Letters to the Editor.

Ground-absorption of Wireless Waves and the Electrical Conductivity of the Earth.

ACCORDING to Van der Pol,[1] Sommerfeld's value of "flat-ground" attenuation can be obtained from the formula:

$$\phi(\rho) = \frac{2+0\cdot3\rho}{2+\rho+0\cdot6\rho^2}$$

where ρ is Sommerfeld's "numerical distance". If d is the actual distance in kilometres from the transmitter ($d >> \lambda$), σ the electrical conductivity of the ground in e.m.u. and λ the wave-length in km., it can be shown that the numerical distance is given by

$$\rho = \frac{\pi 10^{-15}}{6\sigma} \frac{d}{\lambda^2}$$

provided wave-length is not too short ($\lambda >$ 200 m.) and the ground conductivity not too poor.

The formula is valid within a few per cent. for values of ρ up to 50.

By applying this formula to the radio-field-strength measurements round the various transmitting stations, we have obtained the following values of the effective conductivity of the earth for some of the *metropolitan cities* in a few directions: field strength at any longer distance d. This ratio plotted against distance d in a given direction gives the attenuation curve for that direction. Taking two points on this curve σ is calculated. It is expected that this *calculated* value of the earth-conductivity over metropolitan areas will be smaller than the *actual* value of the same, for attenuation of wireless waves in big cities is usually larger than in open countries due to energy-losses in large structures, buildings, etc.

For *open countries*, the value of land conductivity is of the order of 10^{-13} e.m.u. (see Pol, T. L. Eckersley, Dellinger and Corbeiller[5]).

It is curious that the open-country values of σ obtained from field-strength data are decidedly larger than those obtained by direct experiments with soil which agree on the other hand with the city-values of σ given in the table. For Daventry and Cambridge specimens of soil, for example, Ratcliffe and White's[6] values of σ under normal moisture conditions are $4\cdot5 \times 10^{-14}$ and $2\cdot6 \times 10^{-14}$ e.m u. respectively ($\lambda = 360$ m.). Our own measurements also by the method of Ratcliffe and White with specimens of

Cities	Directions	Range	σ in e.m.u.	Remarks
Calcutta ($\lambda = 370$ m.)	North-East	8 – 18 km.	$2\cdot60 \times 10^{-14}$	From Rakshit's field-strength data.[2]
	South	6 – 10 km.	$6\cdot00 \times 10^{-14}$	
London ($\lambda = 360$ m.)	North	0 – 20 km.	$1\cdot80 \times 10^{-14}$	From Barfield and Munro's data.[3]
	South	0 – 20 km.	$1\cdot80 \times 10^{-14}$	
New York ($\lambda = 492$ m.)	A	3 – 6 km.	$2\cdot90 \times 10^{-14}$	From Bown and Gillett's field-strength data.[4]
	B	8 – 10 km.	$8\cdot00 \times 10^{-14}$	
	C (hilly)	1 – 2 km.	$0\cdot80 \times 10^{-14}$	
Washington ($\lambda = 469$ m.)	A	0 – 20 km.	$2\cdot80 \times 10^{-14}$	Ditto.
	B	0 – 20 km.	$1\cdot65 \times 10^{-14}$	

In computing the above values of σ, we take the attenuation factor equal to $\frac{E.d}{E_0 d_0}$, where E_0 is the value of the field-strength at a distance d_0 which is so near the transmitter that there is no perceptible ground absorption and E is the value of

Dacca soil yielded a value equal to $2\cdot2\times10^{-14}$ e.m.u. for $\lambda = 181\cdot5$ m. The percentage of moisture to dry soil by weight is about 20 on the average. "For moderately damp land," Strutt's[7] value of σ is 5×10^{-14} e.m.u. (frequency $= 2 \times 10^6$ cycles/sec.). Recent measurements of Smith-Rose[8] give

