receiver depends on the tuning, and the equation shows that this must allow for a slight departure from p on either side. An alternative and different way of putting it, is to say that the fluctuations of sinuosity may prolong themselves by a sort of loud-pedal effect, and cause indistinctness; unless some automatic damper can be applied. This might conceivably be possible, by a relayed magnetic field, but meanwhile I suggest that the easiest way of taking the variations of amplitude into account is to express them as the boundaries of a wave-band, to the whole breadth of which the receiver should be competent to respond.

I understand from a private letter that Sir Ambrose Fleming intends to put this to the test of experiment, and see if extremely selective tuning which serves for bass notes will be equally effective for the high-pitched harmonics essential for clear articulation; and vice versa. How wide a band must be to achieve this under customary conditions, I do not know, and I hope he will tell us the result; at present he does not believe in a wave-band at all, and his heresy must be of interest to all wireless experts. I rather sympathise with heresy, and hope he can substantiate this one of his, but I am exceedingly doubtful. The heterodyne method, of regarding a sinuous disturbance of fluctuating amplitude as a superposition of pure tones of slightly different frequencies, seems at first artificial, as he says, but it appears to correspond with experience; and if so, it is an interesting justification of the use of a trigonometrical equivalence familiar to many schoolboys, that " the sum of two sines is equal to twice the sine of half the sum into the cosine of half the difference ".

OLIVER LODGE.

Normanton House,
Lake, Salisbury, Feb. 6.

MR. BEDFORD's letter in NATURE of Feb. 8 appears to me to explain the difficulty raised by Sir Ambrose Fleming's article very clearly, but it is perhaps interesting to give the solution he indicates and evaluate the current set up in a receiver of frequency $r/2\pi$ when receiving a wave of frequency $p/2\pi$ modulated to $q/2\pi$.

If we write $p+q=\lambda$, $p-q=\mu$, the equation to be solved to give the disturbance in the receiver tuned to frequency $r/2\pi$ is

$$\ddot{u}+k\dot{u}+r^2u=\frac{A}{2}\{\sin\lambda t+\sin\mu t\}$$

and the solution is

$$\frac{A}{2}\left\{\frac{\cos\epsilon}{k\lambda}\cos(\lambda t-\epsilon)+\frac{\cos\epsilon'}{k\mu}\cos(\mu t+\epsilon')\right\}$$
$$+Ce^{-\frac{kt}{2}}\sin\left\{\frac{\sqrt{(4r^2-k^2)}t}{2}+\alpha\right\},$$

where $$\cos\epsilon=\frac{k\lambda}{\{(\lambda^2-r^2)^2+k^2\lambda^2\}^{\frac{1}{2}}}$$

and $\cos\epsilon'$ has a similar meaning with μ substituted for λ, while C and α depend on the initial conditions. These would normally be $u=\dot{u}=0$, when $t=0$.

Hence if $r^2=\lambda^2=(p+q)^2$,

$$\cos\epsilon=1,\quad\epsilon=0,$$

and the first term in the bracket becomes

$$\frac{1}{k(p+q)}\cos(p+q)t.$$

Thus a receiver tuned to a wave of frequency $(p+q)/2\pi$ will be disturbed by the incidence of a wave of frequency $p/2\pi$ modulated to $q/2\pi$, and unless the ratio of the resistance to the inductance of the receiving circuit is large, that is, unless k is large, the disturbance will be considerable.

Similarly, if $r=p-q$, a note of frequency $(p-q)/2\pi$ will be reinforced.

If r is not equal to λ or μ, disturbances of frequencies $(p+q)/2\pi$ and $(p-q)/2\pi$ will still be produced in the receiver, but the amplitudes will be small.

In any event, then, there will be the two side-band waves which under favourable conditions will produce large effects.

R. T. GLAZEBROOK.

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Surrey.

IN his comments on my letter in NATURE of Feb. 8 Sir Ambrose Fleming makes in rather categorical terms some statements that I think he would be inclined to modify if he could give this question a little more consideration. I would remind him that an unduly selective receiver most certainly *does* fail to reproduce high notes in their proper proportion. The effect is well known and observable at any time by anyone having a receiver in which the reaction is under proper control.

I agree that many receivers are insufficiently selective for practical purposes, but this neither alters the fact that a too highly selective receiver distorts by failing to pick up the side-bands nor proves anything with regard to their non-existence. I would submit, in fact, that theory, laboratory experiment and all practical experience unite in proving that in every sense of the word the side-bands do actually exist and that official regulations must necessarily be based on considerations of width of band as well as of amplitude.

CECIL L. FORTESCUE.

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Feb. 12.

THE correspondence in NATURE of Feb. 8 (p. 198) on the subject of the wave-band theory of wireless transmission has directed attention to the question of the physical existence of the so-called ' side-bands ' The following experimental results seem to indicate that these ' side-bands ' have, in every sense of the word, a very definite physical existence.

(1) It is possible to isolate one of the side-bands at the transmitting station and to transmit it separately, as in the system of single side-band transmission used on the trans-Atlantic telephony service.

(2) Bown, Martin, and Potter (*Jour. Instit. Radio Eng.*, vol. 14, p. 57) transmitted a modulated wave, received the carrier and the two side-bands separately, and showed that the ionised regions of the atmosphere had treated the three component waves in different ways, as if they were physically distinct. It appears that the atmosphere recognises the side-bands as separate entities.

(3) Rupp (*Zeit. für Physik*, **47**, p. 72; 1928) used a modulation method to change the frequency of a light wave, so that it could pass through a selectively absorbing vapour which had stopped the unmodulated wave.

J. A. RATCLIFFE.

Cavendish Laboratory,
Cambridge, Jan. 31.

THE correspondence on the existence of the Fourier components of a modulated carrier wave (NATURE, Feb. 8, p. 198) does not seem to have made the subject quite clear. The existence of anything cannot be a mere matter of point of view, neither can the root of the matter be exhibited by the form of the mathematical treatment necessary.