Square, W.C.; on the expiration of the lease of these less convenient premises, a fund was raised by private subscription among members and others, and the present building was erected in 1914-15.

Another side of the Institute's activities is concerned with the maintenance of a strict code of professional conduct, with professional status, and matters germane to appointments in the public service. An appointments register is largely used by members and prospective employers, and a benevolent fund has been instituted so that temporary assistance can be given in case of need. The usefulness of the Institute is also apparent in the organisation, both at headquarters and at local sections, of lectures on matters of professional interest, and in the publication of "Official Chemical Appointments" (a directory) and the registrar's useful guide entitled "The Profession of Chemistry." "Chemistry as a Career" is the title of a booklet containing a synopsis of lectures given by the registrar before college chemical societies during 1921-23. These books convey a warning as well as encouragement, for they clearly indicate that only a certain type of mind or personality can hope to attain even minor eminence, that material rewards are seldom of the richest and often of the poorest, and that real devotion to the

spirit of service and inquiry is both expected and exhibited.

Although the variety and importance of the services which the chemist renders to the community are even now but inadequately realised, the Institute of Chemistry has thus done much to define, to explain, and to improve his position in both public and private practice; it has equally endeavoured at all times to assist His Majesty's Government in matters on which chemistry has a bearing, and in return the work and qualifications of the Institute have been in a large measure recognised by the State. At the time of its foundation, few universities and colleges provided satisfactory preparation for the profession of chemistry; indeed, it is difficult to realise what the position to-day would have been had this contribution to the development of systematic chemical education been withheld, and had no attempt been made to bring together in one body those who practise in a calling which is now acknowledged to be so vital to the progress of the civilised world. The strength and the future influence of the Institute will be fostered by the continued loyal co-operation of its fellows and associates in the maintenance of their own status and in the protection of such of the interests of humanity as are specially within their knowledge.

Belief and Evidence in Water Divining.

By Dr. HUGH ROBERT MILL.

AT the Public Works, Roads, and Transport Congress recently held in the Agricultural Hall, Islington, the subject of water divining was introduced by Prof. J. W. Gregory, who read a paper setting forth the admitted facts and stating his own reasoned judgment with the candour and conviction of an experienced man of science sure of his ground and satisfied with his conclusions. So frankly did he acknowledge the widespread popular faith in the use of the divining-rod as a means of finding water that the writer of a leading article on dowsers and doubters in the *Times* of Nov. 25 appears to class him amongst the believers. Prof. Gregory, however, developed the case against the dowsers with a convincing moderation and clarity of reasoning, and in the issue of Dec. 2 he stated that his paper showed "that the evidence of all the controlled experimental tests in England of which I know is against water or oil . . . divining."

This important paper may be summarised as follows. The literature of the subject is enormous, and Prof. Gregory, who appears by his citations to have been exceptionally well read in it, does not claim to have read one-hundredth part of what has been written. He relies largely on the recent book on the divining-rod by Sir William Barrett and Mr. Besterman, but brings much personal experience to supplement it. He points out that while at one time the expenses of a water-diviner employed by a public body were surcharged on the members, recent decisions have allowed the cost to be met from public funds, and a diviner

has even been employed in the crypt of St. Paul's Cathedral to seek for the water channels below the foundations.

The cause of the movements of the divining-rod may be explained in one of three ways: (1) by fraud and practical jokes; (2) by unconscious imposture; (3) by some actual force which acts on the rod directly or indirectly. This third view Prof. Gregory was at one time inclined to share, believing that the diviner might possess some idiosyncrasy in virtue of which he might be affected by slight sharply contrasted differences of moisture in the atmosphere, but he abandoned it because it would not explain the response of the divining-rod to things other than water, and would not account for water-diviners obtaining results in rain; moreover, it was dismissed as improbable by three eminent physiologists whom he consulted.

There are three rival lines of explanation: (1) that the rod responds to some physical stimulus, possibly allied to radioactivity, as upheld by M. Henri Mager. As such matters were remote from Prof. Gregory's own province he submitted Mager's book "Les Baguettes" (1920) to Prof. Desch, who found that its arguments did not furnish any support for the view that the diviners have any powers of detecting water or minerals. Mager's claims were also dismissed as extravagant and absurd by the U.S. Geological Survey; (2) that the movement of the rod is due, though perhaps unconsciously, to the diviner. This is the view elaborated by Barrett and Besterman, who

dismiss the evidence for an external physical force by arguments which seem unanswerable. Their claim is that the diviner has a sort of second sight, the evidence for which is on a par with that brought forward by spiritualists for their alleged clairvoyance; (3) that the diviner unconsciously or subconsciously moves the rod owing to an impulse due to unintentional suggestion from the bystanders or by his recognition of indications favourable for water. The process of subconscious movement of the rod by the dowser is explained by Dr. Millais Culpin in his "Spiritualism and the New Psychology" (1920), as an example of the dissociation of the various streams of activity which flow side by side in the human brain, and Prof. Gregory considers that some of the best dowsers, like Mullins, probably act by this process, giving expression to the results of long experience or special quickness of perception of signs of water at the surface.

