Calanus and Euphausids, and it is not known whether these latter contributed to the trace.

In summarizing the observations on the scattering layers in the sea, we conclude that no generalization is possible as to their cause. However, in the abovementioned shallow waters there are layers which are: (1) diurnally migrating and analogous in behaviour to some of the deep scattering-layer observations of the American authors; (2) of wide occurrence, being present in the English Channel, southern North Sea, and the Bear Island area; (3) at times very extensive, stretching over 70 miles in the western English Channel and 20 miles at Bear Island; (4) of relatively short existençe in comparison with the deep scattering layer; (5) probably caused by young fish 12 mm.–12 cm. in length, their air bladders playing a great part in rendering them more liable to interfere with the transmissions of the echo sounder.

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WINDS AND TURBULENCE IN THE UPPER ATMOSPHERE

It was at one time thought that winds and mixing of the atmosphere occurred mainly below about 12 km., where the temperature was known to decrease upwards, and that above this level, in the so-called stratosphere where the temperature was thought to be independent of height, the atmosphere was considered to be more or less at rest and stratified in horizontal layers of uniform density. At intervals, observations of self-luminous objects such as meteor trails and luminous night-clouds have suggested that the atmosphere at heights of about 100 km. is turbulent, and even that uniform winds occur there. These observations are infrequent and present such an incomplete picture of the upper-atmospheric motions that meteorologists have not been in a position to try to explain them. Recently, however, several new radio methods have been developed by which the turbulent and wind-like motion of the ionosphere can be investigated, and, since these methods do not depend on the chance occurrence of some self-luminous phenomenon, it appears as though they may soon provide a reliable description of upper-atmospheric motions which meteorologists can then attempt to explain.

With the object of collecting and comparing results of the radio measurements and presenting them in outline to the meteorologists for their consideration, a Geophysical Discussion on "Winds and Turbulence in the Ionosphere" was held at the Royal Astronomical Society on February 23, with Mr. J. A. Ratcliffe (Cavendish Laboratory, Cambridge) in the chair. The radio methods described all depend on the recognition of some irregularity in the ionosphere and then on measurements of the rate at which it moves either in a turbulent irregular way or horizontally with a wind-like motion. The experimental methods differ in their ability to detect and use irregularities of different size and in different regions of the ionosphere.

Dr. W. J. G. Beynon (University College, Swansea) gave a short account of the observations of G. H. Munro[1], who worked in Australia and used ordinary ionospheric sounding equipment at points separated by tens of kilometres. Munro identified certain large-scale phenomena on the P'–f curves and found that they were often approximately repeated, but with a time lag, at the different observing points. He deduced that there were irregularities in the horizontal distribution of ionization in the F-layer with a 'size' of about 400 km. and that they appeared to move with velocities of the order of 100–200 m./sec. The movement was predominantly towards the east; there did not appear to be any regular diurnal change in the direction of movement, but a seasonal variation, with a rather sudden change at the equinoxes, was noticed. Dr. Beynon himself has observed similar movements in the F-layer: during the Second World War[2] when he found that sometimes ionospheric irregularities which appeared to influence the transmission from Zeesen (Berlin) to Slough would also influence waves reflected vertically at Slough some time later; and in more recent experiments made between Swansea and Slough (230 km. distance), when he has found that the direction of motion sometimes changes in the course of one day.

Some experiments of a different nature, which seem to throw light on the same large-scale irregularities in the F-layer, were described by Mr. E. N. Bramley (Radio Research Station, Department of Scientific and Industrial Research). He has measured the direction of arrival of a short train of radio waves reflected from the ionosphere at nearly vertical incidence, and has deduced that the layers of constant ionization are often tilted through angles of a few degrees. Comparison of the observations made at points separated by about 27 km. has led to the conclusion that similar tilts occur at the two places but with a time lag which corresponds to the passage of a disturbance overhead. These disturbances have a size of about 100–500 km. and move with a velocity of about 35–350 m./sec., with a general tendency to move towards the east. Mr. Bramley stressed that observations of this kind lead only to a knowledge of changes in the distribution of the ionization and do not necessarily imply the presence of winds in the atmospheric gases.

Another method of investigating the F-layer was explained by Dr. A. C. B. Lovell (University of Manchester), and also by Mr. Ratcliffe, who described results obtained by Mr. M. Ryle (Cavendish Laboratory, Cambridge). In this method the waves received at the ground from a 'radio star' on wave-lengths of 3·7 m. (Lovell and Ryle) and 6·7 m. (Ryle) are studied. Their amplitude is often found to vary with time in a way analogous to the scintillation of optical stars, and experiments with spaced receivers[3] have shown that these variations are produced by irregularities in the terrestrial ionosphere having lateral dimensions of the order of 5 km. These irregularities are associated with the conditions in the F-layer which produce 'spread-F echoes' on ionospheric sounding equipment. Dr. Lovell thinks that there is some evidence that the ionospheric irregularities are smaller towards the polar regions.

