tables shows that wherever it is possible to give g sums, that they show an accuracy of considerably better than 1 percent, but we believe this result to be entirely fortuitous.

The configuration $1s^22s^22p3s$ is compared with Houston's[7] calculations for this configuration and the two levels with $j=1$ show considerable deviation from LS coupling and gratifying agreement between theory and observation.

Of particular interest in connection with the configuration $1s^22s^22p3p$, is the line λ6379, which has a pattern belonging definitely to a transition in which $\Delta j=0$, thus showing that Fowler and Freeman's and Pretty's designation of the level $3p\ ^1P_1$ (called by them $3p\ ^1D_2$) is incorrect, as pointed out by Edlén, on the basis of selection rules.

The configurations $1s^22s^22p3p$ and $1s^22s^22p3d$ show a large perturbation of the middle term of the middle triplet. $3p\ ^3P_1$ has a g value of 1.530 and $3d\ ^3D_2$ has a g value of 1.114, the LS g values being 1.500 and 1.167, respectively. Both of these results are too far different from the LS values to be accounted for on the basis of experimental error. No other levels of the configurations are close enough to produce perturbations of so large a magnitude. Nevertheless there are perturbations in both cases, as is evidenced by the fact that the $3p\ ^3P$ separations are in the ratio 1.65 : 1 instead of 2 : 1; and the $3d\ ^3D$ separations are in the ratio 2.52 : 2 instead of 3 : 2 for LS coupling. In addition to this, it has been pointed out by Condon and Shortley[8] that the intermultiplet separations are also considerably different from the LS values for the $2p$ and $3p$ configuration for the whole isoelectronic sequence C I, N II, O III, being in the ratio of 2.27 : 2 instead of 3 : 2 for $P-D/D-S$. They attribute this to interaction between the $2p$ and $3p$ configurations. There could also be configuration interaction between either of these configurations and the configuration $1s^22p^4$; and between the $3d$ configuration and $1s^22s2p^3$. Perturbations of this type are electrostatic, however, and their effects on g values would come as a result of their spoiling the electrostatic parameters which would in turn perturb the LS ratios and thus secondarily affect the g values.

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The Refractive Index of Water for Electromagnetic Waves Eight to Twenty-Four Centimeters in Length

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Wave-lengths were measured in air and water for continuous waves produced by magnetron and positive grid oscillators. Although high in absolute value, the index of refraction thus determined shows a decrease with increasing frequency, indicating a start of the drop toward the infrared value.

INTRODUCTION

EARLY attempts[1,2] with electromagnetic waves from spark sources have been made to detect experimentally the beginning of the dispersion region where the index of refraction of water drops from the long wave value of $\mu=\sqrt{\epsilon}=9$ toward the infrared value of $\mu=1.33$. This paper reports an investigation in the interval of wave-lengths from eight to twenty-four centimeters, making use of the improved stability obtainable with the magnetron and positive grid oscillators as sources of short electromagnetic waves.

Debye[3] and Bernal and Fowler[4] give some theoretical discussion indicating probable dispersion in this region.

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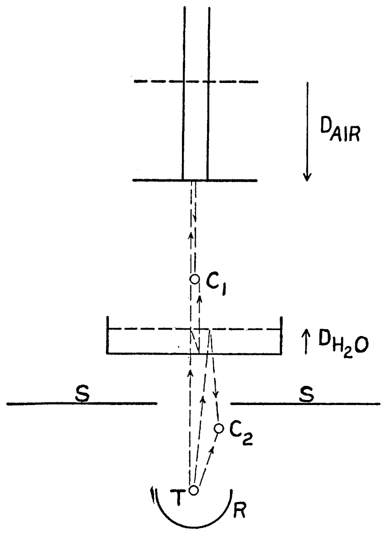

FIG. 1. Wave-length measuring system.

Experimental Method

The wave-length measuring system, Fig. 1, is a modification of that described by Miesowicz.[5] Polarized radiation from the transmitting antenna T, reinforced by the reflector R, passes between the screens S and up through the tank of water, reaching the crystal detectors C_1 and C_2 over the indicated paths. It can be seen that each crystal receives two beams of energy, one of which has been retarded over the other by passage through two thicknesses of the water. By interference, the energy received at either crystal goes through maxima and minima as the water thickness is varied. The spacing between successive maxima or minima of this interference curve, plotting current from the crystal detector against the water thickness, is one-half the wave-length of the waves in water. Similarly, the movable reflector shown above the crystal C_1 produces interference from which the wave-length in air can be determined. Fig. 2 shows several typical curves for both air and water.

The transmitters used are similar in general to those described adequately in the literature[6–11] except that the magnetron tubes were designed and built to be useful over a range of an octave for each tube. The positive grid tubes were of conventional design.

A more elaborate interferometer system, designed to measure the absorption coefficient as well as the index of refraction, was built and tried but proved unsatisfactory because of the intense diffracted energy which came around the mirrors employed in the interferometer. Its mirrors were 12 by 16 inches in size. Satisfactory results might be obtained with a much larger system, though a greater beam intensity would be required.

