Transactions of the Royal Society of Edinburgh: Earth Sciences, **89**, 1–9, 1998

Dowsing physics: interferometry

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ABSTRACT. Interferometry, a technique widely used in physics to study radiation fields, has been applied to the investigation of dowsing. Pairs of horizontal linear components, typically some metres in length and a metre or so apart, and parallel in a vertical plane, produce patterns of lines that can be mapped by dowsing rods. The lines are parallel to each other and to the components, and are equally spaced. The spacing of the lines depends on the length, separation and composition of the components. The existence of the patterns shows that the dowsing field is wave radiation. Since there is no detectable difference between patterns produced by pairs of components made of good electrical conductors such as copper, and those produced by good insulators such as uPVC, it is concluded that the radiation field is not electromagnetic. Furthermore, aluminium and tin behave differently from copper and steel. The spacing of the lines has been found to depend on time of year. It increases rapidly in late April and falls rapidly in late November; in between these times it appears to be relatively stable except for an isolated maximum in early March. It shows a high degree of repeatability from year to year.

KEY WORDS: bio-location, radiation, field, interferometer, detectors, electromagnetic, conductors, insulators, fringes, charge, excitation, decay, time.

Dowsing is a long-established technique used worldwide for finding underground structures, having been used for several centuries at least to locate mineral veins and water. Although Agricola (1556) is believed to have provided the first published account of it, Kemlo (1995) points out that the first recorded case in this millenium dates from AD 1430 in a surveyor's record of a German silver mine, where it was used to locate new mineral veins. It is still used extensively for that purpose, especially in eastern Europe where it is called bio-location, but the range of applications has greatly increased (Dubrov 1993).

In Britain alone, many thousands of people working on estates, farms and building sites use dowsing in the course of their work. It is commonly used to locate field drains, water and gas supply pipes, and electricity and telephone cables. Many professional dowsers are employed for similar purposes under contract to utility companies; others—often professional engineers—have set up their own resource exploration companies. It is used with success also in archaeology (Bailey *et al.* 1988) and in geology (Mills 1994).

For such people, dowsing is a proven technique that brings practical benefits. It was the location of a blocked drain by a neighbour that first provided a demonstration of dowsing to the present writer, and led him to make experiments which showed that the phenomenon can be investigated by interferometry. This is a method by which waves in any medium are caused by suitable apparatus to interact with each other and to create patterns. Familiar examples to the non-scientist are harmony in music (sound waves) and the popple caused by crossing patterns of ripples on a pond (water waves). Physicists and astronomers use it with light and radio waves. This paper reports on its use to investigate the dowsing field. It has been found that the field depends on time, and on the geometry and materials of the interferometers; but first a brief description will be given of the dowsing detector rods and their use in this particular application.

1. Detectors

Various hand-held devices are used in dowsing. If the reader is tempted at this point to dismiss the research as inevitably too subjective, three matters should be borne in mind.

Firstly, in order to replace the subjective detector systems currently in use by one that eliminates the human element from the detection process, and that is one of the primary objectives of present research, it is necessary to discover the nature of the field involved in dowsing. It is unlikely that this can be done without using the presently available detectors.

Secondly, it should not be forgotten that much valuable astronomy and astrophysics was carried out in the last two centuries and the first half of this century using a very subjective detector system: the eye. The scientific community did not wait for the development of photographic and photoelectric detectors before seeking to understand the nature of the Universe.

Thirdly, every detector has a sensitivity threshold. For a stimulus above the threshold, the question arises as to whether the detector just detects its presence, or does more than that and measures its strength; and in the latter case how accurate is the measurement. The design and the analysis of results of experiments must take into account the limitations of the detectors. This is a common situation in experimental physics and applies, neither more nor less, to dowsing interferometry.

To return to the matter in hand, the design and use of dowsing detector rods: perhaps the most familiar image to the general public is that of the water diviner with a Y-shaped hazel stick. However, by far the most common device, and the one generally used for the location of pipes and cables, consists of a pair of L-shaped rods that can be of any material but are usually metal. The short part of the L forms the handle. Typically, this will be 15 cm or more in length, the long part of the L being 30–40 cm. Commonly available materials (especially on farms and building sites) are wire or rod with diameters ranging from about 1 mm to 3 mm, e.g. galvanised steel fencing wire, copper cable, brazing rod (alloy). Heavier rods may be less sensitive, but also less susceptible to interference and to wind.

The rods are held with the handles vertical and the long parts parallel and pointing forwards. They are usually held directly in the hands, some friction being desirable to prevent spurious rotation due to unsteadiness or to wind. However, those effects cause both rods to rotate in the same sense, whereas the dowsing effect causes them to rotate in opposite senses. Rods mounted in tubes or bearings give more sensitivity, and some professional dowsers have developed quite sophisticated arrangements, one at least having been patented.

Repeatability is the essence of experimental physics, and for those who may wish to repeat any of the experiments to be described, precise details of the way the detector rods are held and used are important. With the thumb upright, the rod handle/tube is held vertical along a line from the ball of the thumb to the base of the palm, emerging between the bottom of the little finger and the wrist. All the fingers are wrapped round to hold it firmly, with the first finger just below the horizontal part of the rod. The rods should be held with the hands comfortably close to the shoulders, elbows close to the sides of the body, but relaxed. Each rod should be tilted so that the main length slopes downward a little away from the body, giving a slight self-centring effect (like the castor angle on a car), but when swaying slightly from side to side both rods should swing easily and stay roughly parallel.

In use, walk slowly and steadily taking short steps: less than a shoe length; concentrate on keeping the hands absolutely steady; practice across known underground drains, pipes and cables until confident that meaningful rotations of the rods are being regularly obtained. Real dowsing rotations are usually surprisingly positive and fairly sudden. As the detector rods are carried across the line of an underground linear structure, or close to an isolated object, they rotate towards each other.

