The Crystal Detector as a Rectifier of Short Waves[1]

MILDRED WILLIAMS BULLIET, Rockford, Illinois

The present paper is a report of an investigation into the supposed identity of Hertzian and heat waves.

Hertzian[2] and heat[3] waves that are polarized are reflected or transmitted by wire gratings in the same manner. Both groups of wave lengths have the property of being reflected when the grating has its elements parallel to the plane of polarization and transmitted when they are at right angles. In Hertzian waves this plane is identified with the direction of the spark. In the case of reflection, apparently a current is produced in the grating to give an opposing effect when parallel. An attempt was made to find this current in both wave length groups.

As a crystal detector seemed to be the only means available for detecting short waves, preliminary data were taken to determine if it were capable of detecting very short waves. An interference apparatus, as in Figure 1, consisted of two plain metallic mirrors, M_3 stationary,

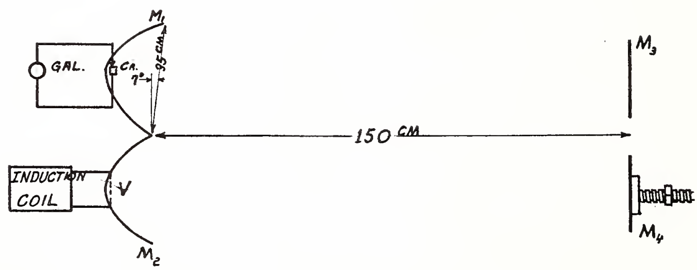

Fig. 1.

and M_4 set on a wooden base which was moved by a screw, and two parabolic metal mirrors, M_1 *and* M_2, with spark transmitter and galena crystal detector placed at their respective foci. Two spark gaps were made for producing waves of different lengths. For eight-centimeter waves, two 5/8 penny brads supported brass balls eight millimeters in diameter. The spark between the balls occurred in oil, and the connection to the induction coil was by air gaps. For four-millimeter waves, bits of No. 40 copper wire were cut in one-millimeter lengths, immersed in oil, and connected to the induction coil through Geissler tubes. To obtain the data for all of the positions of M_4, corresponding readings were taken on the galvanometer. The data are indicated in graphs 2 and 3.

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[2] Hertz, Electric Waves, 178.
[3] DuBois, H., and Rubens, Annalen der Physik, 32:243.

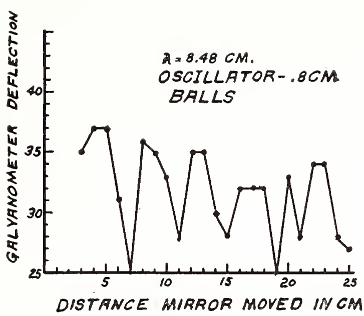

Fig. 2.

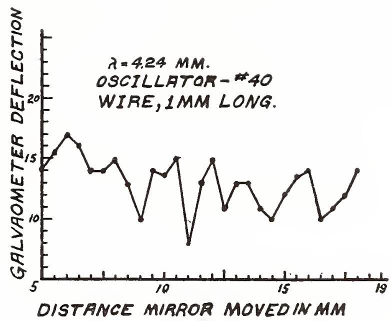

Fig. 3.

The wave length produced by the vibrators, as determined with the crystal, checked with data taken by other experimenters. The crystal was found to be sensitive to waves as short as four millimeters. Shorter waves of uniform length were not obtained.

In an effort to establish the fact that a current was produced in the grating by polarized spark waves, a grid was connected to a crystal detector and a sensitive galvanometer. The grids ranged in shapes from twelve inch squares to rectangles 5 by 30 inches. They also varied in size and in the number of wires. The spheres or oblong oscillators used to produce the spark waves transmitted wave lengths from eight centimeters to several meters. In some of the oscillators the spark occurred in oil. All were connected to the induction coil through air gaps. The induction coil was not shielded for some of the data. However, practically all data were taken with the induction coil either in a grounded copper screen box or in a steel box. In all of the data taken, no difference was indicated as to whether the grid was parallel or perpendicular to the plane of polarization. This electromotive force introduced into the untuned grid indicated the same spurious effect that Smith-Rose[4] called the "antenna effect" in the untuned practical direction finder.

In a receiver tuned to a short radio wave transmitter, a maximum electromotive force was indicated on the galvanometer when the receiver was parallel to the transmitter and none when it was horizontal. An untuned receiver under the same conditions gave the same small reading in both cases.

Since an electromotive force was found to exist in a wire grid that is excited by spark waves, an effort was made to find in a fine grid the existence of an electromotive force that was produced by heat waves.

This fine grating made by the National Bureau of Standards consisted of a half silvered glass plate with rulings made as close together as possible and yet have the silver strips continuous. As R. W. Wood and H. Rubens had succeeded in isolating long heat waves of the order of one-tenth of a millimeter from a Welsbach burner, this source was used. Since the rectification of short waves by a vacuum tube is limited by its physical dimensions[5] the crystal detector seemed to be the only rectifying device that might work. Therefore it was used in the two sets of apparatus that were made to find a current.

[4] Smith-Rose, Proc. Inst. Radio Eng., 17:434.
[5] Schreibe, A., Annalen der Physik, 73:54.

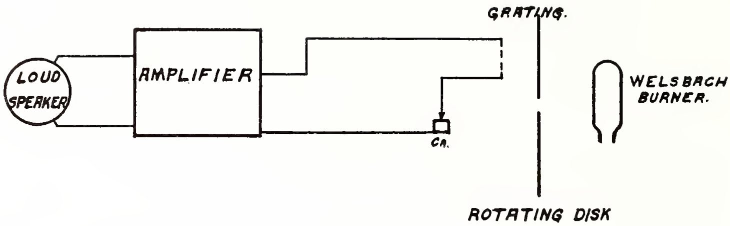

Fig. 4.

Figure 4 shows an audio frequency amplifier with an amplification constant of approximately 50,000 connected in series with the grating and the crystal detector. A rotating sector composed of a disk eleven inches in diameter and cut with twenty-four slots of about an inch width was placed between the Welsbach burner and the grating in order to modulate the wave with a frequency of about four hundred. The output of the amplifier was connected to a loud speaker. Although the alternating current hum in the speaker was not appreciable, no additional sound could be heard when the Welsbach burner was lighted and the disk rotated.

In the second piece of apparatus, a direct current amplifier using an FP 54 tube was connected to the grating and the crystal detector. This circuit was sensitive enough to pick up a potential as low as 10^{7} volts. It was necessary to shield all the apparatus except grid from the heat waves to avoid a spurious galvanometer deflection. Negative results were again obtained.

In the course of experimenting it was found that heat waves incident upon a crystal detector connected to a galvanometer showed a deflection that was opposite that of the spark waves. O. W. Pierce[6] made reference to this same condition and said it was observed with nearly all crystals. Evidently there are two ways that a crystal acts.

[6] Pierce, O. W., Physical Review, 28:153.

In conclusion it must be admitted that the essential results of this investigation are negative. However, this may be interpreted as positive evidence that the selected method of approach contained inherent limitations which defeated the purpose. That is, it would seem to be well established that a crystal detector used in a conventional radio circuit is not capable of detecting heat waves although it is good for spark waves in the region of four millimeter wave length. It is to be hoped that new methods may be devised for electrically detecting heat and, perhaps, light waves so as to establish experimentally the theoretical conclusion that these waves differ from Hertzian waves only in length.

I wish to thank Professor A. L. Foley, under whom this research was done, for his interest in the research and his valuable suggestions and Professor R. R. Ramsey for his aid.