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THE PROBLEM OF WATER DIVINING

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There are many people in almost every country of the world who claim that a divining rod or some such indicator will move in their hands as they walk along and cross the path of an underground " stream ".

Claims are made that oil or minerals can likewise be found or that the path of a missing person can be followed. Still other claims relate to medical diagnosis and the selection of suitable animals for breeding purposes.

The form of the indicator used by different diviners varies from a forked twig to pieces of bent wire or a pendulum. A few diviners dispense with an indicator altogether and claim to divine by changing sensations in their bodies.

Water divining is probably the most popular form of this practice. Elaborate techniques are used to estimate the depth and quality of underground water from the number of times the rod moves or the " strength " of its turning.

Is divining nothing but a remnant of a magical practice from a superstitious age? The widespread belief that there is some truth in the claims of diviners makes it important that scientific investigations should be made either to substantiate or refute these claims.

In this review of some of the important investigations of divining phenomena an attempt has been made to evaluate the evidence at hand.

FIG. 1. Sixteenth century woodcut showing diviners in action. A–Twig, B–Trench.

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THE ORIGINS OF DIVINING.

The origin of divining is lost in antiquity, but it probably had its beginnings in primitive religious practices. The first recorded use of the divining rod specifically for locating underground objects was in the Harz Mountains of Germany about the year 1430. In 1518 Martin Luther included the use of the rod in his list of acts which break the first commandment.

In 1556 Agricola discussed divining at some length in his book, *De Re Metallica.* He observed that since the rod does not move in the hands of all men there cannot be any specific affinity between the object of the search and the rod. The phenomenon must be due to some quality of the diviner himself.

Towards the end of the eighteenth century water divining (or dowsing as it is sometimes called) had considerable attention focused on it from academic circles and the general public, particularly in France and England. Theological circles continued to frown upon the practice as being devil-inspired.

In the last decade of the nineteenth century Prof. (later Sir William) Barrett, Professor of Physics at the Royal College of Science, Ireland, attempted a " scientific " study of the phenomenon of water divining. The book published in 1926 by Barrett and Besterman—*The Divining Rod*—is one of the most important references on the subject. A bibliography relating to water divining now contains many hundreds of titles from almost every country of the world.

A survey conducted a few years ago by the Melbourne University School of Agriculture showed that in the Western District of Victoria 37 per cent. of graziers believed in water divining, 47 per cent. placed no faith in it as a method of locating underground water, and 21 per cent. were uncertain on the subject.

In a survey in the U.S.A. (Hyman and Vogt, 1958) it was found that about 25,000 professional diviners are currently practising. Many " divining experts " have made considerable sums of money for performing their feats. A fee of ten pounds per bore site is quite usual in Australia, while in the U.S.A. people pay up to one hundred dollars or more for a diviner to locate one bore site. Other diviners consider their power to be God-given and do not charge for their services.

Water Diviners and Geology.

Before any interpretation of the phenomenon of water divining can be attempted, widespread misconceptions about the occurrence of underground water must be considered in the light of the established facts of hydrogeology.

It is commonly believed that all underground water flows in " streams " or " rivers ". Examples are cited of quite fast-flowing underground rivers in caverns formed in limestone. Such water courses have been formed by water moving along narrow joints and crevices in the limestone and enlarging these spaces by dissolving the rock over long periods of time. Limestone is much more soluable than most other types of rock, especially in water containing dissolved carbon dioxide. Nevertheless the conditions for cavern formation are met with only in certain circumstances in limestone above the water table—that level in the rock beneath which all the available spaces between the rock particles are occupied by water. So underground rivers are very much the exception rather than the rule for the movement of underground water.

All underground water is derived initially from rain-water (with the exception of sea-water trapped in marine sediments or condensed water vapour from volcanoes). Some of the rain-water runs off the land surface into rivers and lakes while some is evaporated or transpired from the soil by plant life. A variable proportion of the rain-water, depending on local conditions, seeps down under the influence of gravity through the soil to the underlying rocks. Here it lies in the minute pores between mineral grains or, in older and more consolidated rocks, in narrow joints and fractures. In general, underground water does not move in rivers as water does at the land surface, but rather in these very restricted spaces through rocks which are porous and permeable or fractured.

