Miss G. M. Warnock discussed food and family size. An analysis of the effect of children on food expenditure had already been published in the 1952 report of the Survey: in the paper presented at the symposium, this analysis was extended to cover food consumption. Moreover, by means of regression estimates it was also found possible to arrive at 'notional' figures for the food consumption and nutrient values of the diets of adults and children respectively, and to apply these to families containing varying numbers of children.

In the concluding paper, Dr. I. Leitch, director of the Commonwealth Bureau of Animal Nutrition, reviewed the day's proceedings and made comparisons between the findings of the pre-war Carnegie survey (the welcome publication of which she announced to be imminent) and those of the National Food Survey. She suggested a number of points in the preceding papers which required further examination, mentioning as examples the extent of wastage of food in households of different composition and the influence of the occupation of the male earner on their consumption patterns. She stressed the need for further economic analyses of the results of the National Food Survey and emphasized its great potential value.

The symposium included two sessions for discussion. The first covered a wide range of subjects which related chiefly to technique. Points were made on methods of assessing social class, the intelligence-levels of informants who did and did not co-operate in the Survey, the degree of variance in the results, the contribution of school meals, the pattern of family shopping and the distribution of food within the family. The second included more detailed questions relating to the later papers, for example, the extent to which domestic pets might account for the excess of intake over requirements in the homes of elderly women, and the extent to which the pre-war Carnegie survey results might be directly compared with those of the National Food Survey.

The symposium was thus not only of value in giving members of the Nutrition Society a fuller picture of the National Food Survey than can be gleaned from the published reports. It equally provided those responsible for the detailed work of the Survey with an opportunity of viewing the results against a wider background and of benefiting from the lively discussion and constructive criticisms of an interested and informed audience.

¹ Ministry of Food, "The Urban Working-Class Household Diet, 1940 to 1949" (London: H.M.S.O., 1951).

² Ministry of Food, "Domestic Food Consumption and Expenditure, 1950, with a supplement on Food Expenditure by Urban Working-Class Households, 1940-1949" (London: H.M.S.O., 1952).

³ Ministry of Food, "Domestic Food Consumption and Expenditure, 1951 (London: H.M.S.O., 1953). Ministry of Food, "Domestic Food Consumption and Expenditure, 1952" (London: H.M.S.O., 1954).

GEOPHYSICAL ASPECTS OF SOLAR FLARES

IN recent years the study of solar flares has become of interest to geophysicists and astronomers alike. To the geophysicist, the subject is of interest chiefly because of the direct information it can provide concerning the study of solar-terrestrial relationships. It was this particular aspect which formed the subject of the Geophysical Discussion held at the Royal Astronomical Society on November 26, at which the chair was taken by Prof. V. C. A. Ferraro.

Carrington's classical observation of a flare was made on September 1, 1859. But solar flares are seldom seen in the integrated light of the sun, and it was not until methods had been devised many years later for observing the sun's surface in monochromatic light that a systematic study of solar flares was made possible. Since then much information has been obtained, and the Geophysical Discussion dealt principally with the geomagnetic, ionospheric and radio influences of solar flares.

Mr. H. W. Newton (Royal Greenwich Observatory) described by means of slides the chief characteristics of solar flares so far observed. Their basic association with sunspots, their sudden appearance and short life relative to sunspots, their great extent for those of first magnitude, and certain repetitive features are of significance in studying their geophysical effects. In particular, the distinctive development curve of typical flares with its high and brief peak (flash of radiation) should be noted.

Two types of effects are recognizable: (1) from solar electromagnetic radiation, producing effects on the day hemisphere; and (2) from solar particles affecting both day and night hemisphere. The former include the geomagnetic crochet, the short-wave radio fade-out, the long-wave improved transmission and solar 'noise'. A number of crochets synchronous with great flares have been used in conjunction with the observed maximum of the visible light ($H\alpha$ usually) to give a time-interval (effective time of travel from sun to earth) to the 'sudden commencement' of the ensuing geomagnetic storm. A histogram, of 5-hourly intervals over the 72 hr. following the crochet, shows a distinct peak at the interval 17-21 hr. The average from all the data was nearly 30 hr., the most active storms giving a significantly shorter interval of 22 hr. These results, Mr. Newton concluded, confirm and extend the purely statistical relationship between the greater sunspots and the greater geomagnetic storms; but flare occurrence does not explain a large proportion of the smaller storms, namely, those with indefinite onset and a tendency to recur at intervals of twenty-seven days. For these storms, the corona has to be invoked, but results so far lack coherence.

