lower boundary against which waves travelling nearly vertically are sharply reflected. Now the apparent dielectric constant $\epsilon = 1 - \frac{4\pi^2 Ne^2}{m\omega^2}$ (where N is the density of electrons) diminishes with N, and even becomes zero for waves of 31·4 metre length and a density of *circa* 10^6 electrons per c.c. Moreover, with the dispersion law expressed by ϵ we easily obtain for the phase and group velocity: $v_{\text{phase}} \times v_{\text{group}} = c^2$, so that at the places where the electron density is near the critical one, the phase velocity becomes infinite, *but at the same time the group velocity approaches zero.* When it now happens that the relative variation of the electron density with height over a distance of a wave-length is small, then the waves may penetrate and soak well into the Kennelly-Heaviside layer and travel in regions where the group velocity is small; they will thereupon be reflected at the region where ϵ approaches zero.

It is obvious that in these circumstances a considerable time may elapse before the echo is received, though the waves have never travelled outside the earth's atmosphere. This point of view would also explain the curious echoes observed by A. Hoyt Taylor and L. C. Young (*Proc. Inst. Radio Eng.*, **16**, 561; 1928) which were distinct from the well-known round-the-world echoes (as was also remarked by Prof. Appleton at the last U.R.S.I. meeting). In fact, according to this explanation, any time-interval between signal and echo can be expected to occur, the phenomenon being wholly governed by the gradient of the electron density. This explanation fits in well with the fact that the time interval between signal and echo is extremely variable.

Our view is, therefore, that the group is compressed and 'bottled' for some time in those regions where the group velocity approaches zero.

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IN connexion with Prof. Størmer's interesting letter on this subject in NATURE of Nov. 3, it may be of interest to inquire whether by purely terrestrial agencies such long temporal retardations of short wave signals may be explained. Abnormally long retardations of such signals, returned from the upper atmosphere, were first announced by A. H. Taylor and L. C. Young (*Proc. Inst. Radio Eng.*, vol. 16, May 1928), who, in experiments carried out between Rocky Point and Washington, obtained retardations corresponding to a distance of transit of 2900 km. to 10,000 km., although the great circle distance between the stations was only 420 km. In discussing these experiments in a paper at the Brussels meeting of the Union Radio Scientifique Internationale in September last, it was pointed out that wireless waves, meeting the ionised layer at vertical incidence, would travel upwards until they were 'reflected' at a point where the group velocity was reduced to zero, and that if the ionisation gradient in this region was not large, the waves might be appreciably retarded before and after reaching the critical value of ionisation. Put quantitatively, the retardation of any signal sent up from the ground and received there again is $\frac{1}{c}\int\frac{ds}{\mu}$ (where c is the velocity of radiation *in vacuo, ds* an element of path, and μ the refractive index), and this quantity may greatly exceed $\frac{1}{c}\int ds$ if μ is very small for an appreciable part of the path.

Now the retardations observed by Engineer Hals and Prof. Størmer are much longer than those observed by Taylor and Young, but that intermediate values are sometimes obtained is evidenced by some work carried out in this laboratory by Mr. R. L. A. Borrow, who has succeeded in getting photographic registration of the echoes from Eindhoven (PCJJ) corresponding to retardations of 1 sec. The question arises whether waves of 30 metres can remain travelling with a low group velocity in the ionised layer for such a long period as 10 sec. and yet be of appreciable intensity on arriving again at the ground. As possible paths we might consider the waves as travelling round the earth in the ionised layer or as travelling horizontally into the sunset (or sunrise) discontinuity in the layer and being reflected there. If we consider the group velocity to be small, the calculation of the attenuation experienced by the waves turns out to be simple, the signal intensity being reduced to $e^{-ft/2}$ of its initial value, where f is the frequency of electron collisions with air molecules and t is the time of retardation in the layer. If we assume commonly accepted values for f at 250 km. above the earth's surface, a signal of 10 sec. retardation would be e^{-5009} of its original value, while at 400 km. the corresponding figure would be e^{-50}. Thus, unless the ordinarily accepted values of f are considerably in error, the attenuation of signals retarded by travelling at these heights would be very great. But if there were sufficient ionisation at heights of 600 km. or more, it is certain that retardation without much absorption could take place, although our inadequate knowledge of the values of f for such regions precludes a more quantitative statement.

There is, however, another possibility. If we think of the ionised layer as a 'reflecting' shell, the waves sent out by an emitting station will converge to some point near the Antipodes, which, in turn, may be regarded as a source from which another set of waves emerges. Now it is known that conditions in the layer alter very rapidly, so that the points to which the waves converge every $\frac{1}{7}$ sec. (the time of a circumferential journey) will vary rapidly. It thus may be some seconds before a particularly loud repetition of a signal reaches a particular region of the earth.

In conclusion, it may be pointed out that information relating to the question of terrestrial or extra-terrestrial 'reflection' may be obtained by testing whether waves of 30 metres, meeting the layer at approximately vertical incidence, actually penetrate it. Experiments to decide this point for slightly longer waves have been carried out in transmissions between the National Physical Laboratory and this laboratory as part of the programme of the Radio Research Board of the Department of Scientific and Industrial Research, and it is hoped that similar tests may be made on 30 metres shortly.

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The Hydroxyl Radical in Flames.

THE evidence in favour of the view that the hydroxyl radical is present in flames has been summarised recently by Bonhoeffer and Haber (*Z. Phys. Chem.*, **137**, 263; 1928). There is no doubt that this radical is the emitter of the 3064 A. band, present in the spectra of hydrogen flames, and Hulthén and Zumstein, and Bonhoeffer have shown that this band occurs in absorption when water vapour is heated to high temperatures. The discovery of the existence of this radical in flames has an important bearing on the development of our knowledge of mechanisms of the