Large areas of Australia are occupied by artesian basins. In such basins rain-water seeps underground in certain areas called intake areas, where highly permeable rocks are found at the surface. The water then seeps down as in a sponge and may pass beneath other rocks which are relatively impermeable. Often these rock strata dip down towards the centre of an artesian basin so that water in the permeable stratum, the aquifer, is under pressure as it moves further beneath the impermeable stratum, the aquiclude. Such aquifers and aquicludes may cover areas of hundreds or even thousands of square miles in an artesian basin. Several aquifers may occur one below the other with aquicludes between them. (See Fig. 2.)

When a bore penetrates the aquiclude the pressure in the aquifer forces water up the bore until it reaches an equilibrium or static level. This level may be above the land surface, in which case the water will flow freely from the bore, or it may be below the land surface in which case the water must be pumped from the bore.

In most areas where relatively porous and permeable rocks occur near the surface the underground water is not under pressure beneath an aquiclude, but rather maintains its own static level which coincides with the water table. The water table may cut the land surface, as in the case of springs,

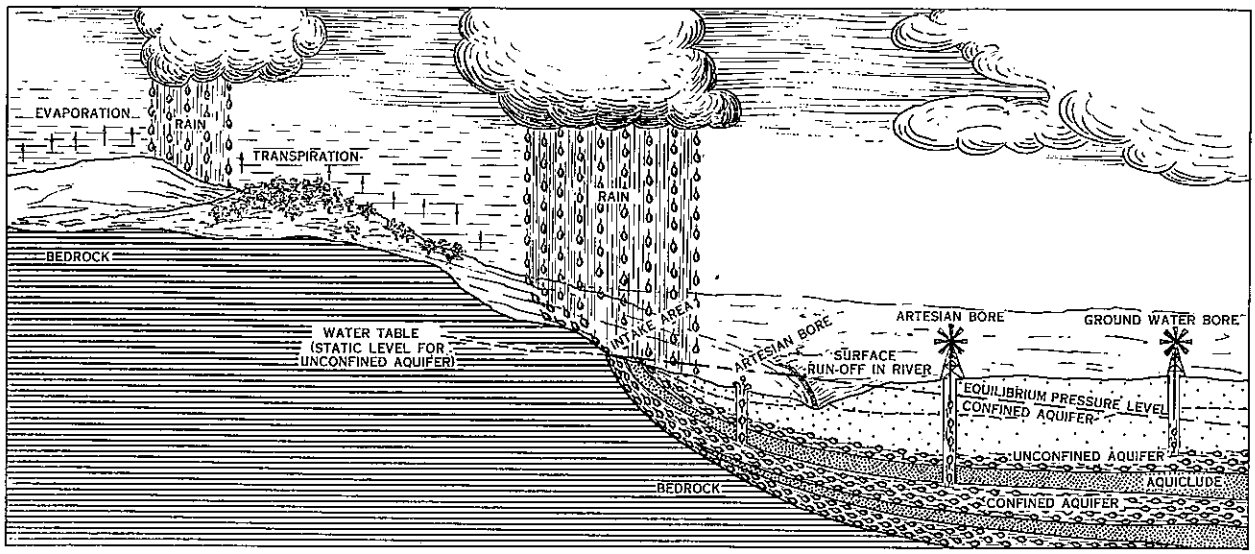

FIG. 2. The hydrological cycle.

or it may be at a depth of a hundred or more feet, depending on the rainfall and the nature of the country.

Non-pressure ground water is derived from rainwater which has fallen in the neighbourhood of the bore where it is found. Artesian water, on the other hand, may travel hundreds of miles from an intake area provided suitable strata dip downwards for such great distances. The rate of travel of underground water may be extremely slow—as little as a few inches or feet per year.