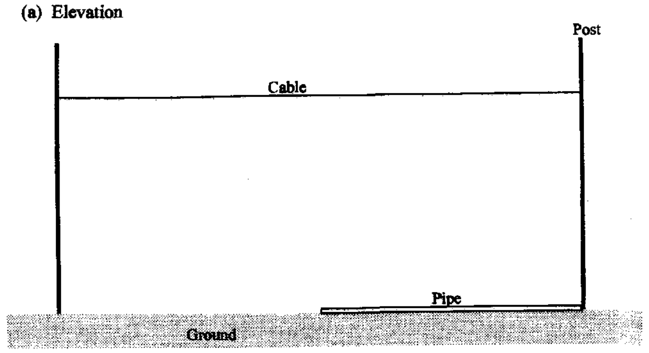
2. Interferometers

2.1. Introduction

Although dowsing is used extensively to locate underground structures, it appears not to be so widely known that the detector rods rotate also when carried across the line of an overhead structure such as a cable, where the term 'cable' is used in the general (nautical) sense not necessarily implying an electrical conductor. Furthermore, the loci of detector rod rotations in the neighbourhood of vertically disposed pairs of parallel horizontal linear structures map a pattern of lines parallel to those structures (Reddish 1993) (Fig. 1). The spacing of these lines changes as the geometry or material of the structures is changed. The patterns are familiar to physicists as those produced by constructive interference resulting from interaction between structures and a radiation field. Consequently they provide a means of investigating the dowsing phenomenon by techniques well established in physics. Interferometers are widely used in optical and radio astronomy.

Dowsing interferometers are simple and inexpensive to build. It is much easier to instal and to change an overhead cable than an underground structure, so all interferometers used for the experiments described in this publication have used above-ground structures. A particularly important feature is that they can be reproduced easily by others. Measurements of the spacings of the interference fringes provide numerical data, with standard errors derived from repetition. Since the interference fringes are invisible, accurate repetition leaves no doubt about the reality of the dowsing detection.

(a) Elevation



(b) Plan

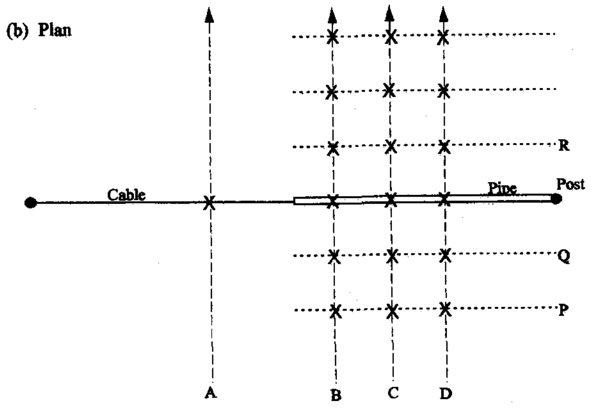


Figure 1 A dowsing interferometer showing the interference fringes and how they are measured: (a) elevation view; (b) plan view. When the dowsing rods are carried under the cable along track A, they rotate only below the cable. When they are carried along tracks B, C, D ... across the pipe and under the cable, they rotate at regular intervals forming a pattern of lines P, Q, R ... etc. The spacing of the lines depends on the length of the pipe and the material of which it is made. The presence of the interference pattern is evidence that the linear structures interact with a radiation field to create standing waves.

2.2. The perpendicularity effect

When dowsing detector rods are carried across the line of an overhead linear structure such as a cable, erected over level ground, they rotate when the carrier is vertically below (Reddish 1993); note that repeated experiments have shown that in all cases it is the position of the carrier's feet on the ground, not of the rods in his hands, that determines the location. However, when a cable is erected over steeply sloping ground, the detector rods rotate not vertically below the cable but where the perpendicular from the cable to the ground meets the ground (Fig. 2(a)). The effect has been confirmed by further experiments, in which a walkway that could be tilted to various angles was placed beneath the overhead cable (Fig. 2(b)).

On smooth level ground, the perpendicular coincides with the vertical, but if the ground is irregular the perpendiculars are dispersed to an extent depending on the degree of irregularity. Consequently, it is to be expected that the interference fringes produced by a two-component interferometer constructed on irregular ground will be widened by small irregularities and distorted by large ones. This is confirmed in the following subsection.

2.3. Interferometers in practice

The actual interference fringes produced by an interferometer of the type shown in Figure 1 are illustrated in the diagrammatic map given in Figure 3. The site, which is in a remote area of the Scottish Central Highlands and was used for all the large-scale outdoor interferometry described in this publication, is rough grassland. It is grazed intermittently, sheltered from the most frequent winds by woodland to the S and W, and has a few scattered trees, tree stumps and boulders in the open area used for the interferometers. There is a very gradual slope of about one arc degree, N-wards to the shore of a loch. The interferometers are erected roughly E–W. Despite its disadvantages, it has the important advantage of there being no existing underground pipes or cables or overhead cables in an area of several hectares, that could interfere with the experiments.

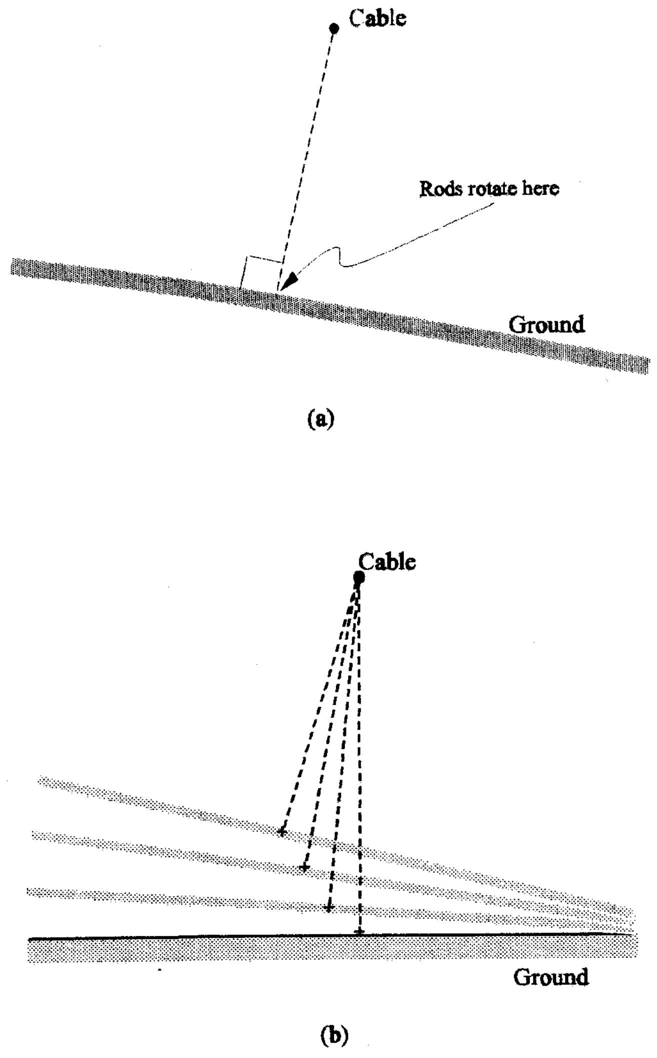


Figure 2 (a) When a cable is erected over sloping ground (shown in cross-section), the detector rods rotate not vertically below the cable but where the perpendicular from the cable meets the ground; (b) this is confirmed by using a walkway with an adjustable inclination.

