Radar Observations During Meteor Showers 9 October 1946

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A SERIES OF RADAR OBSERVATIONS for the purpose of detecting ionization caused by meteors entering the earth's atmosphere was made by Central Radio Propagation Laboratory, National Bureau of Standards, at the suggestion of R. A. Helliwell, of Stanford University, beginning on 7 October 1946. An unusually rich meteor shower was expected on 9 October, during the passage of the earth through the orbit of the Giacobini-Zinner Comet. The observations were made at the Sterling, Virginia, Laboratory of the Bureau, where regular experiments in radio wave propagation are conducted.

The radar used for these observations was a standard Signal Corps type SCR-270-D, operating at about 107 megacycles, with its antenna oriented at an azimuth of 315° and with a vertical elevation angle of 45°. The width of the main beam of the radar antenna was approximately 40°×20° between half power points, the major axis being vertical. The radar transmitter had a peak pulse power of about 100 kilowatts. Visual observations, similar to those reported by Oliver Perry Ferrell in a letter to the editor of the *Physical Review* (1946, **69**, 32), were made on the type A radar oscilloscope. Photographs were made of the observed echoes on a PPI presentation oscilloscope with a rotating time base having a period of two minutes; the antenna was, of course, not rotated. A sample photograph of the observed echoes is shown in Fig. 1.

Provision had been made for mounting two cameras synchronized with the radar camera in order to photograph that area of the sky included in the radar beam. Because of rain and heavy fog, this phase of the program could not be carried out. On 9 October the equipment was put in operation at 7:30 P.M., 75° W mean time. The "A" scope was monitored by an operator who kept a log showing the time, range, and approximate duration of all transient radar echoes observed. Fig. 2 shows data obtained by visual count of the echoes observed on the type A oscilloscope on the nights of 9 October and 11 October. The rate of occurrence rose from approximately 8 per hour between 7:30 and 8:30 to a peak of over 1 per minute between 10:30 and 11:30, which coincides approximately with the predicted time of 10:00 for the maximum intensity of the Draconid shower. Following this maximum the rate fell to about 20 per hour after 11:15. Distances ranged from about 60 miles to 200 miles. Duration of the transient radar reflections was usually a second or less, although a considerable number lasted for several seconds. Only a few appeared to change distance during the time they could be observed on the screen, and these only in the order of five miles or less.

It is believed that most of the transient radar echoes observed during the tests were caused by meteors. Evidence leading to this belief is the range of distances over which the radar echoes were observed, the maximum rate of occurrence of the radar echoes on the night of 9 October at about the time predicted for the maximum intensity of the Draconid shower,

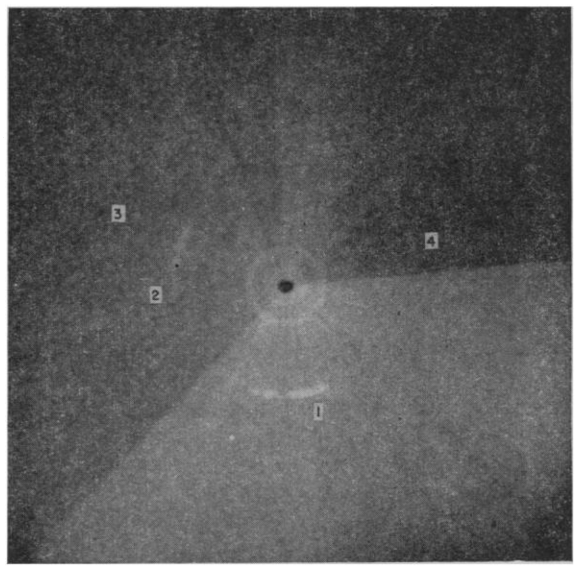

FIG. 1. Sample photograph taken of four transient radar echoes appearing on Radar PPI screen on night of 9 October 1946. Trace (1) indicates an approximate range of 75 miles and an echo duration of 15 seconds; (2) range, 75 miles; duration, 13 seconds; (3) range, 100 miles; duration 1/3 second; (4) range, 85 miles; duration, 3 2/3 seconds.

and the earlier observations of Ferrell and others of coincidences of radar echoes and visible meteors. Although no visible meteors could be observed on the nights of 7 to 9 October, because of clouds, visual and radar observations were made on the night of 15 October, in the course of which 7 visible meteors and 17 transient radar echoes were observed on the A oscilloscope. Preliminary analysis of the data taken indicates that in at least two cases the visual and radar observations were coincident in time. Further analysis of the PPI data may show additional coincidences. Rate of occurrences on other nights did not exhibit the marked peaking exhibited on 9 October, remaining at approximately the lower level of 9 October throughout the period of observation.