It has been suspected[4,7] for some time that the 'scintillation' of the radio stars is caused by regular movements of the ionospheric irregularities, and recent experiments using spaced receivers have con-

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firmed the presence of steady movements of the irregularities with speeds of the order of 100 m./sec. A surprising result, mentioned by Mr. Ryle, is that the direction of the wind along the east–west line has, on some occasions, been found to reverse within a time of about thirty minutes.

Mr. G. J. Phillips (Cavendish Laboratory, Cambridge) described measurements on the E-region at a height of about 100 km. He used the method of S. N. Mitra[5] in which short trains of radio waves are received, after reflexion from the ionosphere, on three receivers situated close to the transmitter and separated from each other by distances of the order of 100 m. From the fading observed at the three receivers, it is possible to deduce that the E-layer has an irregular structure in which the smallest size of irregularity is about 200 m., and that the irregularities move with random turbulent speeds of about 1 m./sec. On most occasions the random movement is almost completely masked by a regular wind-like movement with a speed of the order 80 m./sec. Measurements of the speed of this wind have been made on three days every month over the past two years, and although there is a considerable amount of irregularity in the behaviour, there also seem to be some regular features—for example, the behaviour in the summer months has been more regular than in winter, and has shown a wind predominantly towards the west by night and towards the east in the midday hours. Somewhat similar results have been obtained by workers using the same experimental methods in Washington, D.C. A harmonic analysis of the results shows a statistically significant semi-diurnal solar tide. The horizontal tidal motion found is represented by a vector with a clockwise rotation having a magnitude of 20 ± 10 m./sec. and directed towards the east at 0630 hr., but no statistically significant lunar tidal component has been found. There is some evidence to show that the F-layer has a fine structure of the same sort of size as that in the E-layer, and that it moves with similar velocities. On some occasions the velocity measured with waves reflected from the E-layer is reversed within half an hour, but it is just possible that this reversal represents phenomena occurring at two different heights.

Dr. Lovell summarized work done by L. A. Manning and others[6] in the United States. He measured the Doppler effect on waves reflected from meteor trails and deduced that it corresponded to a wind with a velocity of the order of 30 m./sec. The height of these trails was known to lie somewhere in the region of 80–100 km. Most of the wind-like movements were towards the north-east or to the south, and there were some rather sudden changes of direction which might possibly correspond to different directions at different heights. Dr. Lovell also mentioned some experiments made by his own colleagues, in which the rapid fading of the echo returned from meteor trails was studied, and from which it was deduced that there were irregular turbulent velocities of about 25 m./sec. at levels of about 90 km.

Mr. Ratcliffe summarized the radio evidence as shown in the accompanying table.

Approximate heights	Horizontal size of irregularity	Turbulent velocity	Drift velocity	Worker and remarks
>300 km.	5 km.	—	100 m./sec.	Lovell & Ryle. Some reversals within 30 mins. (Ryle).
250 km.	500 km.	—	100 m./sec.	Munro, Beynon. No diurnal variations. Seasonal changes near equinoxes. Movement predominantly towards east.
250 km.	100–500 km.	—	35–350 m./sec.	Bramley. Movement towards east.
250 km.	$\nless$ 200 m.	1 m./sec.	80 m./sec.	Phillips.
100 km.	$\nless$ 200 m.	1 m./sec.	80 m./sec.	Phillips. Some regularity in diurnal behaviour repeating over 2 years and in America. Some rapid reversals.
90 km.	Ionized meteor trails	25 m./sec.	—	Lovell.
90 km.	Ionized meteor trails	—	30 m./sec.	Manning. Reversals of velocity possibly related to small changes of height.

Discussing these results from the point of view of a meteorologist, Prof. P. A. Sheppard (Imperial College of Science and Technology, London) emphasized that temperature difference provides the most probable source of the energy required for the wind-like motions. If geostrophic winds with a velocity of about 50 m./sec. in an east–west direction were to be produced by a horizontal temperature gradient in a layer of thickness 10 km., this gradient would have to be of the order of 1° C. per 100 km. in a north–south direction. In a changing pressure field it is also possible to have an isallobaric wind which flows from a place where the rate of change of pressure is high to a place where it is low. If winds of velocity 50 m./sec. were produced in this way in a layer of thickness 10 km., there would have to be a temperature gradient changing at the rate of 4° C. per hour per 1,000 km. Even near sunrise a differential heating of this magnitude is unlikely. It can be shown that Eulerian winds, flowing from regions of hot air to regions of cold air, would require a diurnal temperature variation of 10° C. and would be accompanied by a marked seasonal variation of wind. Prof. Sheppard stressed that it is difficult to explain the reversals of wind which have been reported, and he suggested that the most likely explanation is that there is a quasi-geostrophic flow in different directions at different levels and that the radio observations do not always apply to the same level.

In the free discussion which followed, Mr. Ryle pointed out that even if the observations made with waves reflected from the ionosphere could be explained in terms of reflexions from different levels at different times, this is not a possible explanation of the reversals of velocity deduced from observations of radio stars, since in that case the radiation has passed through the whole of the ionosphere. Other speakers stressed that, although the radio observations detect changes in the electron density, they do not necessarily imply the bodily movement of the atmosphere, and in this connexion Dr. R. E. Scorer doubted whether there is any mechanism which might reasonably be expected to produce a wave-

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like disturbance in the ionosphere such as that suggested by D. F. Martyn[8].