Figure 3 shows that large-scale irregularities, and isolated structures such as trees and tree stumps, cause the fringes to be substantially distorted. The differences between positions obtained walking from the cable, and walking towards the cable, probably give a measure of fringe width and are shown by different symbols. The best track, in the sense that it produces the best agreement between the individual measurements and the mean straight lines, and also the least differences between measurements made outwards and back, is marked 'usual track' and is the one used for all measurements given subsequently. It is the most smooth and level, and furthest from large irregularities.

Interference patterns consisting of parallel straight lines have obvious advantages in measurement and analysis, and therefore types of interferometer that produce them (in ideal conditions) have been preferred. The overhead structure, usually a cable as previously defined, is here referred to as the primary component because it generally remains fixed throughout a series of measurements during which the other, parallel, component (frequently a length of pipe on the ground or another cable) is changed in length, position or composition from one set of measurements of the interference pattern to the next. This parallel component is consequently referred to as the secondary component.

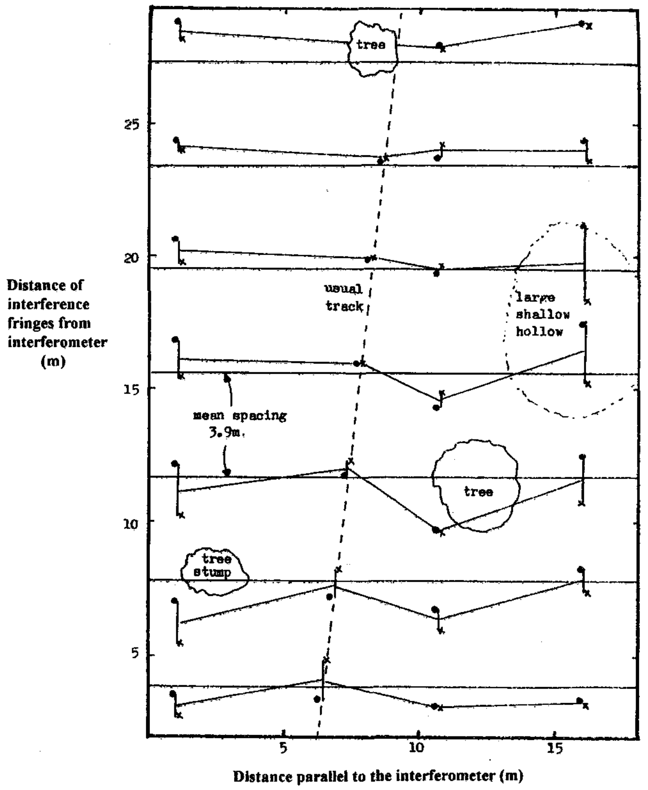


Figure 3 Plan of interference pattern produced by the interferometer discussed in subsection 2·3, showing distortion and widening of interference fringes by ground objects and surface irregularities. Primary component: overhead cable, 1·0 mm-diameter single-strand copper cable sheathed in 3·8 mm diameter PVC; length 21 m, height 4·3 m. Secondary component: 18 m of 50 mm-diameter polythene pipe laid on the ground parallel to and vertically below the cable. Crosses mark the positions of detector rod rotations walking outwards; filled circles those walking back.

Besides this large-scale outdoor interferometer, several other types of interferometer have been developed and used. They will be described briefly here, and in detail in later sections where results obtained with all the interferometers are given.

A second type of interferometer uses the same primary component, but the large fixed secondary is replaced by a small one, half a metre or less in length, carried by any suitable means transversely above the detector rods and hence parallel to the primary (Reddish 1993). It maps out patterns similar to those in Figures 1 and 3, but has the advantage of making it possible to investigate the behaviour of a much larger range of materials because of the small quantities required, and can be used immediately with any existing primary component.

The weather is a limitation in two ways. Wind affects the detector rods directly, and the rotations are noticeably weaker when the ground is wet. Wet and windy weather is not infrequent in Highland areas, and sometimes one may wait weeks for conditions suitable for prolonged experiments; all too often they are stopped before completion. A demonstration by C. M. Humphries (pers. comm.) that two-component

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dowsing interferometers of a smaller scale can be constructed and used effectively indoors was consequently an important advance, making it possible to carry out experiments in laboratory conditions regardless of the weather. This has proved to be particularly significant in the investigation of time-dependent effects. These compact interferometers were at first horizontal parallel pairs of cables in a vertical or horizontal plane, three or four metres long and about two metres above the ground; but several variations have been developed, including rotating interferometers, and some small enough to carry in a brief case.

Encouragement was also given by R. C. Jennison (pers. comm.) who described dowsing experiments he had made indoors.

2.4. Pattern decay

When one of the two components of the interferometer is removed, the constructive interference will stop and it was to be expected that the fringe pattern would disappear instantly; this did not happen; it faded over a period of half an hour or more; see Table 1. The average distance between rotations of the rods before the PVC pipe was removed is 4·8 m, with an rms dispersion ±0·5, the standard error of the average being ±0·25. The same figures are found for the averages after the PVC pipe was removed, showing that the spacing of the interference fringes did not change as the strength of the effect declined. Note that it took about 30 minutes for the pattern to decay to a level at which it was not detectable except for the innermost fringe, and that the outermost fringes decayed first, indicating that they may be the weakest.

These experiments suggest the possibility that there is a ground charge or excitation of some kind, produced by the fields that result from the constructive interference, and which takes time to decay.

2.5. Setting up procedures

2.5.1. Time between changes. The pattern decay effect (subsection 2.4) makes it clear that sufficient time must be allowed, after making any change to the interferometer, for the previous pattern to decay completely and the new one to become fully established. The example given in Table 2 below shows that several hours may be needed for a set of measurements with one configuration of the interferometer.

