LETTERS TO THE EDITORS

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Circular Polarization of Solar Radio Noise

IN two recent communications to these columns[1,2] we have reported the existence of powerful radio emissions in the 5-metre wave-length band from sunspot areas. Since such radio waves must travel through regions of considerable ionization in escaping from the sun, it occurred to us that the magneto-ionic theory of radio wave propagation[3], which has proved so useful in elucidating phenomena in the terrestrial ionosphere, would be applicable in the case of the corresponding solar envelope. According to this theory, characteristic polarizations are imposed on radio waves in their transmission through an ionized medium under the influence of a magnetic field, due either to differential absorption of the oppositely polarized magneto-ionic components or to the suppression of one component by electron limitation. Such effects are most pronounced if the radio wave frequency in question is either of the same order as, or less than, the electronic gyro-frequency determined by the imposed magnetic field. There is also the possibility that the noise itself has a magneto-gyric (electronic) origin.

Prompted by considerations of this kind, the state of polarization of solar radio noise was examined experimentally, on a frequency of 85 Mc./s., at the Operational Research Group Station of the Ministry of Supply during the recent period of sunspot activity (July 27 and 28, 1946). The polarization was, on that occasion, found to be circular, and of left-handed sense (viewed looking forward along the direction of propagation). This result is clearly connected with the local magnetic field in the vicinity of, and radially outwards from, the sunspot area itself, and indicates still one more example of the way in which radio wave phenomena may be used in the investigation of solar events.

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Aug. 23.

[1] Appleton, *Nature*, **156**, 534 (1945).
[2] Hey, *Nature*, **157**, 47 (1946).
[3] Appleton, *J. Inst. Elect. Eng.*, **71**, 645 (1932).

Solar Radiation on 175 Mc./s.

Appleton[1] and Hey[2] have directed attention to the fact that radio-frequency energy, with some of the characteristics of random 'noise', is emitted with greatly increased intensity from the sun under the conditions of violent disturbance associated with a large sunspot. These observations were confined mainly to the region of frequencies near 60 Mc./s.

Pawsey, Payne-Scott and McCready[3], who have made observations on 200 Mc./s., suggested that radiation of this type is also observable under less disturbed conditions.

In order to investigate other aspects of this phenomenon, we have constructed a device which automatically records and measures the 'noise' received on 175 Mc./s., and which has a sensitivity such that a power of 3×10^{-15} watts (approximately 1 per cent of the receiver noise power) can be detected. This sensitivity corresponds to a thermal energy temperature of 30° K., and it has been possible to record the 'noise' received from the galaxy on a small broadside aerial consisting of eight half-wave dipoles.

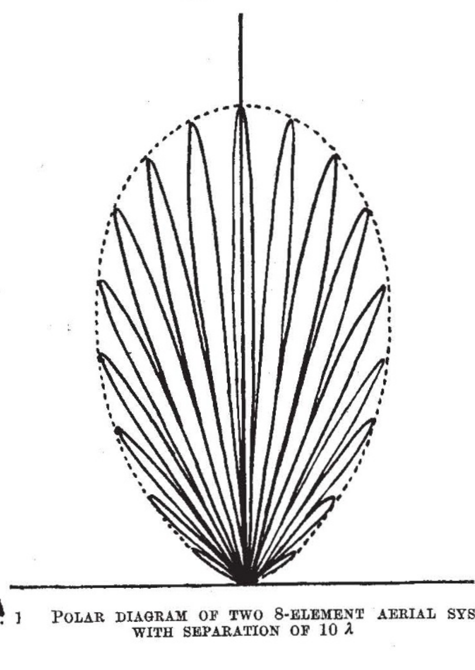

Fig. 1 POLAR DIAGRAM OF TWO 8-ELEMENT AERIAL SYSTEMS WITH SEPARATION OF 10 λ

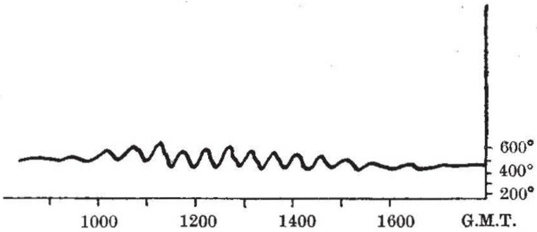

Fig. 2. RECORD OBTAINED WITH 10 λ SEPARATION (JULY 17, 1946)