Prof. Gregory goes on to examine the evidence as collected in Barrett and Besterman's book in order to determine which of these conflicting explanations is the most reasonable, and he deals in turn with a series of experiments on which the authors of that book relied as examples of the triumphs of the dowsers over the geologists as water finders. His decision is that the happy selection of the sites in the four cases considered was in accordance with common sense and did not require cryptesthesia. He cites a number of independent tests of the powers claimed by water-diviners, and shows that both geological surveys and individuals have on many occasions proved the inadequacy of the claims made. Similar tests with regard to dowsing for mineral oil were equally negative. It is pointed out that testing the divining-rod is difficult and promises no answer that will be universally accepted because the claims of different diviners are so contradictory and elusive that any test may apply only to the individual tested, and perhaps to him only on a particular day. It is pointed out that in the case of the Abbé Paramelle, claimed by Barrett and Besterman as a diviner who did not use a rod, the Abbé's own explanation that he found water by studying the indications of the surface is perfectly satisfactory.

As regards the nature of divining, Prof. Gregory says that the successful water-diviner is probably a quick observer who has usually had considerable experience in the search for water, and as he goes over the ground he probably recognises clues to the presence of underground water which subconsciously lead to movements of the strained muscles of the hands holding the rod. In some cases such an experienced dowser will probably score no higher a proportion of successes than a competent geological expert would do, while in other cases the reputation of the diviner is made by lucky coincidences which are remembered and exaggerated while the failures are forgotten. It is concluded that although the claims of the divining-rod are invalid, an expert diviner may be useful under some conditions.

The outcome of Prof. Gregory's discussion seems to be that the use of the divining-rod is a survival of primitive magic, and that there is no reason to suspect the existence of unrecognised properties of matter or power of mind from the experiences and performances of dowsers. From the point of view of the geologist it seems both reasonable and right to decide that further investigation of the divining-rod is waste of time and that his special knowledge can be of more service to the advancement of science if applied in other directions. Nevertheless, there are other points of view, and recent advances in physical and psychical science may enable a keen and cautious investigator to reach some more positive conclusion than the evidence now available justifies. Instead of taking as the subject of study the exploits of the expert dowser who has an axe to grind, or of the amateur enthusiast who has a theory to uphold, might it not be better to try some simple person who, while not using it for pay or reputation, is possessed of the gift—if gift it be—of finding a divining-rod turn in his hands in the neighbourhood of underground water?

Stress is usually laid on the erratic or even contradictory results of many of the experimental tests which have been made, as opposed to the certain and repeatable results of scientific demonstrations. But scientific demonstrations of this kind only become possible when all the conditions are known and are under control. Is this yet possible in the measurement of perception? If not, may not indications be found sometimes which indicate true relationships, though on a second attempt the demonstration may fail utterly? Every listener to distant broadcasting stations knows that for a week at a time he may pick up Cork every night and fail to find Belfast once, whereas at another time, though using exactly the same settings and the same battery strength, he may hear Belfast every evening and never get Cork at all. My view is that the facts which have been proved as to water divining are deserving from the strictly scientific point of view of as full and specialised attention as are the facts relating to electric waves. It would be very satisfactory if it could be established that Prof. Gregory's belief is correct and that the water-diviner succeeds by his quick, even if unconscious, recognition of surface signs that may escape the ordinary observer. It would be equally satisfactory if it could be shown that the nervous system is capable of detecting radiations of a different frequency from those of light and heat, and that water, and perhaps other substances, may emit such radiations at ordinary temperatures. The one suggestion does not seem to be intrinsically more improbable than the other. The research would of course be very difficult, and the first-class minds which alone could pursue it to a satisfactory conclusion can probably devote themselves to much more productive investigations at the present time.

If there is anything in these phenomena, the discovery will undoubtedly be made in the fullness of time, possibly many years hence; but meanwhile,

it is at least satisfactory to find that attention is being paid to things which are involved in such baffling perplexity that the easiest course is to look the difficulty steadily in the face and pass by. When the investigator emerges who is able and willing to tackle the problem, he must not be afraid of finding results which his present knowledge may lead him to think as absurd as the properties of radium seemed before they were discovered.