Note that the conduit used for the secondary in this and the experiments described later was 'said to be' polythene when purchased. Recent experiments indicate that it may not have been, but that it is not PVC either.

In the example in Table 2, the new fringe spacing had not fully stabilised until 2 hours 45 minutes after the change in the configuration of the interferometer. The pattern does not simply change smoothly from the old to the new. Instabilities, sometimes involving the doubling of individual fringes, occur before the new pattern is fully established and measurements are accurately repeatable. Therefore repeated measurements not only give standard errors, but are necessary to ensure that the new interferometer pattern is fully established and stable.

Table 2 Date 22 April 1996. Primary component: overhead cable, single-strand copper wire, diameter 1·0 mm, sheathed in PVC to a total diameter of 3·8 mm, length 21 m, height 4·3 m. Secondary component: polythene conduit on the ground, parallel to and vertically below the primary component, diameter 50 mm. Measurements are distances of detector rod rotations in metres from the plane of the interferometer. Successive rows in pairs are measurements made outwards and back.

Time							
1200	Secondary component increased in length from 12 m to 18 m.						
1235	0	3·0	6·3	9·8	13·9	18·7	24·1 metres
1245	0	7·0	11·9	15·8	20·3	24·8	
1430	0	6·4	11·4	17·1	23·5		
1435	0	6·8	12·6	18·6	24·1		
1440	0	6·3	12·3	18·1	25·0		
1445	0	6·2	12·2	18·9	24·9		

2.5.2. Accuracy of setting up. The interferometer must be set up with adequate precision. The sensitivity of the fringe spacing to tilt of the plane containing the two linear components is much greater than might have been expected. This was found in the course of an attempt to try to understand how the interference pattern is produced.

Most physicists' immediate response to an interference pattern produced by two components is to think of Young's double slit interferometer, but that produces fringes equally spaced in a plane parallel to that containing the slits, whereas a dowsing interferometer with vertically separated components produces fringes equally spaced on the ground, in a plane perpendicular to the plane containing the two components. A form of interferometer that does produce fringes equally spaced in the perpendicular plane is that due to Wiener (1890), where plane parallel waves are reflected back upon themselves. If that was the sort of interference occurring in the dowsing interferometer, the fringe spacing should increase as Secθ when the plane of the interferometer is tilted θ from the vertical (on level ground). It seemed to be a useful experiment to perform. The result was unexpected and of critical importance to achieving accurate dowsing interferometry.

The experiment was carried out twice using the interferometer in Figure 3, each time with a different secondary component on the ground (see figure captions for component details). θ was varied by lateral displacement of the secondary.

In each case, the spacing of the rod rotations was measured along the usual track (Fig. 3), outward and back in accordance with the procedures advised in subsection 2.5.3. Each time the lateral displacement was changed, a period of about an hour was allowed for the new interference pattern to become fully established before the measurements were made.

Table 1 (reproduced from Reddish 1993, pp. 19–20). Primary component: overhead cable, copper wire 1·0 mm diameter, PVC sheathed, length 20 m, height 2·5 m. Secondary component: PVC tube, laid on ground parallel to and vertically below overhead cable, length 4 m, diameter 20 mm. The table gives the distances in metres from the line of the tube and overhead cable at which the rods rotate. There was some difficulty at times due to wind.

Time	14·00	14·05	14·10	14·15	14·20	15·37	15·38	15·44	15·50	15·58	16·05	16·08	
Means													*Means*
24·2	24·6	23·1	24·2	24·5	24·4		24·2	24·1	23·7	weak	gone	gone	24·0
19·4	19·4	18·3	19·8	19·4	20·1	PVC	18·2	19·5	19·7	20·0	19·8?	gone	19·3
15·5	14·5	13·9	15·5	14·7	15·7	pipe	14·5	14·9	14·2	15·1		gone	14·7
10·3	9·9	9·2	10·6	10·6	11·1	removed	9·6	8·8	8·4	9·8	12?	gone	9·2
5·5	5·8	4·6	5·9	6·0	5·3		5·3	4·4	4·2	5·5	5·75	6·0	5·2

The results are given in Figure 4. Especially in the case of the polythene conduit, they display an extraordinary sensitivity of the fringe spacing to lateral displacement of the secondary component. A displacement of only a few centimetres—a rotation of the plane by about one arc degree—produces a measurable effect. Consequently, it is not sufficient to place the secondary component on the ground where it appears to be vertically below the primary component; it is necessary to measure the vertical exactly (or, in the case of sloping ground, the perpendicular).

The results explain in part why earlier experiments had not always repeated as well as was to be expected from the internal errors, but the relationship between fringe spacing and tilt is far from the Secθ dependence that might have been expected. It will be referred to again when we consider the results obtained with rotating interferometers.

2.5.3. Measurement procedures. The practice has been adopted of making one set of measurements of the positions of the fringes walking outwards from the interferometer and another set walking back, for intercomparison. On the outward measurements, a marker is put down each time the detector rods rotate, and at the end of the set, the distance of each marker from the interferometer is measured and recorded. The markers (and the measuring tape if it is readable from eye level) are removed, and the procedure repeated walking back, there being no evidence of where the fringes were on the outward measurements. These sets of outward and back measurements are repeated as necessary until they are in sufficient agreement and stable, see Table 2.