The meeting provided an excellent opportunity for the bringing together of workers in different branches of this subject, and the Royal Astronomical Society is to be congratulated on choosing such a live subject for discussion. The two most important points which emerged from the discussion were: first, because the wind may change in an important way with height, it is essential to measure the height accurately; and secondly, horizontal movements of irregularities of electron density do not necessarily imply bodily movements of the air.

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PLANT CHROMOSOME-RACES AND THEIR ECOLOGY IN GREAT BRITAIN

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SINCE the "Merton Catalogue"[1] appeared, botanists have had in their hands a list of the chromosome numbers of British flowering plants. It provides a starting point for studying the relations between cytology and various aspects of the flora, such as taxonomic problems, geographical distribution and ecology.

Species may occur with more than one chromosome number, having either a few chromosomes more or less than the normal (aneuploid series), or the numbers are in multiples of each other (polyploid series). Now Darlington[2] has pointed out that sometimes polyploids occurring within the species are indistinguishable from one another except on the basis of distribution, while others may show size differences of a general character. Therefore, if one considers those species in the British flora containing a polyploid series which taxonomists have not assessed as separate species on morphological grounds, such chromosome-races, as they can be termed, may yield information on the effect of chromosome doubling in relation to plant ecology.

Chromosome-races can consist of autopolyploids which may have originated from relatively homozygous diploids or from hybrids between varieties or subspecies of a diploid species[3]. Valentine[4] has discussed the classification and nomenclature of different kinds of polyploid series. Sometimes, as in *Valeriana*, individual chromosome-races within the species recognized cytologically can also be identified by pollen size and stomatal index, which increase with rise in chromosome number. Some of the higher chromosomal types within the species have later flowering. Recently, cytologists have taken precautions to record the habitats of the plant material which they examine, whereas earlier records gave no indication of these.

Some examples can be given which show that there is a relation between chromosome-races and the ecology of the species. For example, Hancock[5] found that the three chromosome-races of marsh bedstraw (*Galium palustre*) occupied different habitats. Diploids ($2n = 24$) in Oxford occurred in damp places which dried out in summer. Tetraploids ($2n = 48$) in Devon occupied intermediate habitats, often being submerged in winter and in soil remaining damp in summer. The octoploids ($2n = 96$) in Oxford lived in permanently damp zones and reproduced vegetatively by creeping shoots and roots at the nodes.

In Europe the common whitlow-grass (*Erophila verna*) was found by Winge[6] to consist of several chromosomal types, with a relation between chromosome number and external form. He divided the collective species into four eco-species, two of which occurred in Britain. These are *E. duplex* ($2n = 30$ to 40), which prefers pastures, gravel-pits and roadsides and is so far recorded only in England, and *E. quadruplex* ($2n = 52$ to 64), which Winge found only in Scotland, growing in low-lying grassland and bogs. It is a much larger plant and perhaps better fitted in competition for light with other species in denser plant associations. In general in *Erophila*, higher chromosome numbers go with larger plants; but the higher chromosome types are handicapped by later flowering and inferior seed setting. No doubt further sampling of the *Erophila* complex in Britain will reveal information as to whether (as seems possible) chromosome number in this species gradually increases northwards.

Lövkvist[7] in southern Sweden found that there is both a polyploid and an aneuploid series within the species of lady's smock (*Cardamine pratensis*), as in *Erophila*. Plants with different chromosome numbers occur together in meadows, but there is a regional distribution. Plants with lowest numbers ($2n = 30$) occur in the higher drier parts, while lower parts contain the intermediate races ($2n = 56$ to 68). The highest chromosome-races ($2n = 72$ and 76) are near or in water. This suggests that here there is a direct relation between chromosome number and water content of soil among members of the same species in local competition. A plant from the light soil of the former John Innes site at Merton was $2n = 32$ [8], while plants from three rather wet situations near Cambridge[9] were $2n = 56$, indicating that a similar situation probably holds true in Great Britain.

There are two British chromosome-races of parsley piert (*Aphanes arvensis*) according to Walters[10]. The diploid (*A. arvensis* s. str. $2n = 16$) is a sexual form indifferent to soil acidity and occurring in forty-three vice-counties[11], while the hexaploid, now known as *A. microcarpa* ($2n = 48$), is apomictic and restricted to acid soils; it occurs in thirty-seven vice-counties. Lesser celandine (*Ranunculus ficaria*) occurs in all vice-counties and comprises four chromosome-races, including a sexual diploid ($2n = 16$) producing viable seeds and lacking tubers in the axils of stem leaves, and a tetraploid (var. *bulbifera* $2n = 32$) with these tubers. It rarely has good seed, and reproduces entirely vegetatively by root tubers. According to Turrill[12] these two races probably have an unequal range in Britain: both occur in the counties of Middlesex, Surrey and Buckinghamshire; but only the diploids have been found in parts of Devon and Somerset. Further records of such chromosome-races would be welcome.

Darlington and Mather[13] have re-emphasized that simple chromosome doubling produces both a genetic change and simultaneously establishes a discon-

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