Whether a bore will yield underground water, either free-flowing or by pumping, depends on whether it passes into a zone of permeable rocks which have considerable quantities of water stored in them and which can conduct other water from rocks further away to replenish the store as it is diminished. It is possible to put down a " dry " bore. Even though all the rocks beneath the water table are saturated with water their permeability may be so low that virtually no water flows from them or the rate of flow may be too slow to be useful for practical purposes. This may occur, for instance, in clays which are highly porous (possibly containing 45 per cent. by volume of water), but which do not allow the water to flow between the pores. The problem of finding underground water therefore resolves itself into the problem of locating permeable rocks suitably situated beneath the water table. These rocks may vary from sands, gravels and limestones to fractured and jointed rocks such as slates, quartzites and granites, or porous and permeable zones of volcanic rocks such as basalt.

Conditions of sedimentation prevailing when the rocks of an artesian basin were laid down often varied over wide areas and at different times in geological history. Fine-grained sediments such as clays may be formed in one particular area whereas coarse sands or limestones may be deposited elsewhere at the same level in the sedimentary basin. The hydrogeologist from his knowledge of rock variations and their characteristics may relate this information to the quantity of water which a bore could yield. To do this he must have local geological information from surface mapping and bores on which to base his ideas about the occurrence of underground water in any area.

When a water diviner predicts as a result of movements of his dividing rod that an underground " stream " 15 feet wide is to be found at a depth of 200 feet at a particular site, he is trying to interpret his divining reaction in terms which usually do not apply to the geological conditions of the area. Perhaps he is attempting to locate narrow zones of highly permeable rocks in between impermeable rocks at the same depth. In practice the geological conditions envisaged would seldom be restricted to such a narrow zone (except perhaps in deep leads buried in old valleys by flows, or extensive shear zones in hard rocks).

Attempts to Prove Water Diviners' Claims.

Disregarding the problem of interpreting diviners' statements about the occurrence of underground water in terms of the facts of hydrogeology, let us consider the simple prediction of the diviner—that a bore sunk at a particular site will yield considerable quantities of underground water. If a bore later sunk at that site does yield large quantities of water what evidence does this provide that the diviner " found " it ?

Unfortunately, this type of evidence, in which a bore at a divined site either yields underground water in considerable quantity or fails to yield water as predicted, is all too often the only evidence

advanced to prove or disprove the efficacy of water divining. If the diviner's prediction was correct then he must certainly have some unusual power. If his prediction proves to be wrong then he must have made one of his few mistakes, or the weather was not suitable, or somebody shifted the peg marking the divined site before the bore was sunk, or the diviner was a fraud. So runs the popular discussion on the subject. Very seldom is anything like a controlled experiment carried out to provide evidence for water divining.

In 1899 Sir William Barrett carried out an experiment in which the following precautions were considered necessary to prove the existence of the phenomenon of water divining :—

1. The place chosen for the experiment must be entirely unfamiliar to the diviner.
2. The persons who accompany the diviner should be ignorant of the geology of the district, so that no knowledge could be unconsciously conveyed to him.
3. The diviner must not know beforehand where the experiment was to be conducted.
4. The diviner must be taken to the selected place immediately on arrival in the neighbourhood to avoid possible questioning of the local inhabitants.
5. The geological nature of the selected site should be such that the diviner could not guess at a glance where underground water might be found and should not be a place where the diviner could not be wrong in any prediction, i.e. either uniformly water-bearing or waterless.

The experiment was carried out in County Wicklow, Ireland, with the diviner William Stone, who had achieved widespread fame. Stone used a slender forked twig and divined several sites. His predictions were found on later boring to be quite accurate in that the region where he said water was flowing from north to south did have several successful bores sunk in it. At another site away from this region he said there would be little water and this was later proved correct, too. Barrett concluded that he had carried out an experiment " which conclusively proves the reality of dowsing ".

This is a good example of a man of high academic esteem in one branch of science drawing quite fallacious conclusions from experiments in another branch of science with which he is not familiar. Barrett had been convinced of the reality of divining by the results of many diviners' apparent successes and so was tempted to draw the conclusion which suited his existing theory rather than carefully consider the validity of the experimental facts.

Prof. Cole, Professor of Geology at the Royal College of Science, Ireland, reported that the experiment had been carried out in an ancient valley cut in slates and quartzites which were non-water-bearing, but with water-bearing glacial deposits now filling much of the valley. It was in these glacial deposits indicated by a shallow hollow at the surface that Stone had successfully located water. The prediction about non-water-bearing rocks was on the higher area of slates and quartzites.