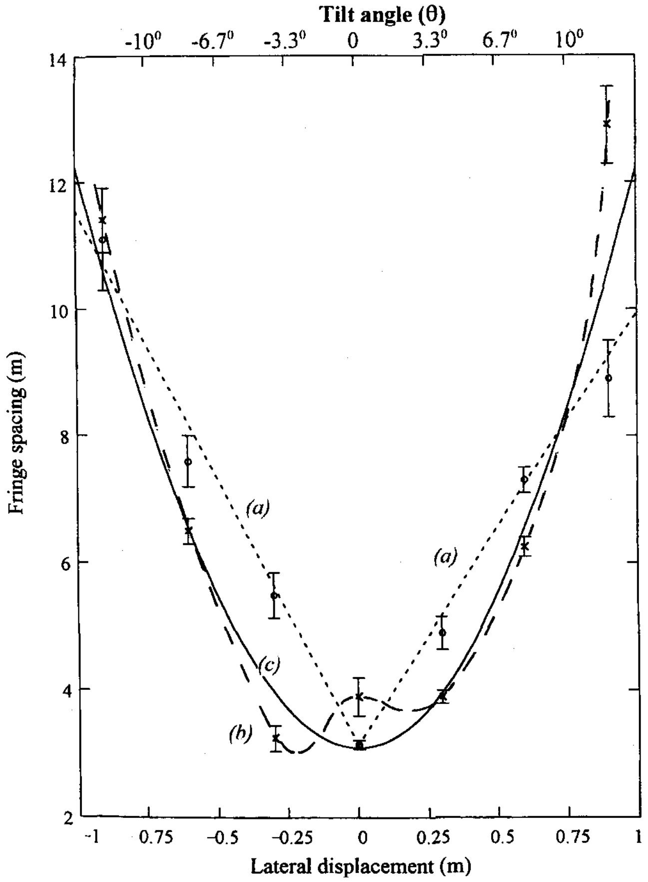

Figure 4 Interference fringe spacing versus lateral displacement of ground pipe. Primary component of interferometer: as in Figure 3. Secondary component, laid on ground parallel to the overhead cable; lateral displacement zero means vertically below the cable: (a) polythene conduit, diameter 50 mm, length 12 m, 20/22 April 1996; (b) PVC pipe, diameter 22 mm, length 20 m, 23/24 April; (c) from equation (2).

In good conditions, the internal difference between pairs of measurements of each fringe can be used to give a measure of fringe width, the detector rods rotating as soon as the stimulus is above threshold. The average of the pair gives the position of the centre of the fringe.

2.5.4. Summary of recommendations. A smooth level site is desirable, and essential for the most accurate interferometry; the interferometer must be set up with precision, the plane containing the components being perpendicular to the ground (except of course when the effects of its rotation are being investigated) and measured to an accuracy of one arc degree or better; a period of an hour or more should be allowed between changes to the interferometer and subsequent measurements; measurements should be made outwards from the interferometer and back, all traces of the first set being removed before the second is made, and continued if necessary until stability and repeatability are established; and finally, for reasons that will appear later, the date and time must be recorded.

3. Interferometry

As shown in Figures 1, 3 and 4, the pattern of responses of dowsing detector rods in the area of parallel pairs of linear structures takes the form of equally spaced lines parallel to the structures. These patterns are of a kind that are familiar to experimental physicists as being generally produced by interaction between an interferometer and a radiation field. It seems reasonable, provisionally, to place a similar interpretation on the dowsing interferometer patterns. We may therefore hope to learn something about the nature and origin of the radiation field, if such it is, by measuring the effects on the patterns of changes in the geometry of the interferometers and of the materials from which they are made.

The account of each experiment begins with a description of the dimensions and the materials of the interferometer. The detection and measurement of the interference patterns follow the procedures laid down in subsection 2.5.3. The resulting numerical data are presented graphically or in tables.

3.1. Experiment 1

Outdoor interferometer: Large-scale two-component interferometer as on Figures 1 and 3. Site as Figure 3. Measurements were made along the 'usual track'.

Primary component: overhead cable, single-strand copper wire, diameter 1·0 mm, sheathed in PVC to a total diameter of 3·8 mm, length 21 m, height 4·3 m.

Secondary component: laid parallel to and vertically below the overhead cable as determined by plumb lines; dimensions and materials as given in (a) to (d) below.

Date: 22/24 April 1996. The results are shown in Figure 5, where each curve represents a complete set of measurements for one of the following types of secondary components:

(a) polythene conduit, diameter 50 mm, in lengths of 6 m. The spacing of the fringes increases with increasing length of the conduit;

(b uPVC pipe, diameter 22 mm, in lengths of 4 m. The fringe spacing depends on pipe length in the opposite sense to that for polythene, increasing rapidly with decreasing length of pipe;

(c) copper pipe, diameter 22 mm, in lengths of 3 m. Not all possible length combinations were used due to limited time imposed by the weather. The dependence of fringe spacing on length follows the same general trend as for polythene, contrary to uPVC of the same diameter;

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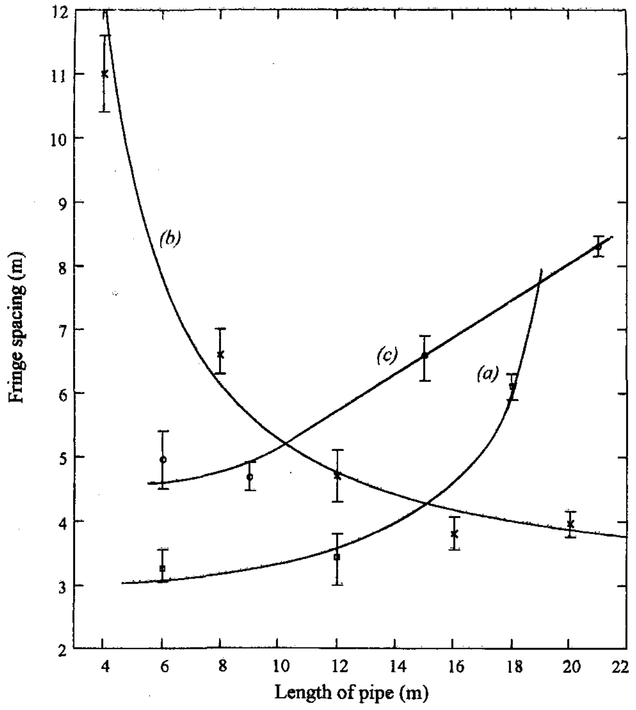

Figure 5 Interference fringe spacing versus length of pipe on the ground: (a) polythene conduit, diameter 50 mm, 22 April 1996; (b) PVC pipe, diameter 22 mm, 22 April 1996; (c) copper pipe, diameter 22 mm, 24 April 1996. Aluminium pipe, diameter 25 mm, produced no interference fringes (24 April 1996). Details of the interferometer are given in subsection 3·1.

(d) aluminium pipe, diameter 25 mm, in lengths of 2 m, joined by aluminium up to a total length of 20 m. The detector rods did not rotate anywhere except directly under the cable as in the absence of a secondary component.

