THE TUNING OF THERMOELECTRIC RECEIVERS FOR ELECTRIC WAVES.

BY A. D. COLE.

IN some earlier work with electric waves,[1] the writer used a modified form of Righi exciter, the two central spheres of the usual form being replaced by thin cylinders with rounded ends. In connection with this work two assumptions were made: first, that exciter and receiver were identical in wave-length, being practically identical in form and dimensions. Second, that Poincarè and Righi are right in regarding the wave-length of a linear receiver as twice the length of the receiver itself. The purpose of the present experiments was to test these two assumptions.

Two exciters were used; in one the radiating cylinders were each 37 mm. long and 3.1 mm. in diameter, in the other 25 mm. long and of the same diameter. Thus the length of the active parts of the two exciters were 74 and 50 mm. respectively, the separating oil gap being of course only a small fraction of a millimeter long. The receiver was made of the same form and diameter as the exciters, but its length was variable and a thermo-junction of fine iron and constantin wires replaced the spark gap. The details of construction were similar to those described in the earlier papers referred to. The coarser German-silver or nickelin wires of the earlier instruments were replaced by a fine wire of constantin, only .025 mm. in diameter. (The thermo-electric powers of these three metals with respect to iron are 20, 39 and 51 microvolts per C° respectively.)

The same kind of iron wire as was used before was again employed, .024 mm. in diameter.

With this receiver deflections of 300 to 400 mm. were obtained with a galvanometer of 5 ohms resistance, the figure of merit being 4.7×10^{-9} with 13 second swing.

[1] Cole, Wied. Ann., 57, 298, or PHYS. REV., 4, 54, 1896; 7, 225, 1898.

The variation in the length of the receiver was secured by sliding tubes of thin metal over its cylindrical ends. Four pairs of tubes of different lengths make possible any length of receiver between 39 and 90 mm. To facilitate these adjustments of the receiver, it was mounted behind a cylindrical lens instead of being placed at the focus of a parabolic mirror in the usual way. This lens consisted of a 2.5 liter bottle filled with benzine. Its efficiency in concentrating the radiation was such that about five times as large a deflection was obtained with it as without it.

It was expected that a maximum effect would be obtained in the receiver when its length was only slightly greater than that of the exciter, on account of their identity of form. Such however was not the case, but instead the maximum was secured when the receiver was about 20 per cent. longer than the exciter. The results of a typical case are plotted in the accompanying curve (Fig. 1) in which receiver lengths are abscissas and galvanometer deflections ordinates. An exciter was used whose total length was 0 mm., the receiver length being changed by steps of about 10 mm. from 39 to 81 mm. Four readings were taken with each length and then the whole series taken in reversed order. A distinct though not very sharp maximum occurs at 62 mm. With the receiver length equal to that of the exciter (50 mm.) the galvanometer deflections were about 10 per cent. smaller.

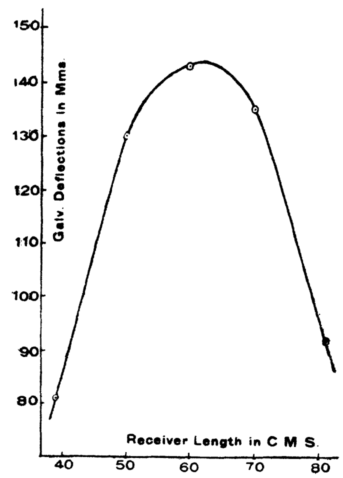

Fig. 1.

The wave-lengths were measured by three interference methods which gave results in fairly good agreement: (1) by reflection on a plane mirror behind the receiver as in Hertz's original measurements; (2) by reflection on a plane mirror behind the exciter, and (3) by Boltzmann's two mirror method.

The general character of the curves obtained is shown by Fig. 2. In this case a plane mirror behind the exciter was used. Abscissas show the distance of the mirror behind the exciter in cm., ordinates galvanometer deflections in mm.

Maxima occur at 15.0, 23.6, 32.0.
Minima " " 9.0, 18.5, 28.0 and 37.5.
Length of intervals between max. 9.6 and 9.4.
" " " " min. 9.5, 9.5 and 9.5.
Mean interval 9.5, $\therefore \lambda = 190$ mm.