It is therefore clear that anybody who had had even a little to do with water boring would tend to select bore sites in the shallow valley even if there was no geological evidence of the underlying rocks. Barrett explains this away by saying that Stone had chosen sites away from the centre of the valley where one would expect to select them and so was not paying any attention to the topography or surface indication of underlying rocks.

The experiment certainly does not prove the efficacy of water divining for one of Barrett's controls (No. 5 above) was not adequate. There was no way of determining the success which one could expect as a result of chance selection of bore-sites or selection based on intelligent guesswork so that these results could be compared with those of the diviner.

If in a given area the chance of putting down a successful bore is 80 per cent. (defining " successful " in terms of a certain volume of water per hour for a given bore diameter and steady pumping level over a sustained testing period), then many diviners may be found to predict correctly that bores will be successful. On the other hand, if the chance of being successful in a random selection of bore sites is only 10 per cent., then very few diviners may be found to predict correctly. That is, until we know what are the chances of obtaining underground water by random selection of bore sites in an area for which there are no surface indications of variations in the underlying rocks then there is no way of proving that the diviner has used any special faculty in finding water if he is successful.

As well as many stories of apparent success for diviners in selecting bore sites in uncontrolled experiments there are many instances in the history of divining of the failure of diviners to locate underground water. It has been noted that where the chances of success in locating bore sites is high the diviners' successes are numerous, but wherever there is little useful underground water the diviners' success is very much less. If there is any truth in the claims of diviners then they should tend to get similar results in all areas where they claim to get movements of their divining rods.

Because of the widespread occurrence of underground water it is usually easier to show that diviners' selections of bore sites are often wrong

by drilling where a diviner has predicted that there would be no water. Take, for instance, the example of a district where 80 per cent. of bores selected on a random basis are likely to prove successful. A diviner may then be 80 per cent. correct if he predicts bores will be successful at divined sites. This success may be sufficient to prove to himself at least that he has some special ability in locating underground water. However, if in the same district the diviner tries to predict which bore sites will prove to be failures, on later drilling he may only be correct in about 20 per cent. of his predictions. In fact many bores which diviners have predicted would be dry have yielded excellent supplies of water.

There is a notable tendency among diviners to ignore such failures or explain them in terms of uncontrolled variables such as interference from pipes or cables, bad weather, or even the presence of hostile witnesses. It is the apparent successes, which in certain areas must by random selection of bore sites be frequent of which we are constantly reminded by the diviners' supporters.

Some diviners have claimed remarkable success where geologists have failed to locate underground water. If this were a consistent trend it would certainly be a worth-while achievement, but only isolated instances are referred to. It must be understood that the water-bearing capacity of some rocks, particularly fractured and jointed rocks which are lithified, is difficult to predict because of its variability in any one area. It is in these rocks particularly that geologists may not be able to locate underground water any more successfully than would be achieved by chance. However, it is useless to compare the results of diviners against those of geologists or chance selection of bore sites in which only a few bores are involved ; to obtain statistical significance the comparison must involve hundreds of bores in many different areas and under different geological conditions. Preferably, different diviners working under conditions which do not interfere with their supposed ability should be employed.

New South Wales Water Conservation and Irrigation Commission Records of Drilling From 1918 to 1943.

The New South Wales Water Conservation and Irrigation Commission sank 3,581 bores between 1918 and 1943 for settlers in the central part of the State where the rainfall varies from 15 inches to about 30 inches per annum.

The settlers were not influenced by the Commission in the fixing of bore sites. Some settlers made their own selection, locating bores primarily where the water was required for use. Other settlers employed water diviners to select the sites. The drilling foreman reported before the bore was sunk whether the site had been divined or not. The published records of this drilling are as follows (Ward, L. K., 1946) :—

Classification of Boreholes.	Divined.		Not Divined!	
	Number Drilled.	Per Cent.	Number Drilled.	Per Cent.
Bores in which supplies of 100 gallons or more per hour of serviceable water were obtained	1,284	70·5	1,475	83·8
Bores in which supplies of less than 100 gallons per hour of serviceable water were obtained	184	10·1	93	5·3
Bores in which supplies of unserviceable water were obtained	87	4·7	60	3·5
Bores in which no water was obtained	268	14·7	131	7·4
Total	1,823	100·0	1,758	100·0

These statistics meet some of the conditions necessary for comparing the results of water diviners against those of chance.