Mr. J. S. Hey (Radar Research Establishment, Ministry of Supply, Malvern) described an analysis of the distribution across the solar disk of solar flares with associated radio bursts at $\lambda = 4.1$ m. In an analysis of observations during part of 1946-47, it was noticed that radio bursts occurred more frequently in association with flares on the eastern half of the solar disk than on the western half, and it was tentatively suggested that the asymmetry might be due to absorption in solar corpuscular streams.

Subsequent observations of radio bursts up to 1951 have confirmed the radio asymmetry. If the supposition that the asymmetry is caused by absorption in corpuscular streams is correct, it seems probable that a correlation should exist between the distribution of radio bursts and high geomagnetic activity, which might be taken as an index of the arrival of solar particles in the earth's atmosphere.

Recent analysis has indicated that the active solar regions which produce high geomagnetic character figures also have high radio-burst activity; and if the progress of these regions is followed as they cross the solar disk, it is found that the radio-burst activity is a maximum to the east, falls toward central meridian, and rises again slightly on the west. How-

ever, as the anomalous distribution of radio-burst activity tends to occur for all values of magnetic activity, the absorption is not restricted to regions from which corpuscular streams have sufficient velocity to reach the earth.

The question then arose as to whether the asymmetry in the distribution of visual solar flares might be caused by optical absorption, since it is feasible that both radio and optical absorption effects could occur. Analysis of distribution of solar flares observed in $H\alpha$ during the years 1947–50 showed that the asymmetry was more marked when those flares occurring within a few days of high geomagnetic activity were selected. The results strongly suggest that the asymmetry both in the distribution of flares and in radio-bursts associated with flares is an absorption effect, which is emphasized by the selection of observations in close relation to high geomagnetic activity.

Dr. M. A. Ellison (Royal Observatory, Edinburgh) dealt with the flash of ultra-violet radiation generated by a flare giving rise to sudden disturbances in the terrestrial ionosphere, known collectively as S.I.D.'s. These disturbances are confined to the illuminated hemisphere of the earth and may be recorded in a variety of ways. We do not yet know what wave-lengths are involved. We speak of the S.I.D.'s as the 'simultaneous effects' of flares. But, in fact, accurate timings show that they are not quite simultaneous with the flash of visible radiation, as observed in $H\alpha$ light; there is a lag of some minutes between the peak of the flare and the maximum of the ionization which results from it.

The extra ionization caused by a flare is believed to be confined to the D -layer, in the level 60–90 km.; and the study of the various time-delays yields valuable information about the processes which occur in this region.

The S.I.D.'s are recorded in the following ways: (1) crochets in terrestrial magnetism (conductivity effect); (2) short-wave radio fade-outs (S.W.F.) 5–15 Mc./s. and cosmic noise fade-outs (S.C.A.) 18 Mc./s. (absorption effects); (3) sudden phase anomalies (S.P.A.) of very long radio waves 16 kc./s. (lowering of D -layer reflecting ceiling); (4) sudden enhancements of atmospherics (S.E.A.) 27 kc./s. (improved reflectivity of D -layer at oblique incidence); (5) sudden anomalies in the field-strength (S.F.A.) of a distant 16-kc./s. transmitter (interference between ground-wave and sky-wave from D -layer).

At Edinburgh the development curves of the S.I.D.'s have been compared with those of the flares which generate them. The development curve of a flare consists of a plot of $H\alpha$ line-width, or of central intensity, versus time. Either method yields the same values for the times of beginning, maximum and end of the flare. The results for the time-delays are as follows:

	S.I.D. max.–flare max.	No. of cases
(1) Crochets	2.5 min.	13
(3) S.P.A.	5	8
(4) S.E.A.	7	21
(5) S.F.A.	5	8

The standard error in each case is of the order of 1 min. In addition, it was found that after an intense flare (Class 3 or 3+) the ionization in the D -region does not return to the pre-flare value for a period of the order of 1 hr. after all visible radiation has ceased.