Very different interpretations of such curves have been given by different workers. Thus Hertz[1] and Zehnder[2] regard them as a measure of the wave-length of the exciter, Sarasin and de la Rive[3]

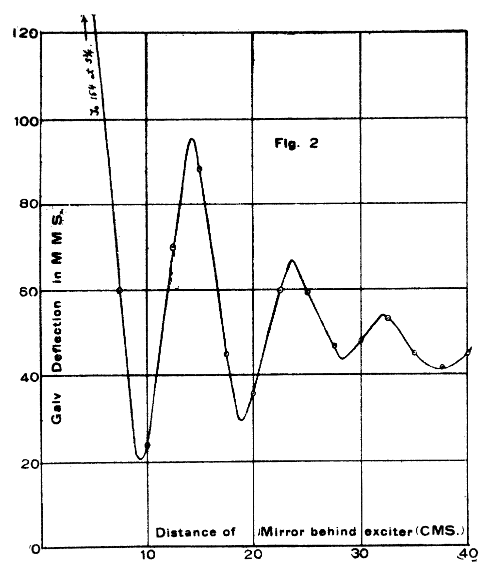

Fig. 2.

and Klemenčič and Czermak[4] have shown that the positions of the maxima and minima depend upon the dimensions of the receiver. Hull[5] concludes that they depend on both receiver and exciter and Willard and Woodman[6] reach a similar conclusion. The differ-

[1] H. Hertz, Wied. Ann., 34, 610, '88.
[2] L. Zehnder, Wied. Ann., 52, 34, '94.
[3] Sarasin and de la Rive, C. R., 110, 75, '90, and Phil. Mag., 31, 289.
[4] Klemenčič u. Czermak, Wied. Ann., 50, 174, '93.
[5] G. F. Hull, PHYS. REV., 5, 16, '97
[6] Willard and Woodman, PHYS. REV., 18, 19.

ent results obtained by these and other observers are in part due to the different kinds of exciters and receivers used and he different ways of producing interference.

With our apparatus the results clearly show that the wave-length measured is that of the receiver. For instance with exciter 74 mm. long and receiver 75, λ measured 188 mm. The experiment was repeated with the receiver length changed; λ changed correspondingly. The original receiver-length was then restored and the exciter-length changed; approximately the original wave-length was again obtained. The following are the figures:

	Exciter Length.	Receiver Length.	λ
Exp. 1	74 mm.	75 mm.	188 mm.
" 2	74	83	220
" 3	50	75	184

In these experiments the interference was produced by a plane mirror behind the receiver. That essentially the same curve is ob-

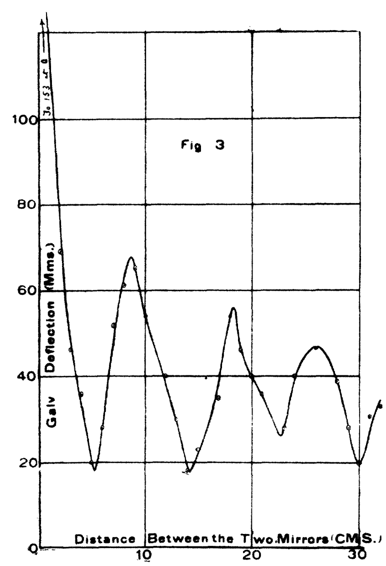

Fig. 3.

tained when the mirror is placed behind the exciter is shown by comparing the data of Exp. 1 with those given in the curve (Fig. 2).

		Mean.
Mirror behind exciter; intervals . . .	9.6–9.4– 9.5–9.5–9.5	9.5
" " receiver; " . . .	10.9–8.9–10.0–9.0–9.2	9.4

Here again the measured wave-length is evidently determined by the dimensions of the receiver. Fig. 3 shows a curve obtained by the Boltzmann two-mirror method. Two parabolic mirrors were used in this case.

Conclusions:

1. When a thermal receiver of linear form is used in connection with a Righi exciter, interference curves show the wave-length characteristic of the receiver.

2. When the receiver length is changed until a distinct maximum effect is produced from a given exciter, it is probable that the fundamental wave-length of each is the same, and an interference experiment will then (and only then) give the wave-length of the exciter.

3. The ratio of measured wave-length to receiver length as shown in five measurements (four referred to above and one other) is 2.53, 2.51, 2.65, 2.45 and 2.47 respectively. Mean 2.52. This agrees well with the value determined theoretically by MacDonald[1] (2.53) and not with the value (2.0) given by Poincarè.[2]

The above experiments were performed during the past summer at Ryerson Laboratory, University of Chicago, and the author is much indebted to Professor R. A. Millikan for placing the resources of the laboratory at his disposal and for his personal interest in the work.

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[1] MacDonald, "Electric Waves" (Adams Prize Essay).
[2] Poincarè, "Les Oscillations Electriques."