The surprising difference in response to the dowsing field by two superficially similar plastics, polythene and uPVC, when used as secondary components with a copper/PVC primary, is surpassed by the even more extraordinary difference between the two metals, copper and aluminium. Whereas copper behaves in a manner generally similar to polythene, aluminium does not produce any interference fringes at all. This confirms the discovery of the anomalous behaviour of aluminium made in early December 1989 (Reddish 1993, p. 8), when used as a secondary to an underground lead pipe. Note in particular that all the curves are asymptotic to a minimum fringe spacing.

These experiments were repeated with the copper/PVC primary replaced by one made entirely of plastic (uPVC strapped to polythene), of the same length but at the lower height of 2·5 m for constructional reasons. The results were generally similar, except for uPVC, the fringe spacing now increasing with length of pipe on the ground, as for polythene and copper.

Further investigations of the effect of changes in the material of the secondary component were made, using an interferometer with a moving secondary component, see subsection 2.3, as follows.

3.2. Experiment 2

Outdoor interferometer: large-scale primary with moving secondary component. Site as Figure 3. Measurements were made along the 'usual track'.

Primary component: as in subsection 3.1.

Secondary component: length 44 cm, carried transversely above the detector rods at a height of approximately 36 cm above them; materials as in Table 3.

Date: 14 May 1996.

Table 3 Effect of using different secondary component materials; outdoors.

Material	Diameter (mm)	Average fringe spacing (m)	Standard error of mean (m)
Lead	15	4·18	±0·16
Alkathene	27	4·93	0·17
Copper	14	4·11	0·15
Steel	3	4·81	0·23
Aluminium	15	no interference fringes	
uPVC	22	4·34	0·13
Wood	10	3·90	0·15
		mean 4·38	

Measurements were carried out on a windy day, at about the practical limit of conditions. The rms dispersion of the average fringe spacings for the various materials about their overall mean of 4·38 m is ±0·37, which is more than twice the average of the internal standard errors of the fringe spacings for the individual materials. This could indicate that some of the differences between materials are real, but this is not confirmed by the better measurements in the following section.

Following the successful use by C. M. Humphries (pers. comm.; see subsection 2·3) of compact interferometers with two fixed components indoors, it was decided that the above experiment should be repeated indoors, and thus unaffected by weather conditions, using a correspondingly shorter overhead cable as the primary component, but the same moving secondaries.

3.3. Experiment 3

Indoor interferometer: fixed primary, moving secondary. Wooden floor, carpeted with woven polypropylene. The length of the room limited measurements to two fringes.

Primary component: overhead cable, material as in subsections 3·1 and 3·2; length 3·5 m, height 1·85 m.

Secondary component: as in subsection 3.2.

Date: 17 November 1996.

The rms dispersion of the averages about their mean of 1·396 is ±0·039, close to the average of the standard errors, ±0·031. It is concluded that differences in material have no effect on fringe spacing in this configuration.

There is a widely held view that dowsing utilises electric or magnetic fields or electromagnetic radiation (Rocard 1966, Mills 1994, Kemlo 1995), but the effects of using different materials in the interferometers are very different from what would be expected if that was the case. Note again the anomalous behaviour of aluminium as the secondary to a copper primary; tin was found to behave similarly.

The relatively small errors achieved in Experiment 3, due primarily to absence of wind and a smooth, level floor, further encouraged the use of indoor interferometry.

Table 4 Effect of using different secondary component materials; indoors.

Material	Diameter (mm)	Average fringe spacing (m)	Standard error of mean (m)
Lead	15	1·355	±0·019
Alkathene	27	1·371	0·026
Copper	14	1·402	0·032
Steel	3	1·478	0·047
Aluminium	15	no interference fringes	
uPVC	22	1·386	0·013
Wood	10	1·386	0·053
		mean 1·396	±0·031

3.4. Experiment 4

Rotating indoor interferometer: the Humphries compact indoor interferometer (see subsection 2.3) used a pair of parallel horizontal cables, and Humphries (pers. comm.) noted that the fringe spacing was the same whether they were in a vertical or a horizontal plane. The rapid change of fringe spacing with the tilt of the plane found for the outdoor interferometer (Fig. 4) indicated that it would be worthwhile investigating the effect of rotation of a pair of parallel cables by successively small angles. Indoor environment as in subsection 3.3.

Components: twin parallel cables 60 cm apart, length 3·5 m. Axis of rotation parallel, central and horizontal, height 1·58 m. Material of each cable: two-strand copper wire, each strand diameter 0·5 mm, sheathed in PVC to form one cable.

Date: 20 November 1996.

Measurements were begun with the plane of the cables vertical, $\theta=0°$, and repeated with the plane rotated in steps of 10° to 180°. They were made walking outwards from the interferometer and back, as usual (see subsections 2.5.3 and 2.5.4), and each pair of measurements was made three times, or more if there were signs of non-repeatability; the maximum was nine times. On average about 30 minutes had to be left between each set of measurements to allow the fringes to become established. The whole series of measurements took 12 hours 30 minutes.

The results are given in Figure 6. Except for the measurement when the plane of the cables was horizontal, $\theta=90°$, at which angle a second fringe was detected within the limit imposed by the length of the room, only one fringe was detected and the distance of this from the interferometer followed a sinusoidal relationship to the angle of rotation of the plane of the interferometer. The detection of the second fringe, however, at twice the distance of the first, confirms the expectation that we are once again dealing with equally spaced fringes.

If the distance of the fringe from the vertical plane through the axis of the interferometer is denoted by D, then it is related to the angle of rotation of the plane of the interferometer about a horizontal axis, θ, by the equation

$$D=4{\cdot}5a(1-0{\cdot}33\cos 4\theta), \tag{1}$$

where a is the separation of the interferometer components, 0·6 m. It has been pointed out by C. M. Humphries (pers. comm.) that the fringe spacings obtained with the large tilting interferometer (Fig. 3) are well represented by an equation of similar form,

$$D=6a(1-0{\cdot}88\cos 4\theta), \tag{2}$$

where a is 4·3 m. These equations provide a clear test for any theory which attempts to account for the dowsing phenomenon in terms of interaction between linear structures and a radiation field of some kind.