The curves with C_2 proved more satisfactory than those with C_1, because the interference with C_2 is superposed upon a straight zero line, while the interference with C_1 is superposed on the absorption curve for the water, making the peaks more difficult to locate. This can be seen by inspection of the water curves of Fig. 2. All curves were interpreted by taking as many independent peak-to-peak and trough-to-trough intervals as possible. Several curves were taken at each wave-length.

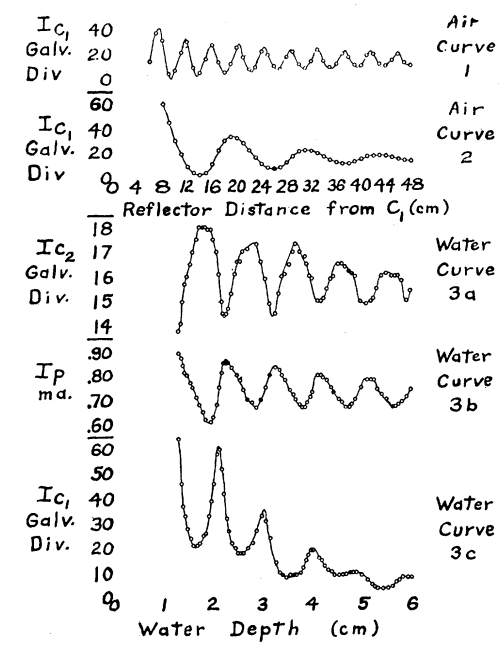

FIG. 2. Typical air and water interference curves. Curve 1. Air. $\lambda_0 = 8.53$ cm. Curve 2. Air. $\lambda_0 = 23.82$ cm. Curve 3. Water. *3a*, interference curve for crystal C_2, Fig. 1, *3b*, reaction on plate current of positive grid tube transmitter, *3c*, interference curve for crystal C_1, Fig. 1. From curves *3a*, *3b* and *3c*, mean $\lambda = 1.89$ cm.

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Results

Table I gives a summary of results for each wave-length and Fig. 3 shows the index of refraction for water, plotted against frequency. The two positive grid tubes had almost the same wave-length. They offered the added advantage of a third indication of interference, exhibited as reaction in the plate circuit of the oscillator itself as the water level was varied. This reaction is objectionable, however, and may introduce an error which could account for the fact that neither of the points determined with these tubes fall on the curve described by the magnetron points in Fig. 3.

The water temperature, recorded in Table I, was not the same for all the runs, but correction for this difference[12] would not shift the points appreciably in Fig. 3. The variation of index of refraction with temperature for long radio waves amounts to 0.23 percent decrease in index per degree increase in temperature. The extreme points on this curve were taken at the same temperature.

Conclusions

Fig. 3 shows a decrease of the index of refraction of water with increasing frequency, in agreement with the suggestions of Debye[3] and Bernal and Fowler.[4] However, the absolute value of the index at the low frequency end of the curve is greater than that given by $\mu=\sqrt{\epsilon}=\sqrt{81}$, where ϵ is the dielectric constant of water for frequencies of the order of a megacycle. An examination of curves 1 and 2 of Fig. 2 at once suggests that the air wave-lengths for the longer waves are not so accurate as for the shorter waves, due to the experimentally limited motion of the wave meter, allowing only a few peaks to be obtained for large λ while many could be obtained for small λ. The type of anomalous dispersion discussed by Debye[3] for this spectral region would lead to a monotonically decreasing value of μ with increasing frequency as shown in the *International Critical Tables*.[13] However, the experimental curve of Fig. 3 indicates a rise in the refractive index in the region between low frequencies and those employed here, and thus indicates a departure from the theory.

It is anticipated that a colleague in this work will carry out plans to investigate this method further. A beat frequency method of wave-length comparison should prove valuable.

The method employed here should be applicable to the study of the index of refraction of many fluids having low conductivity.

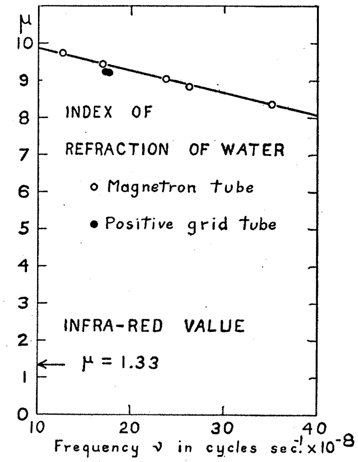

FIG. 3. Refractive index μ for H_2O.

TABLE I. *Summary for H_2O.*

Run No.	Mean λ_0(cm) in air	Mean λ(cm) in H_2O	Temp. °C	Tube used	$\mu=\frac{\lambda_0}{\lambda}$	$\nu=\frac{3\times 10^{10}}{\lambda_0}$
I	23.82	2.45	28	Magnetron #1	9.73	12.6×10^8
II	17.76	1.88	23	Magnetron #1	9.44	16.9
III	17.42	1.89	23	Positive grid #1	9.23	17.2
IV	17.02	1.85	24	Positive grid #2	9.22	17.6
V	12.65	1.40	21	Magnetron #1	9.04	23.7
VI	11.48	1.30	25	Magnetron #2	8.83	26.2
VII	8.53	1.02	28	Magnetron #2	8.36	35.1

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