The records cover a large number of wells spread fairly evenly over a large area of central New South Wales in which 51 per cent. of the sites were divined and 49 per cent. were not divined. It is presumed that many diviners were involved in this work over 25 years, although the exact number is not known. In no case were the diviners under close scientific scrutiny when they selected the bore sites. Failures could hardly be attributed to poor working conditions since the diviners selected sites when and how it suited them.

The results show that the percentage of bores which yielded appreciable quantities of water was considerably higher at sites chosen at random or by intelligent guesswork than at sites selected by diviners. The percentage of bores in which no water was obtained was twice as high for divined sites as it was for non-divined sites.

From these results it would seem that diviners succeed less often than they would by chance alone. This raises a difficulty in the interpretation of these

statistics. The area embracing the boreholes lies partly within an artesian basin where the risk of failure at any bore site is comparatively low, and partly in an area of consolidated Palaeozoic sediments where the risk of failure with bores is somewhat higher. It is not known how the divined and non-divined sites were distributed with regard to these different geological conditions. It may be surmised that settlers would tend to resort to diviners for bore-site selection when the likelihood of failure in their particular district was significant as shown by adjoining bores. In areas where very few bores have been failures there is a marked tendency, as noted in different parts of the world, for farmers to select bore sites on the basis of where the water is to be used without paying regard to water diviners. This tendency could account, in some measure at least, for the considerably poorer results obtained by diviners than settlers who selected bore sites at random or by intelligent guessing.

What is of great significance in these statistics is the fact that in about 15 per cent. of the cases when diviners claimed to have rods move or to have other indications of water as they walked across the countryside subsequent drilling proved their claims to be false. The 85 per cent. of the cases in which they were apparently successful can probably all be explained in terms of chance or intelligent guesswork alone. The diviners may not even get results as good as those of intelligent guesswork.

These results surely demonstrate that, whatever interpretation one may place on the movements of rods in diviners' hands, divining is not a very efficient way of finding underground water. It would be wrong to allow people, through ignorance of these facts to continue to pay considerable sums of money to diviners who believe that they possess some magical and infallible way of discovering underground water.

Why is Belief in Water Divining so Widespread?

There seems good reason to doubt most if not all of the claims of water diviners yet belief in divining has been widespread for many centuries among many different races of people. We must therefore attempt to find an explanation for the persistence of this belief.

The occurrence and movements of underground water are very poorly understood in most sections of the community. Geologists are frequently surprised to hear even highly educated and technically qualified people from other branches of science talking in the most misleading terms about underground water. Superstitions can persist more readily when they concern matters about which most people are ignorant.

We have already noted that in areas where the success of bores is fairly certain, divining is less commonly believed in. It is those areas where the success of a bore in supplying water for farm needs is less certain that diviners are most active, especially in times of drought.

The diviner is commonly a person full of confidence in his own ability to find water and well able to convince the farmer who is in doubt about the success of a bore on his property. The diviner may charge £10 for locating one bore site, but this is only a small proportion of the cost of a bore 100 feet deep with a pump—which could amount to more than £300. The farmer may be tempted to employ a water diviner who claims 100 per cent. success, believing that there may be some truth in the diviner's claims and that it will not add much to the cost to find out. The diviner also removes the responsibility of locating the bore-site from the farmer's shoulders and so can be used as a scapegoat if the bore proves to be a failure.

Some diviners give added reassurance to the farmer by giving him a written guarantee concerning the quality of water to be struck. In one area of the eastern Wimmera Region of Victoria where the quality of underground water is generally poor a diviner of widespread fame guaranteed that the water struck would contain total dissolved solids amounting to less than twenty parts per 1000 (i.e. 20,000 parts per million). The farmer was impressed by this without realizing that water containing 20,000 parts per million of dissolved solids would be useless for farm purposes. Such water would be considerably more saline than water from another bore already on the property which was known to be useless. The diviner could hardly lose on such a guarantee.