It is natural to suppose that the intensities of the visible and ultra-violet wave-lengths in the flare

radiation follow the same course of rise and decay with time, even though only the former can be directly observed. It was therefore assumed that the observed time-delays are to be interpreted as 'relaxation times', due to the sluggishness in the response of the D -layer to the increase in ionizing radiation.

It follows from this that the number of free electrons at this height increases during a flare by five to ten times the normal value. This result is in good agreement with the value derived by Appleton and Piggott from the increase of absorption which is observed during a short-wave fade-out.

The relatively small time-delay for the maximum of the crochet is a most significant feature; it appears to indicate that the crochet currents do not flow at the same level (70–75 km.) as that in which the sudden enhancement of atmospherics and sudden phase anomalies effects originate. It is now generally believed that the S_q currents, responsible for the magnetic daily variation, flow at a height of 100–120 km. The crochet currents are in the same sense as the S_q currents flowing at the time and appear as an enhancement of these currents. But this does not necessarily mean that both are located at the same level. Referring to his 1950 paper, Dr. Ellison remarked upon the following facts: (1) Crochets are associated with intense flares (Class 3+ and 3, and only rarely with Class 2 flares). (2) The radiation from lesser flares (Class 1 and most Class 2) is known to produce ionization at heights of 70–75 km., as shown by the associated sudden enhancement of atmospherics and sudden phase anomalies. This radiation must have traversed the E -layer, yet it produces no increase in conductivity (that is, no crochet is observed). (3) The crochet only occurs during deep ionization of the D -layer, that is, when the 15-kc./s. reflecting ceiling for sudden phase anomalies falls from 75 km. to about 65 km. or lower. (4) Only the more intense fade-outs (about one in three) are accompanied by crochets. (5) The duration of the crochet is much less than the duration of the ionization in the 70–90 km. level, as recorded during the same flare by radio methods. This indicates a higher recombination coefficient, that is, lower level.

For these reasons Dr. Ellison concluded that the crochet currents must be the result of an increase in conductivity at a low level of about 60–70 km.

Again, the crochet currents associated with an intense flare are such as to indicate an increase in conductivity by a factor of less than 2, if we assume that they are caused by simple enhancements of the existing S_q currents. On the other hand, the fade-out absorption during a flare shows that the electron population in the absorbing layer (70–90 km.) undergoes an increase of five to ten times. This fact, together with the short time-delay for crochets and the absence of crochets in association with lesser flares, suggests that the 70–90 km. level does not make an appreciable contribution to the crochet current-system.

The evidence, therefore, points to the formation of crochets through the establishment of an independent current system in the base of the D -layer, the ionization at this level (~ 60 km.) being enhanced only during an intense flare.

Dr. K. Weekes (Cavendish Laboratory, Cambridge) next discussed the ionization produced in the ionosphere during a solar flare. From observations of the changes of height of reflexion and absorption

of waves of radio-frequency near 2 Mc./s. and from the sudden phase anomalies observed with very long radio waves, Dr. Weekes stated that it is possible to make deductions about the distribution with height of the ionization produced during the solar flare. These lead to the conclusion that the greater part of the extra ionization is produced in the lower *E*-region between 95 and 100 km. The increased absorption appears to be due to a more or less independent production of ionization near 70 km. which also gives rise to the effects observed with very long waves.

The variation of the various phenomena with time allows tentative deductions about the ionizing radiation and about various parameters in the ionosphere.

Finally, Dr. H. Elliott (Imperial College of Science and Technology, London) discussed the increases of cosmic rays observed during intense solar flares. He first remarked that during the past seventeen years there have been four occasions on which increases in cosmic ray intensity have been observed at a number of widely separated stations at the time of an intense solar flare. The magnitude of the increase depends on latitude, local time and height above sea-level. On none of these occasions was any increase observed at Huanayo near the geomagnetic equator, and this leads to the conclusion that the primary particles responsible for the increase are charged and have a maximum energy rather less than 10^{10} eV. In addition to these large increases, which have amounted in some cases to more than 100 per cent, it has now been established that smaller increases of the order of 1 per cent occur at the time of less intense flares. Assuming that the primary particles come from the sun, the impact zones on the earth can be calculated by taking into account the deflexion in the earth's magnetic field. Firor has shown that there is rough agreement between the observed and calculated intensity distribution over the earth, which indicates that the particles come from a region on or near the sun.