Since meteoric particles are of very small size, radar reflections directly from them may not be expected. The effects produced are undoubtedly from tracks of highly ionized atmospheric gases and meteoric vapors produced by the impact of the meteors on the atmosphere. Velocity relative to the earth of the meteoric particles from the Draconids is of the order of 2×10^3 cm. per second. A meteoric particle having a mass of only 1 mg. might be expected to produce of the order of 10^{15} ions in passing through the atmosphere if its entire kinetic energy is expended in ionization. The reflections may thus be thought of as due to scattering from a lengthy filament of highly conducting atmosphere entirely different in nature from the layers which produce regular reflections of radio waves. Thus, since the radar employed for the observations emits a polarized beam with its electric vector parallel to the plane of the horizon, discrimination between vertical and horizontal tracks is to be expected. Reflections might not be obtained from visible tracks that are perpendicular to the plane of polarization, while some invisible tracks parallel to the plane of polarization might be detected by the radar. No unusual effects were noted on the regular ionospheric records obtained during the shower.

The encouraging nature of these preliminary results indicates that radar methods of observing meteors may have a number of future applications. One such application would be the routine, continuous automatic recording of the radar echoes for determining the occurrence of meteors during overcast weather when seeing is poor and during daylight hours. It should also be possible to obtain much useful information regarding the nature and physical structure of the ionosphere with this type of radar equipment, as well as how meteor reflections may affect radio propagation and the usefulness of high frequencies.

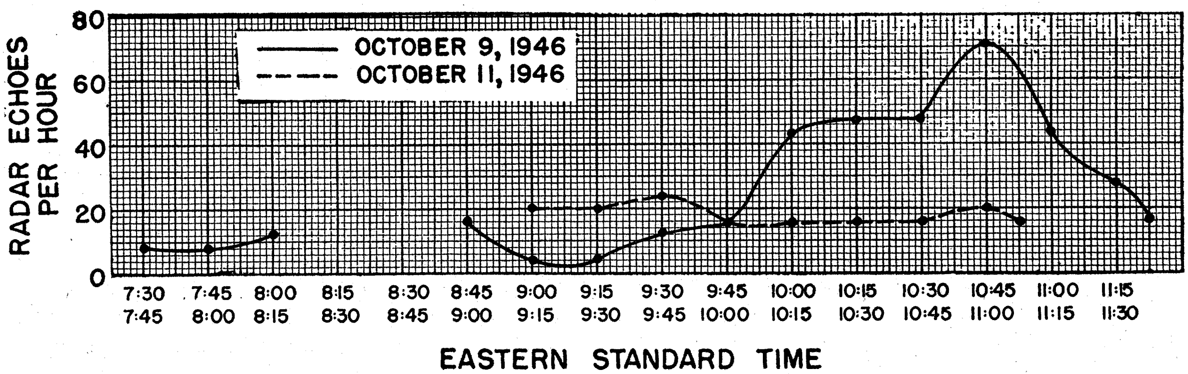

FIG. 2. Rate of occurrence of echoes on the nights of 9 and 11 October 1946 as observed with an Army type 270 Radar beamed 315° clockwise from North at an angle of 45° above the horizon (maximum hourly rate of occurrence of Draconids predicted for night of 9 October).

The Department of Scientific and Industrial Research, London, reported to *Science* that the 9–10 October experiments on the radio method of detection of meteors, organized by Sir Edward Appleton and R. Naismith at the Slough Radio Research Station of DSIR, were completely successful. The report said that astronomers had predicted that the earth would enter the meteor stream of the comet, Giacobini-Zinner, at about midnight, but it was not until between 3: 00 and 4: 00 A.M. on the 10th that the stream had been entered.

The Radio Research Station first detected these echoes in 1932 and has continued to investigate them ever since. A theory was evolved that they were caused by the reflection of radio pulses from meteor trails, and evidence was progressively built up to support the theory. On this occasion the burst of echoes was on a scale greatly in excess of anything previously experienced. The methods used also permitted the average height of the meteor train to be determined, and this came out to be about 60 miles above the ground.

The report pointed out "that it was by purely scientific experiments of this kind that Sir Edward Appleton and the Radio Research Station developed the methods of detecting reflecting bodies at a distance, which later became the basis of practical radar."