When a diviner is proved wrong by subsequent drilling at a site which he has selected he often cannot be found in the district to explain his failure. This fact was prominent in the summer of 1950–51 in south-western Victoria where some areas do not have good supplies of water from underground. A diviner, who claimed in the local press that he "never failed", divined several sites during a drought on the basis of a cash divining fee and an additional fee if the bore proved successful. He continued his divining activities in the area until the first few bores had been drilled to depths considerably in excess of those predicted without striking useful supplies of water—then he moved from the district.

Some staunch believers in divining go to extraordinary lengths to excuse a failure on the part of a diviner. We have noted earlier how diviners explain their failures in terms of "interference" from fences, underground cables, bad weather, and so on. In the same district of the Wimmera Region as was mentioned above one farmer in 1958 was prepared to say that one of his personal enemies must have moved the gin bottle which marked the bore site selected by the diviner when subsequent

drilling proved him wrong. The diviner was re-called to re-locate the " stream " which was supposed to be only a few yards wide. When a second bore was sunk at a new site divined 23 ft. 6 in. from the first and still no useful water was struck, belief in divining must surely have waned in that district.

Perhaps the most important reason for the persistence of the belief in divining is a fact which some people, including many geologists who investigate divining phenomena, fail to appreciate, the fact that many quite sincere people do have rods move in their hands while they walk along concentrating on the object to be divined.

There are many examples in the literature and from known personal experiences, of people who, without conscious deception, have found that the divining rod moves in their hands. Quite often such people have been sceptical about divining until it is suggested that they try to see if the rod moves for them, and to their amazement it does. Accounts of such events are too widespread to be lightly put aside as conscious deception. The difficulty is that once such a person observes the rod move without his conscious effort he usually accepts all the jargon about the coincidence of these movements with the presence of underground " streams " and becomes a convinced water diviner.

What has been indicated above is that the movements of diviners' rods do not necessarily indicate the presence of underground water and that, as a method of locating underground water, divining produces no better results than intelligent guesswork.

What Makes the Diviner's Rod Move ?

The theories which have been advanced over the centuries to explain the movements of diviners' rods and to correlate these movements with the proximity of underground water, oil, minerals or the tracks of people, have been many and varied. These theories fall into four main categories which we may briefly discuss.

1. *Deliberate deception.*

Some people have claimed that all diviners deceive their onlookers by consciously contracting their forearm muscles and so causing the divining rod to move. Although this may explain some diviners' activities it is doubtful whether fraud alone could explain the persistence of the belief in divining for so long among many different people.

It has been suggested that the movements of divining rods may be due to the difficulty experienced in preventing the rod moving to some extent as the diviner walks along. Divining rods are usually held in awkward positions which may increase this difficulty and cause relatively large movements of the rod with slight changes in the position of the arms.

It seems unlikely that this explanation alone can account for all the movements of divining rods. Prof. Sommer, a psychologist in the University of Gieszeer (Germany) has shown that changes in the state of contraction of the forearm muscles begin before the divining rod starts to move (Tromp, 1949). The muscle contractions appear to initiate the movement and are not a consequence of it. In some diviners this first movement of the rod is followed immediately by a much stronger contraction of the forearm muscles in which auto-suggestion appears to play a large part.

This does not mean that the movements are all a figment of the diviner's imagination, but that the movements are brought about quite unconsciously. If there is much deception involved it would appear to be self-deception in the interpretation of the causes of the muscle contractions, rather than the fact that they sometimes do occur.

2. *Physical interaction between the divining rod and the object being divined.*

Various forms of this theory have existed in some circles since the earliest times of divining. It is clearly quite incompatible with the facts claimed by most diviners. Some diviners do not use a rod or indicator at all, but simply divine by changing sensations in their bodies. Others divine from maps or aerial photographs which could hardly represent the physical nature of the object divined so as to interact with the rod. The rod does not move unless the diviner is concentrating specifically on the subject—so there must be a psychological factor involved. The rod will not move if the diviner's arms and hands are firmly held.

Agricola observed as early as 1556 that the phenomenon is due to some quality of the diviner and that the indicator is only a dispensible mechanism for registering arm movements. By demonstrating this fact, however, we do not explain the phenomenon for we must still determine what causes the unconscious contractions of forearm muscles under these circumstances.