In the short discussion that followed, Prof. Ferraro directed attention to the interest for the theorist of Dr. Ellison's conclusion that the crochet currents flow at a level of about 60–70 km. For the question now arises as to whether one can account for the electromotive force needed to drive the crochet currents. Attention was also directed to the fact that no corpuscular radiation associated with solar flares other than that with speeds of about 10^8 cm./s. and 10^{10} cm./s. has so far been detected. We must await further developments to see whether this is, in fact, the case, or whether there is a continuous velocity spectrum in the corpuscular radiation ranging from about 10^8 cm./s. to 10^{10} cm./s.

V. C. A. FERRARO

FIELD-EMISSION AND SURFACE PHENOMENA

SYMPOSIUM AT PITTSBURG

A SYMPOSIUM dealing with field-emission and surface phenomena was held at the Mellon Institute, Pittsburgh, Pa., during November 10–12, and was attended by about eighty members. A banquet was held at the University Club, at which the guest speaker was Dr. W. E. Schoupp, director of development, Westinghouse Atomic Power Division, who spoke on power sources of the future. Dr. M. M.

Wachtel (Westinghouse) was chairman of the Symposium Committee responsible for the excellent conference arrangements.

The first session, devoted to field-emission and electrical breakdown, was opened by a paper by F. Llewellyn Jones (Swansea, Wales) on problems of the cold liberation of electrons and discharge initiation. With fields $\sim 10^5$ V./cm., two liberation mechanisms are found. One is dependent upon the presence of sites, for example, negative ions of water molecules, from which detachment occurs under the electric field; the removal of water vapour practically eliminates the emission. The other mechanism arises after the passage of a discharge, and apparently involves cold emission in a field enhanced by positive ions at a cathode tarnish layer; the role of such films was discussed. E. W. Mueller (Pennsylvania State) discussed emission due to momentary stripping of adsorption layers of barium, thorium and sodium with high electric fields up to 375 MV./cm. (field desorption). The field is sharply defined for any given adsorbate and depends on the crystallographic structure of the substrate. Auto-ionization can occur before the molecules touch the metal, and continuous field ion emission is made possible by surface migration to the emitting area. Application to mass-spectrometry was indicated. L. H. Germer (Bell Laboratories) discussed the role of field-emission for the extreme cases of breakdown under very high gas pressure and also *in vacuo*. For the former, the mechanism proposed is the field-emission of electrons following the Fowler–Nordheim equation in a field enhanced by the presence of positive ions near the cathode, the effective increase in the secondary coefficient γ thus corresponding to a lower sparking potential in the breakdown criterion. For vacuum breakdown, vaporization of the anode is suggested with ionization of the vapour atoms, the resulting positive ions enhancing the field of the cathode to produce field-emission. Experiments on a formative time-delay of high-vacuum sparks were described by H. G. Heard (California) using a pulse which rose in 6.6×10^{-10} sec. and of duration $\sim 5 \times 10^{-9}$ sec. It was found that initiation of a vacuum spark depends on two effects: a current precursor, and its subsequent rise. The measured delays cannot be reconciled with any clumping or cathode heating mechanisms.

The next session dealt with electron and ion sources. The production of high-energy electron beams was described by L. Marton and R. A. Schrack (National Bureau of Standards). Field-emission offers an attractive source for certain electron optical applications; for high brightness and small virtual areas make field-emitters more effective than thermionic sources when spots less than 0.3 micron are desired. Application to small X-ray sources, electron-probe micro-analysis, and to the determination of composition and orientation in the microcrystalline structure of metals was described. A paper entitled "Can One Observe Individual Atoms and Molecules in the Field Emission Microscope?" was read by J. A. Becker (Bell Laboratories). The discussion was concerned with the origin of very bright spots on the screen of a field-emission microscope, from the behaviour of which it is concluded that they originate in individual atoms or molecules adsorbed in a special state. M. G. Inghram and R. Gomer (Chicago) described a mass spectrographic analysis of the ions formed in hydrogen (and other gases) in the Müller field-ion microscope; the peak width for mono-energetic 10,000-V. ions was 20 V.,