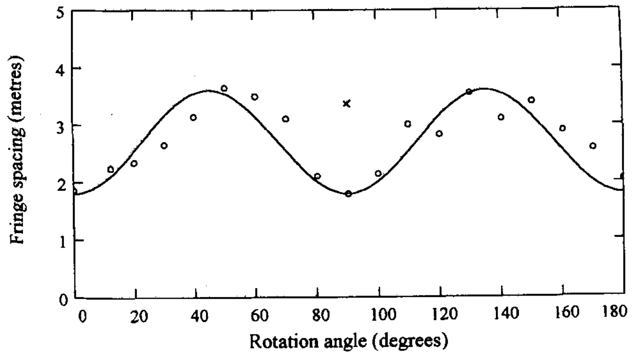

Figure 6 Rotating indoor interferometer (see subsection 3·4). The circled points are measured data; the curve is given by equation (1); the point indicated by a cross is the position of the second fringe.

3.5. Time dependence

Interferometry at the outdoor site at Rannoch was carried out, somewhat intermittently, during five years from 1991 to 1996, limited by weather conditions, availability of local accommodation, and other commitments. There were sometimes worrying discrepancies between measurements of fringe spacings made on one occasion and those on another, using the same interferometer configuration, differences greatly exceeding internal errors. For instance, the curve for uPVC in Figure 5, which shows measurements made on 22 April 1996, is of the same form but considerably displaced from the corresponding curve in Figure 1 in Reddish (1993), the data for which were obtained on 20/21 November 1992 using an identical interferometer on the same site.

As was pointed out in subsections 2.3, 3.2 and 3.3, the type of interferometer that uses a small moving secondary component is insensitive to the material and geometry of the secondary, it is quickly set up and can be used with any existing primary. Since it also provides measurements of fringe spacings immediately, giving information on the strength, sharpness and repeatability of fringes, it became a habit to use it at the start of each interferometry session as a test of conditions.

These data, covering the whole five years, were extracted from the field notebooks over the period, and plotted against date *regardless of year* (Fig. 7). Although there are gaps in midwinter and in midsummer for the reasons given above, there is a clear dependence of fringe spacing on time of year, the hand-drawn curve indicating a maximum of about 5 m in summer, falling rapidly in November to about 1·5 m. Confirmation is provided by the lower asymptotes of the measurements with the fixed two-component interferometer referred to for April 1996 and November 1992, which fall close to the curve.

The rms deviation of the fringe spacings from the curve is ±0·28 m. This is only 9% of the variation over the year. Some at least is due to errors of measurement of fringe positions and deviations in fringe position due to ground irregularities. What remains, less than 9% and perhaps much less, sets a limit on the year-to-year variations over the period 1991 to

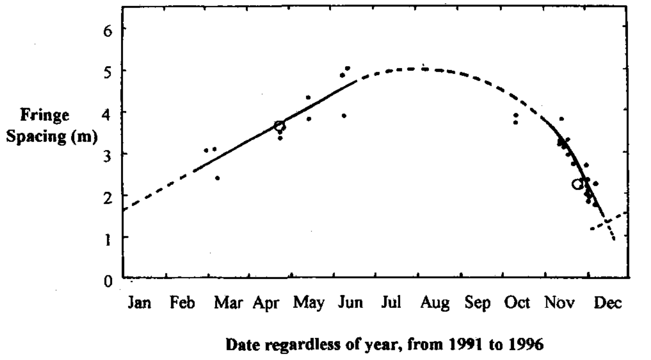

Figure 7 Dependence of fringe spacing on date, regardless of year (measured with the outdoor interferometer over a period of five years). Each dot represents the average of a complete set of measurements using a moving secondary interferometer component; open circles are the lower asymptotes of measurements made with the interferometer configuration described in subsection 3·1 using a PVC pipe length of 20 m, on the dates shown. The rms dispersion about the hand-drawn line is ±0·28 m, not more than 9% of the annual range; at least part of this dispersion will be due to errors of measurement, and the remainder sets an upper limit on the year-to-year variation.

pon

1996. This must be taken into account when considering possible sources of the dowsing field.

Figure 7 was plotted towards the end of the third week in November 1996. Measurements with an indoor interferometer using a moving secondary component had already been made (subsection 3.3) and had demonstrated the high level of accuracy that could be obtained, free from interruptions by the weather, enabling daily measurements to be made.

The interferometer used for these daily measurements was as follows:

Indoor interferometer (see later):

Primary component: overhead cable, length 4 m, height 2 m, material as in subsection 3.4.

Secondary component: wood, diameter 10 mm, length 44 cm, carried transversely approximately 36 cm above the rods, as in subsections 3.2 and 3.3.

Measurements were made as usual, walking out from the primary and back. Most of the data consists of the average of five out and back sets.

The results to mid-May 1997 are shown in Figure 8. The fringe spacing reaches a minimum of about 1·5 m at the end of November. Thereafter it remains below 1·8 m until late March, with an isolated maximum around 30 December. The steady climb during the period 20 March to 21 April is not surprising given Figure 7, but the sudden increase by a factor of about two to 4 m during the last week in April was unexpected. The size of the room limited indoor interferometry to a maximum fringe spacing of 3·5 m, so when it began to increase quickly from day to day, measurements using the same interferometer were made outside as well as inside to compare results; they are shown by different symbols in Figure 7. All measurements after 25 April were of necessity made outside and are therefore subject to interruption by weather. Nevertheless they show that the steep rise slowed from 27 April and stopped on 2 May, the fringe spacing then remaining close to 4 m for several days.

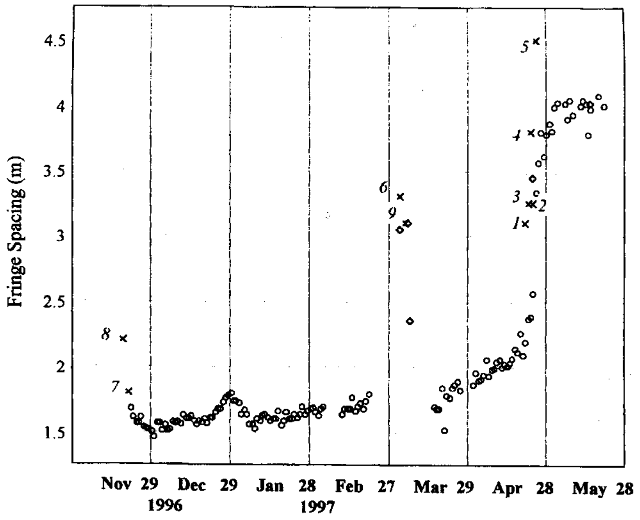

Figure 8 Interferometer fringe spacing versus date, regardless of year. Open circles: daily measurements beginning 22 November 1996, using an indoor interferometer up to a spacing of 3·5 m, and outdoors with the same interferometer above 3·5 m. Diamonds: daily averages of the earlier outdoor measurements shown in Figure 7. Crosses: lower asymptotes of measurements made with the large fixed two-component interferometers from 1991 to 1996 (data from Table 6); note that (5) was interrupted by rain and the value is uncertain. The gap in the daily measurements from late February to mid-March is due to absence on holiday; the data from previous years indicate that there was a local maximum at that time, similar to the smaller one centred on 30 December. Note the close agreement between the measurements made with different interferometers, at three different sites separated from each other by some 200 km, and in different years from 1991 to 1997.