[1] Van der Pol, *Exp. Wireless & W.E.*, Oct. 1930.
[2] H. Rakshit, *Phil. Mag.*, Jan. 1931.
[3] Barfield and Munro, *Exp. Wireless & W.E.*, 1928–29.
[4] Bown and Gillett, *Proc. I.R.E.*, Aug. 1924.
[5] Pol, Eckersley, Dellinger and Corbeiller, *Proc. I.R.E.*, July 1933.
[6] Ratcliffe and White, *Phil Mag.*, Oct. 1930.
[7] Strutt, *Exp. Wireless & W.E.*, Jan. 1931.
[8] Smith-Rose, *Proc. Roy. Soc.* (A), May 1933.

higher values of σ which, however, agree with the average open-country value obtained from field-strength data. For example, $\sigma = 1 \times 10^{-13}$ e.m.u. when the moisture content of the Teddington soil is 20 per cent.

Emphasis should not, however, be laid on these comparisons. There are uncertainties in the soil conditions, *viz.*, nature of the ingredients, moisture-content, vegetation on the surface, etc. Besides, it should be remembered that Sommerfeld's formula is applicable to vertical dipole aerials. The application of this formula to the field-strength data obtained with a transmitting aerial which gives directional effect cannot therefore be expected to give a correct estimate of σ. Again, the length and the lay-out of the aerial may at times considerably affect the attenuation of wireless waves from which the effective conductivity of the earth is calculated. If the ærial be an inclined multi-pole ærial, a part of the waves may be concentrated upwards. The old transmitting aerial of our wireless laboratory may be mentioned in this connection. The lead-in wire from the horizontal part of the aerial wire was very much inclined to the vertical and the total length from the insulated end of the aerial to the earth-point was about a third of the radiated wave-length. The voltage antinode was at the insulated end and a node somewhere down on the lead-in wire. Electrical oscillations could evidently take place between one part of the aerial to another in a slanting direction causing thereby a concentration of waves upwards. As a consequence, we[9] obtained a high value of attenuation in the city of Dacca.

Attention should therefore be directed to the transmitting aerial in order to get a correct estimate of σ by the application of Sommerfeld's theory of ground absorption to radio-field-strength data.

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[9] Chowdhuri and Khastgir, *Ind. Jour. Phys.*, **8**, Part V.

The Arc Spectrum of Selenium.

IN a recent paper,* the authors have published a set of energy levels newly found out in SeI, in the course of an extensive investigation on the spectrum of Selenium. Some of these levels were arbitrarily designated by the symbols *a*, *b*, etc., *h*. In the light of the (unpublished) results obtained by one of the writers (S.G.K.)† on the arc spectrum of Tellurium, it is possible, by a comparison of these two spectra, to make the following definite assignment of four of the above levels of SeI, thus:

Level Designation		Level Value	
Old	New	SeI	TeI
f	$5s(^1D)\ ^3D_2$	13379	14071
g	$^3D_1$	13357	13923
h	$^3D_3$	13316	13840
e	$^1D_2$	15183	15553

The corresponding levels identified in TeI are also included for comparison in the above table. It will be seen that both in SeI and TeI, the ^3D term is partially inverted although in SI‡ it is normal and further the ^1D term is deeper than the ^3D, of this configuration.

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* *Proc. Roy. Soc.*, (A), 1934, **145**, 695.

† *Curr. Sci.*, 1933, **2**, 210; see also Bartelt, *Zeits. f. Phys.*, 1934, **88**, 522.

‡ Frerichs, *Zeits. f. Phys.*, 1933, **80**, 156.

An X-Ray Investigation of the Crystals of M-Azotoluene.

THE crystals of m-azotoluene have been studied by the rotation method and the following values have been found for the dimensions of the unit cell:—

$a = 11{\cdot}88$ Å, $b = 13{\cdot}75$ Å, $c = 7{\cdot}52$ Å.

Thus $a : b : c = 0{\cdot}8581 : 1 : 0{\cdot}5469$.

This is in good agreement with the ratio determined by the crystallographers ($a : b : c = 0{\cdot}8556 : 1 : 0{\cdot}5438$.§ The crystals belong to the rhombic bipyramidal class.$ The observed halvings show that (hol) planes are

§ Gröth, Vol. **5**, p. 66.

$ Gröth, *loc. cit.*