3. *Interaction between various physical forces and the diviner's body.*

In this category are some of the most weird and illogical ideas of " pseudo-science ", employing the latest scientific terms out of context and without justification to explain the movements of the diviner's rod.

One such " pseudo-scientific " theory is that expounded by A. A. Cook in his book, *The Natural Science of the Divining Rod.* This theory states that all bodies, living and non-living, give off " radial waves ", a sort of electromagnetic radiation, the " frequency " and " polarity " of which depend on their source.

Cook carried pieces of coloured cloth representing the wave-length of the object sought or samples of the object itself which enabled him to " tune " himself into the specific wave-length of " radial waves " and so trace them to their origin. It is unfortunately true that some ill-informed people accept such a theory because of its apparent scientific authority. In fact, there is not one sound piece of evidence on which to base Cook's elaborate theory.

Other people have claimed that it is electric currents produced by the movement of underground water through rocks or variations in the earth's magnetic field which the sensitive diviner can detect. It is suggested that the variations in field strength cause excitation of the forearm muscles directly or stimulate some special sense organ in the body. Tromp (1949) carried out experiments to determine whether minute changes in magnetic or electric fields could in fact be detected by diviners. He found that in laboratory experiments the most sensitive diviners might be able to detect variations in magnetic fields only if they were at least 100 times greater than those occurring at places where the diviner's rod had turned in field trials. Similarly, quite large voltages were required to give contractions of forearm muscles when applied directly to electrodes on the skin. The diviner's rod had turned in places where there was no such stimulus.

From these experiments and the general body of physiological knowledge it seems most unlikely that direct stimulation of muscles or nerves by variations in magnetic or electric field strengths can explain the divining phenomenon.

4. *Psychological and psychic theories.*

There are many aspects of diviners' reactions which can be adequately explained only in terms of a psychological theory. We have seen how psychological factors are often said to play a big part in the success or failure of divining, especially the presence of hostile witnesses or the disposition of the diviner at the time—a fact which indicates that auto-suggestion may be important in divining reactions.

We have also seen how the diviner's rod only moves when he is concentrating on the subject and how the same movements may occur as a result of concentrating on different subjects at different times. Some diviners claim that they get the usual movements of their indicators over maps and photographs which could not represent the countryside or the particular subject represented in any way but symbolically.

This is not to say that all such diviners are frauds for suggestion can influence behaviour very strongly in most of us. This fact has been demonstrated many times when the firm suggestion has been given to an audience in a suitable psychological " atmosphere " that when they clasp their hands together they will not be able to pull them apart however hard they try. Most people are incredulous when they find that they must await further suggestions before they can in fact pull their hands apart.

Long-continued suggestions that the divining rod will move of its own accord, when received in a suitable psychological state, can probably explain all of the strong muscle contractions which many diviners experience after the divining rod first begins to move. The initial movement may in some cases be due to the difficulty in holding the rod quite steady as the diviner walks along. We have already noted, however, that the initial muscle contractions may precede the turning of the rod.

Tromp (1949) observed physiological changes in the electrical properties of the skin on the palms of the hands during divining reactions. These changes are due to the so-called psychogalvanic reflex, in which sweat gland activity is altered rapidly when the person undergoes even a slight emotional reaction or change of attention. Such changes depend on a certain novelty in the stimulus to catch the attention and do not persist once the same stimulus has been repeated many times. One is usually not aware of such changes and cannot consciously control them.

The general state of contraction of muscles can also be unconsciously controlled, although by different nerve fibres from sweat gland activity. The electrical properties of the skin, as well as muscle " tone ", pulse rate, the depth and rate of breathing, the state of contraction of the walls of small blood vessels in the skin, and several other physiological parameters have been extensively studied by psychologists as indicators of psychological states in people.

Showing relaxed subjects a series of photographs depicting such scenes as a group of football players, yachts on a harbour, a starving man in a loin cloth, or a geometrical abstraction, produces physiological responses characterized by increased muscular tension, activation of palmar sweating, development of a slower, larger pulse, constriction of blood vessels in the skin, and a relative inhibition of breathing. The responses are usually quite small so that they often go unnoticed by the subjects. However, a particular scene may arouse a more obvious response in certain subjects (Davis, R. C., and Buchwald, A., 1957).

