independent defence, the work of certain expert palæontologists engaged on micro-palæontological research for a purely commercial end, coupled with the measure of success already realised, surely provides some vindication.

The organised investigation of foraminiferal assemblages as a basis of zonal stratigraphy, particularly as applied to sub-surface exploration for oil, has derived considerable impetus, if it has not actually evolved, from the intensive work of American palæontologists, more especially those in the employ of oil companies operating in the Gulf Coast region of North America. Considering the comparatively short time taken in developing necessary technique and accumulating the data to work on, the results already achieved are as surprising as they are significant. It is not as though the Foraminifera claimed at the outset of this intensive work a long-established reference library: on the contrary, the literature was scanty compared with that of many other fossil faunas, though the study had at least the example of Chapman and the inspiration of Cushman to guide it. In this connexion Dr. Dumble has written of these palæontologists that they "had very little knowledge to start with and had to build up their own methods" . . . while another expert, Miss H. T. Kniker, now states, "Examination of thousands of well samples has shown which species have limited vertical ranges and therefore which forams can be relied on to make correct stratigraphic correlations. We have learned to do this even on single species, and all of our correlations are made in the main on undescribed forms."

On the other hand, Dr. T. W. Vaughan says that it "appears very doubtful if there is a zonal distinction" of value among the Foraminifera for the discrimination of geological horizons. Further, he says, "In any event, 25 per cent. is about the maximum percentage of the smaller Foraminifera to which any stratigraphic significance may be attached, and it is more probable that the significant percentage is between 3 and 12 . . . 88 to 97 per cent. of the fauna . . . does not possess zonal value. . . . From available evidence, similar faunas of small Foraminifera are indicative rather of similarity in ecologic conditions than of identity in age." This has, on the whole, been the attitude of European oil geologists and certain palæontologists, who have not hesitated to criticise Cushman for his "tendency to split species to a much greater degree than has been done by others," to which 'splitting' he attributes a large part of his success in stratigraphic correlations on the basis of Foraminifera.

Such scepticism as exists regarding the correlative value of Foraminifera finds root in the general impression of the wide space and time distribution of these organisms, and is legitimately maintained so long as we view them from the point of view of world-distribution and their general literature. Until recently, in the absence of local terms of reference such as those emanating from the Texas laboratories, a Cretaceous or Tertiary species of Foraminifer, if still living to-day

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in the sea, has naturally been regarded as worthless from the zonal or even correlative aspect, and thus has Schuchert sought to explain the critical attitude of Vaughan and others. The whole point of the detailed work, however, is its intensiveness, as is the case with petrographic research under similar conditions, and the fact that local assemblages, rather than precise species, constitute the basis of study; zoning is effected by recognition of slight variations in morphology, ornament, etc., by creating new species or new varieties much as in the case of the ammonites previously cited. The question of percentage of living Foraminifera in any faunule, a point on which Vaughan has laid some stress, is entirely subordinated by the specialists to the question of the actual species present and their manner of combination in any particular faunule. According to Cushman, "the time value of forams . . . is entirely dependent on this splitting (of species), for putting together species which are of short range into one long one would entirely defeat the purpose of close correlation."

Mesozoic and Cainozoic Bryozoa have long been recognised as important indexes of horizon, though in the Gulf Coast oil-field region they are of far less frequent occurrence than the Foraminifera. Schuchert has no doubt whatever regarding their true value for sub-surface correlation, and advocates strongly their use on the basis of Canu and Bassler's classical work. According to Bassler, of the two orders of Bryozoa, namely, Cyclostomata and Cheilostomata, the former has potentially little value in sub-surface work, from the fact that precise diagnosis rests on the preservation of the ovicell, almost an impossibility with oil-well samples. The Cheilostomata, however, can be determined from minute fragments and all characteristics can be ascertained, even though only a few individuals or zoœcia are preserved. They tend to indicate limited time-zones over wide areas, and various structures shown on the zoœcium are significant of depth of water, temperature, nature of ocean bottom and character of marine habitat. Add to this that the calcareous structures are generally highly ornate and variable in that ornament, and the possibility of treating them on the same intensive lines as the Foraminifera is apparent. Canu and Bassler describe 742 forms of North American Early Tertiary Bryozoa in their work, many of which are beautifully illustrated.

Ostracods, as we now realise from the Wealden formations of Great Britain, are potentially valuable as time-indicators, though here again much intensive work has yet to be done before they are fully appreciated. Analysis of well-cuttings from the Gulf Coast region reveals their presence and significance, and Schuchert has directed attention to the highly ornate forms of the valves of these minute crustacea, but the Texan species have yet to be worked out. Ulrich and Bassler have demonstrated their potentiality as guide-fossils to limited portions of certain American palæozoic formations, which research at least forms an adequate basis of future investigation.

In so far as Radiolaria, Diatomacea, sponge spicules and echinid spines are concerned in sub-surface work, at the present time we must regard them in much the same light as petrographers regard sporadically occurring mineral species in oil-well samples: of local and possibly direct differential or confirmatory value. As Schuchert says, "each worker must learn what local dependence can be placed upon these isolated occurrences."

Thus it is clear that while a degree of scepticism regarding the use of micro-organisms in stratigraphical correlation may still be maintained on certain technical grounds, the results so far achieved by the American school are worthy of general attention. It is yet one further example of how much the pure science may owe to one phase of its economic application. Readers are referred to the volumes of the American Association of Petroleum Geologists for 1924 and 1925 for several important papers in connexion with the above, and particularly to Schuchert's excellent summary of the subject in volume 8, 1924, pp. 539-553; these volumes are available for reference in the Science Library at South Kensington.

Sterility and Rejuvenation.

It has been known for a long time that the sexual activity and characteristics of the individual depend on the presence of the sexual glands in an actively functioning condition. Their removal or atrophy as in old age leads to loss of sexual vigour together with changes in the secondary sex characters which may result in the development of a neutral individual, or even in the assumption of certain of the characteristics of the opposite sex, according to the species studied.

Various methods have been used for supplementing a deficiency in the individual's own secretions, such as grafting glands from another member of the same or an allied species, the injection of extracts of the glands, and in males, the ligature of the duct which conveys the sperm from the testes to the urethra: the latter operation (vasoligation) has been performed on the assumptions that the secretions on which the secondary sex characters depend arise from the interstitial cells of the sex glands, and that ligature of the duct, by causing atrophy of the sperm-producing cells, will allow the interstitial cells to hypertrophy, owing to the increased space and nutriment provided. The return of the secondary sexual characteristics does not imply a return of fertility, since, for the latter, the sex glands themselves must be actively functioning *in situ*: that is, atrophied or diseased glands must be reactivated. Grafting alone, therefore, will not restore fertility, except, perhaps, in the case of the female, unless the animal's own sex glands are also reactivated or rejuvenated by means of the secretions from the graft.

Sterility in the female can be caused not only by atrophy (or removal) of the ovaries, but also by persistence of the corpora lutea. During pregnancy these bodies persist and prevent ovulation, and occasionally this occurs apart from pregnancy as a pathological phenomenon and produces sterility, fertility being restored by their removal. It is of interest, in connexion with recent work on the isolation of an

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