Letters to the Editor.

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Short Wave Echoes and the Aurora Borealis.

ON Feb. 29 of this year I received a letter from Engineer Jørgen Hals, Bygdø, Oslo, in which he says: "I herewith have the honour to advise you that at the end of the summer 1927 I repeatedly heard signals from the Dutch short-wave transmitter station PCJJ (Eindhoven). At the same time as I heard the telegraph-signals I also heard echoes. I heard the usual echo, which goes round the earth with an interval of about $\frac{1}{7}$ second, as well as a weaker echo about 3 seconds after the principal signal had gone. When the principal signal was especially strong, I suppose that the amplitude for the last echo 3 seconds after lay between $\frac{1}{10}$ and $\frac{1}{20}$ of the principal signal in strength. From where this echo comes I cannot say for the present. I will only herewith confirm that I really heard this echo."

Immediately I heard of this remarkable observation, it struck me that the wireless waves were reflected from those streams and surfaces of electrons to which I was led by theoretical investigations on the aurora borealis in my paper published in 1904 in *Videnskabsselskabets Skrifter*, Christiania ("Sur le mouvement d'un point matériel portant une charge d'électricité sous l'action d'un aimant élémentaire.") In reference to that paper, and the subsequent more complete one in *Archives des Sciences physiques et naturelles*, Geneva, 1907, one of the most striking features of the theory was that streams of electrons coming from without towards the earth were deviated by the earth's magnetic field in such a way that an immense space was formed free from electric particles, and having the shape of a torus described by revolution of an oval tangent to the magnetic axis of the earth at the centre. These results were also in full agreement with Kr. Birkeland's remarkable experiments with cathode rays directed towards a magnetic sphere, described in 1901 in *Videnskabsselskabets Skrifter* ("Expédition norvégienne de 1899–1900 pour l'étude des aurores boréales"). If now the wireless signals could penetrate the Heaviside layer, they would pass into this empty space, and might be reflected by the walls of the electrons forming its outer boundary. The long time interval between the principal signal and the echo agrees well with the immense dimensions of these toroidal spaces.

It was now very interesting to me to obtain more evidence of these remarkable echoes, and last spring and summer I organised a long series of observations, for which I am very much indebted to Dr. van der Pol, at Philips Radio, Eindhoven, for his very efficient work in sending signals, and further to Elektrisk Bureau, Oslo, to the Norwegian Telegraph Administration, and to Engineer Hals, for aid in arranging the reception of the signals. The observations were continued during October, but no certain evidence was obtained before Oct. 11. Eindhoven emitted during the afternoon very strong signals of undamped waves of wave-length 31·4 metres, and Hals and I heard very distinct echoes several times, the interval between signal and echo varying between 3 and 15 seconds, most of them coming about 8 seconds after the principal signal. Sometimes two echoes were heard with an interval of about 4 seconds. I immediately telegraphed the success to Dr. van der Pol at Eindhoven, and asked him to control and verify the effect. Next day I received the following telegram: "Last night special emission gave echoes here varying between three and fifteen seconds stop fifty per cent of echoes heard after eight seconds stop van der Pol."

After this it seems that we have here a new and remarkable phenomenon, the study of which may throw much new light on the electric currents in space outside the earth and on their connexion with the aurora borealis and magnetic storms. The variability of the phenomenon indicated by the observations agrees well with the corresponding variability of aurora and the magnetic registrations. CARL STØRMER.

The Expansion of Charcoal accompanying Sorption of Gases and Vapours.

IT has been emphasised in a recent paper (Bangham, *Phil. Mag.*, **5**, 737; 1928) that our knowledge of the sorption process must necessarily remain incomplete so long as attention is focused solely on the behaviour of the gas or solution, to the entire neglect of any concomitant effect on the solid sorbent with which it is in contact. It was shown by Meehan (*Proc. Roy. Soc.*, A, **115**, 199; 1927) that even such a rigid structure as a block of charcoal expands considerably when taking up carbon dioxide, the expansion being of the same order as the water-movements of building materials as determined in the experiments of Stradling. From the theoretical point of view the effect is discussed in broadest outline in the first of the papers mentioned, but it is clear that much experimental work is necessary before a fully developed theoretical treatment is possible.

A modified form of Meehan's apparatus, made to our design by Messrs. Becker, has enabled us to make some preliminary measurements of the linear expansion of charcoal which has sorbed known weights of water vapour at pressures short of saturation. It was found that the expansion is not—as one might have supposed—directly proportional to the quantity of vapour sorbed, but that the curve obtained on plotting the variables is concave to the *expansion* axis, even in the region where the pressure of vapour is a considerable fraction of the saturation pressure. Apart from providing fairly direct evidence—if such were lacking at this stage—for the chemical, as opposed to the capillary-condensation theory of sorption at such pressures, this fact appears to throw considerable light on the question of the usual form of sorption isotherm, since it indicates that the mechanical disturbance suffered by the solid during the sorption of a given quantity of gas becomes greater and greater as the sorption proceeds.

It is remarkable that, within experimental error, the expansion is directly proportional to the *square* of the sorption value. The data obtained for carbon dioxide are also in substantial agreement with this relation; they are, however, subject to certain corrections which can be estimated with accuracy only when the apparatus is cut down. The following table gives a summary of the results so far obtained:

	Water.			Carbon Dioxide.		
	s.	η.	$\frac{\sqrt{\eta}}{s}$.	s.	η.	$\frac{\sqrt{\eta}}{s}$.
Increasing sorption series	2·22	0·056	0·106	0·900	0·087	0·326
	5·18	0·226	0·092	1·227	0·149	0·315
	6·83	0·416	0·094	1·418	0·177	0·297
	8·59	0·626	0·092	1·557	0·232	0·309
	8·98	0·689	0·093	1·843	0·295	0·294
				1·980	0·338	0·293
Decreasing sorption series	7·40	0·475	0·093			
	5·78	0·231	0·095			
	4·21	0·139	0·089			

s = Sorption value in milligram molecules.
η = Expansion in arbitrary units.