Similarly, with auditory stimulation consisting of a noise from an electric buzzer, subjects who are instructed to relax and not to react to the buzzer, involuntarily undergo increased muscle tension as measured by the frequency of nerve impulses recorded electrically over the muscles of their arms when the buzzer sounds. The muscle tension response shows a latent period of about 0·1 seconds and lasts for about 0·5 seconds. An interesting feature of this experiment is that the size of the

FIG. 3. Leicester Gataker dowsing with his bare hands.

response is proportional to the state of tension in the muscles before the auditory stimulus is delivered. If the forearms are tensed before the buzzer sounds the increase in muscle tension is much greater (Davis, R. C., 1948).

The muscle " tone " of certain people, when in a state of expectation with their forearms tensed and hands gripping a divining rod, may undergo unusually large changes in response to a sudden shift of attention. Under certain circumstances this change may cause a slight movement of the divining rod, regardless of whether the stimulus which catches the diviner's attention is visual, auditory or simply a whim of his subconscious mind. Certain visual stimuli, such as the nature of the country or the presence of a patch of green grass, may subconsciously be given the status of clues to the whereabouts of underground water and arouse a minor emotional reaction in the diviner. Auto-suggestion may then bring about the more vigorous muscle contractions which many diviners experience.

Such a theory as is outlined above to explain the initial movement of the divining rod can also explain the sensations of those diviners who use no indicator but simply divine by changing sensations within their bodies. It is true that some people feel quite strong sensations in their skin or abdomen in the same way that all of us undergo minor changes in certain physiological parameters as a result of sudden shifts of attention or emotional reaction.

At the beginning of this century Sir William Barrett proposed a " cryptesthetic " theory of divining in which a suggestion is received by the diviners subconscious mind " by means of a sensibility as yet unknown to us ". This suggestion then causes involuntary muscle contractions which are indicated by the rod held in such a way that slight contractions of the forearm muscles will cause a considerable movement of the rod. Barrett claimed that the unknown " sensibility " was closely related to clairvoyancy and others since have tried to relate water divining to extra-sensory perception of some kind or other.

Experiments with Henry Gross, an American diviner, showed that although he recorded divining reactions over some concealed jars with which he was being tested, he was unable to distinguish between jars containing water and those which did not (Gardner). Even if after many thousands of trials Gross should demonstrate some ability to reflect jars containing water which could not readily be explained by chance and which suggested that some form of extra-sensory perception was involved, this would not explain why the divining rod moved in the cases when he was wrong in the trials.

There seems to be no way of distinguishing the very few cases when the possibility of extra-sensory perception in locating objects could not be overlooked from the much more frequent cases in which the movement of a divining rod has no significant meaning at all. Such movements can occur in the usual manner as a result of psychological stimuli which bear no more than a fortuitous relationship in the unconscious mind of the diviner to the object being sought.

CONCLUSIONS.

We may conclude from the available evidence that the movement of the divining rod is due to involuntary muscular activity in the arms of the diviner. The initial stage of this movement may be due to slight changes of " tone " in the diviner's tensed arm muscles when, in a state of strong expectation, he undergoes any slight emotional reaction or sudden shift of attention. Certain stimuli such as the sight of a patch of green grass or the nature of the terrain may subconsciously act as clues to the whereabouts of underground water and so have some emotional significance to the diviner who is diligently searching for water. Slight changes in muscle " tone " can occur without the diviner being aware of them. The later stage of the movement of the divining rod, in which there may be more vigorous muscle contractions, is probably due solely to auto-suggestion once the rod begins to undergo some movement.

What has been clearly demonstrated is that divining cannot be upheld as an efficient means of locating underground water and that movements of the diviner's rod do not necessarily indicate the presence of underground water. The apparent success of a water diviner can be adequately explained in terms of chance or intelligent guesswork.

Continued and extended studies of hydrogeology and a greater understanding by the community of the occurrence of underground water are of the greatest necessity in the future development of our underground water resources. The further study of divining, however, must be the responsibility of psychologists and physiologists, rather than geologists.

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