Note the close agreement between measurements made at Edinburgh and at Aberdeen on successive days—in one case on the same day—using the same interferometer components and configuration in different indoor surroundings (Table 5). The agreement indicates that this type of interferometer is not particularly sensitive to its immediate environment, and shows that it gives the same results at locations 200 km apart.

The spacing of the fringes in the pattern produced by an interferometer generally depends on two factors: the wavelength of the radiation and the geometry of the interferometer. With this in mind, the minimum fringe spacings for each and every configuration, reached asymptotically, published and unpublished, are given in Table 6 and added to Figure 8. It is notable that they are closely similar to the fringe spacings measured by the interferometer with the moving secondary. It is inferred that these fringe spacings represent the wavelength of the radiation, and larger spacings on any given date are produced by the differences in the interferometer configuration.

Table 5 Average fringe spacing (m).

Date	Edinburgh	Aberdeen
1996 28–29 Nov	1·53 ± 0·04	1·52 ± 0·05
1996 02 Dec		1·57 ± 0·11
1996 03 Dec	1·57 ± 0·03	
1996 23 Dec	1·61 ± 0·04	1·61 ± 0·06
1997 02 Jan		1·72 ± 0·06
03 Jan	1·64 ± 0·06	

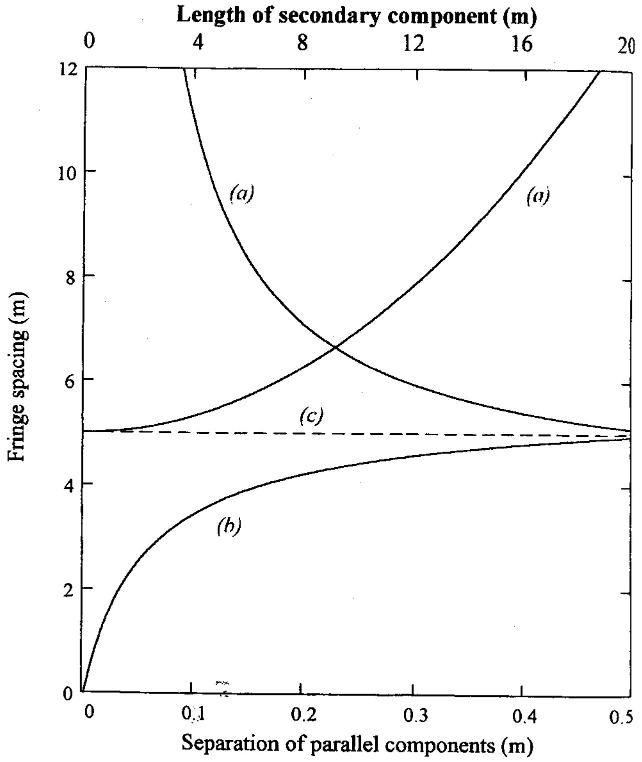

Figure 9 (a) Large outdoor interferometer (top scale); (b) compact interferometer (bottom scale); (c) interferometer with moving short secondary. (a) and (b) are asymptotic to (c). This common boundary depends on time as shown by Figure 8.

Table 6 Minimum fringe spacing for each configuration.

Reference number on Figure 8	Figure	Curve	Date*	Minimum fringe spacing (m)
1	4	a	20–22 Apr	3·1
2	4	b	23–24 Apr	3·25
3	5	a	22 Apr	3·25
4	5	b	22 Apr	3·8
5	5	c	24 Apr	4·5
6	not published	b	3–4 Mar	3·3
7	6	—	20 Nov	1·8
8	not published	a,b,c	16–21 Nov	2·2
9	not published	d	5 Mar	3·1

*Regardless of year

It would clearly be of interest to have measurements made simultaneously in the northern and southern hemispheres, particularly in April and in November when the fringe spacing is changing so dramatically, and also to have daily measurements continued through several years.

3.6. Asymptotes

It was noted in subsection 3.1 that when using the large-scale outdoor interferometer, the dependence of interference fringe spacing on the length of the secondary component for each material (Fig. 5) is represented by a curve that is asymptotic to a minimum spacing. On the other hand, twin-cable compact interferometers, of the type used as a rotating interferometer in subsection 3.4, produce a dependence of fringe spacing on the separation of the cables that is asymptotic to a maximum fringe spacing.

On a given date, these asymptotes are found to be the same, and equal to the fringe spacing obtained with an interferometer using a short moving secondary component. This common boundary, towards which all the interferometer measurements tend (Fig. 9), is the fringe spacing that depends on time of year as shown in Figure 8, and appears to represent the basic wavelength of the dowsing radiation field at any given time.

4. Conclusion

During 1997, the decision by several experienced physicists in Edinburgh to co-operate in research into dowsing (the now-named Dowsing Physics Group), working closely with physicists overseas, has led to considerable progress in several of the topics touched upon in this paper.

1. (1) Simultaneous interferometry in northern and southern latitudes is now in progress. Besides the value of the results that are being obtained, it has demonstrated that dowsing interferometers can be set up and used quickly and effectively by others.
2. (2) The aluminium anomaly (see subsections 3.1–3.3), which included tin and was more recently found to include gold, is being extended to examine the behaviour of an ever-widening range of materials.
3. (3) Compact, tilting and rotating interferometers are being used increasingly to study the interaction between structures and the dowsing field.
4. (4) Changes to the detector system (section 1) have shown that different interference patterns can be detected, re-inforcing the indications of (2) and (3) above that we may be dealing with more than one field.

These topics will be the subjects of papers to be presented for publication by members of the Dowsing Physics Group and their colleagues in due course.

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MS received 19 May 1997. Accepted for publication 22 April 1998.