For the purpose of investigating solar radiation under conditions of low solar activity, it is necessary to discriminate against the background of galactic radiation. While this could be achieved by building an aerial to give a sufficiently narrow beam, a very large structure would be required, and observation would be restricted to a short time every day unless arrangements were made for moving the polar diagram of the aerial. An alternative method was therefore used, analogous to Michelson's method for determining stellar diameters. Two aerial systems were used with a horizontal separation of several wave-lengths, and their combined output was fed to the receiving equipment. Such an arrangement produces a polar diagram of the form shown in Fig. 1 where the angle between zeros is governed by the spacing of the two aerials and the envelope is determined by the polar diagram of each individual aerial system. If the angle between minima is sufficiently large compared with the solar angular diameter, then, as the aerial polar diagram is swept past the sun by the earth's rotation, any radiation from the sun should be recorded as an oscillatory trace.

Fig. 2 shows a typical record obtained with an aerial separation of 10 λ, and with only slight solar activity (July 17). The oscillatory contribution due to radiation from the sun can be seen superimposed on the slowly varying background of the galactic radiation. Records of this type enable an estimate to be made of the level of solar radiation even when it is only about one quarter the galactic contribution, and at the present time we have found that the sun is usually sufficiently disturbed to give such records. The power is indicated on the diagram in terms of an 'equivalent aerial temperature', and is the power which has to be fed to an aerial in a black-body enclosure of this temperature, to maintain equilibrium. The temperature of a distant source whose radiation obeys a black-body distribution may be estimated from the observed equivalent aerial temperature by correcting for the ratio of solid angles of source and aerial polar diagram.

During the appearance of a large sunspot between July 20 and August 1, the solar radiation was much increased, and the opportunity was taken to use the apparatus to determine the angular diameter of the source, by observing the ratio of maximum to minimum intensity as the polar diagram of the two aerials with a separation of many wave-lengths was swept past the sun. This experiment was carried out with a series of different aerial spacings, the final value being 140 λ, and a sample of the records obtained with this spacing is shown in Fig. 3. The maximum/minimum ratio obtained under these conditions corresponds to a source diameter of 10 minutes of arc. Any inequalities in the two aerial systems would result in an over-estimate of diameter, and this is therefore a maximum value.

Since the value obtained does not greatly exceed the diameter of the visual spot, it is reasonable to relate the source of this radiation with the visual spot itself, or a region closely associated with it.

During the afternoon of July 25 the observed intensity attained a value which would correspond, in the case of black-body radiation from a source of this diameter, to a temperature greater than $2 \cdot 10^{9}$ ° K.

Since the existence of such temperatures in a region from which radiation of this wave-length would escape seems improbable, we considered that the radiation was non-thermal in origin, and the possibility of ordered electron motion was therefore investigated by an examination of the polarization of the radiation. This was carried out by arranging the two aerial systems of the 'Michelson' device to be polarized in planes at right angles to each other. If the radiation were emitted by a completely random 'thermal' source, the two perpendicularly polarized components would not be phase-coherent and no interference effects would be observed. The existence of interference effects would show the presence of phase coherence, and hence prove that the radiation was not of 'thermal' origin. Further, by noting

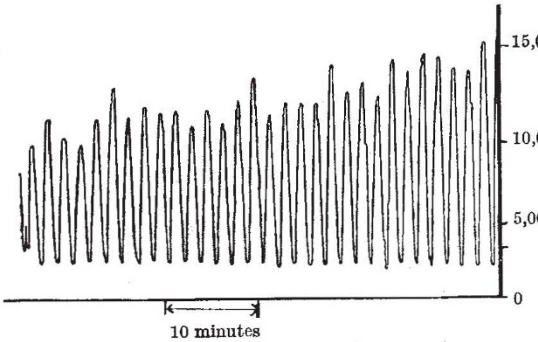

Fig. 3. RECORD OBTAINED WITH 140 λ SEPARATION (JULY 26, 1946)