In the course of correspondence in the *Times*, induced by the article on dowzers and doubters already referred to, Mr. A. A. Campbell Swinton outlined in the issue of Nov. 30 a scheme of in-

vestigation which he suggested might be taken up by the National Physical Laboratory. He proposes the construction of an underground channel through which a controlled supply of water might be allowed to flow or percolate in such a manner that the fact of sensitiveness to the presence of water could be tested and, if found, the rate of transmission of the impulse from the water to the dowser might be measured. If this suggestion were acted upon, a committee, which would satisfy both the credulous and the sceptical, could no doubt be brought together to arrange details of the tests.

The Use of Radio-Elements as Indicators.¹

By Prof. FRITZ PANETH.

THE use of radio-elements as indicators is a special chapter of radioactive investigation, which differs from the topics usually treated under the name of radioactive research, in so far that the radio-elements are here not the object of the study, but are used as a mere agent in the solution of problems which in general have nothing to do with radioactivity at all. These problems may be found in very different branches of chemistry, physics, and even biology, and it is to be expected that radio-elements as indicators will be more used the more familiar the advantages of this method become to non-radiologists.

Only an elementary knowledge of the principles of radioactivity is necessary in order to understand and even to apply the method. It is based upon the extreme sensitivity of radioactive measurements, and upon the chemical relations of the radio-elements to ordinary elements.

As to the first point, it is well known that by help of an electroscope, invisible and imponderable quantities of radioactive matter can be detected and exactly measured. From the radio-element thorium *C*, for example, which can very frequently be used as an indicator, 10^{-17} gm. allows for exact qualitative and quantitative determination. Now thorium *C* is 'isotopic' with ordinary bismuth. Since isotopes show identical chemical properties, it is possible to substitute the radio-element for its inactive isotope, and to acquire information concerning the element in extremely dilute solutions. The chemical behaviour of bismuth may thus be elucidated by a study of thorium *C*. In certain cases it is found advantageous to mix a certain amount of the radio-element with a sample of the inactive element in order that an otherwise indeterminable fraction of the original quantity may be detected or determined electroscoically. Instances in which such minute fractions of an element have been separated by some such process as diffusion, solution, or volatilisation, are discussed below. By choice of

the appropriate ratio between the quantities of inactive element and radio-element in the sample, it is possible to cover the entire range of mixtures from those detectable only by means of the electroscope to those containing readily weighable amounts of material.

In selecting a radio-element for use as an indicator, it is generally desirable to find one that may be detected in very small amounts. It must be borne in mind, however, that the half-value period (*T*) varies inversely with the intensity of radiation, and that an element detectable in small quantities invariably has a short half-value period. It would therefore never be feasible to employ radium *C'* (*T* = 10^{-7} seconds) or thorium *C'* (*T* = 10^{-11} seconds) as indicators. Even the three indicators available for the element thallium are too short-lived for a number of experiments.

For this reason it is not practicable to use all of the elements included in the well-known lists of radioactive isotopes for the present purpose. Only the elements named in the following table can find practical application. Those to be recommended most highly are underlined in the table.

Even radio-elements such as ionium, uranium *X*₁, and uranium *X*₂, which possess no inactive isotopes, frequently are of service in increasing the radioactive intensity of their longer-lived, less active, and therefore less readily detectable radioactive isotopes. Uranium *X*₁, for example, is mentioned in the table as a satisfactory indicator for thorium. So also, thorium *X* may be used as indicator for radium, and radium *A* for polonium. But radium and polonium themselves may in a broader way be employed as indicators in certain lines of work. For, in the narrower sense, the function of the radio-elements 'as indicators' may be conceived to be restricted to those experiments in which the radio-elements are substituted for their active or inactive isotopes. In the broader sense, however, this function may be extended to cover any procedure in which the radio-element is used as an instrument in the detection, determination, or investigation of matter in minute quantities.

A brief account of some examples, where radio-

¹ From an address delivered to the Bedson Club, Newcastle-upon-Tyne, on Mar. 17, 1927. A fuller discussion of the subject in English by the same author, with references to the literature, will shortly appear in Volume 2 of the Baker Lectures, delivered by non-resident lecturers at Cornell University (Ithaca, N.Y.). For literature, see also G. Hevesy and F. Paneth, "Manual of Radioactivity" (Oxford, 1926).