solution of sodium chloride, were in good agreement with those found by analysis. Thus in two samples, for example, the totals for chlorine calculated as NaCl were 6.443 and 6.541; the totals found were 6.535 and 6.61 grams. Chlorine likewise is apparently as free as in an aqueous solution.

The writer is at present developing a calcium electrode to determine the state of calcium in the blood.

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The Dimensions of Area.

IN my "Physics," pp. 423-426, it is maintained that it is incorrect to attribute to area (or volume) the dimensions L^2 (or L^3); but no example of an error arising from such attribution could be given. It has since occurred to me that an excellent and important example is provided by Child's high vacuum current law, according to which σ , the current density, is proportional to $\left(\frac{e}{m}\right)^{\frac{1}{2}} \frac{V^{\frac{3}{2}}}{l^2}$.

The laws assumed in the deduction of this relation are (1) $\frac{V}{l} \cdot A = a \cdot e$ (Poisson's equation), (2) $\sigma \cdot l \cdot A = \beta \cdot e \cdot v$, (3) $m \cdot v^2 = \gamma \cdot e \cdot V$, where A and v are area and velocity, and a , β , γ formal constants or no-dimensional magnitudes. If in place of A we write l^2 , we find that $\sigma^2 l^3 m \left(\frac{l}{e}\right)^n V^{n-4}$ is no-dimensional for all values of n . The solution is ambiguous and the Child relation is not deducible by dimensional argument, as it clearly ought to be. If, on the other hand, we retain A , $\sigma^2 l^4 \left(\frac{m}{e}\right) V^{-3}$ is the only no-dimensional magnitude independent of A and v ; we obtain a unique and correct result.

The removal of the ambiguity must be due to the introduction of some additional law. This additional law is that the ratio of the area in (1) to the area in (2) is independent of l , or that l is perpendicular to A in both cases, or that the electrons follow the lines of force. If we omit the important magnitude shape in stating the dimensions of A , this law cannot be introduced into the dimensional argument, because there remains no magnitude to measure direction.

The additional law is not quite strictly true because of the inertia of the electrons. It follows, therefore, that if the electrodes are arranged so that the curvature of the lines of force is very great, small departures from the Child relation are to be anticipated. But so long as the curvature is small, the relation will hold if the systems compared are geometrically similar, differing only in their size l . So far as I know, the relation has hitherto been proved only for parallel plane and concentric cylindrical electrodes; experimentally it is known to be true over a much wider range.

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19 Holland Park, W.11, June 4.

The Resonance Theory of Hearing.

MR. ACKERMANN (NATURE, May 20, p. 649) is probably correct when he states that the first incoming sound wave sets all the resonators of the ear temporarily in vibration, and also, that as the sound waves continue the vibrating resonators decrease in number until only those are left in motion that are executing either sympathetic or forced vibration in time with the incoming sound waves. But surely he has left out of account the probable

amplitude of the motion performed by the resonators, and the probable physiological properties of the mechanism, when he judges the intensity of the sound stimuli sent along the auditory nerve to the brain to be directly proportional to the number of resonators that are swinging at any moment?

At the present time we have practically no information concerning the type of response given by the auditory nerve. It may, like certain motor nerve fibres, obey the all-or-nothing law, or it may conduct with a decrement, or it may be graded in its response. But in all these cases the amplitude will be an important factor in deciding the response given by any one hair cell and nerve fibre. But there are, I think, other physiological factors which Mr. Ackermann has overlooked. For although we cannot directly stimulate the hair cells of the cochlea electrically and ascertain the approximate relationship between strength of stimulus and strength of response, so that we can demonstrate clearly that the auditory mechanisms have such physiological properties as threshold, latent period, simultaneous and successive contrast (as we can, for example, in the case of the skin end organs), yet we have sufficient evidence that these properties are exhibited also by the auditory mechanism as by the other organs of special sense. Reconsidering now the case that Mr. Ackermann has taken, and assuming as a basis for calculation—

- that the sound wave energy entering the ear in unit time is constant;
- that the pitch is constant;
- that the mean amplitude of all the resonators in vibration at any one time is inversely proportional to the number in vibration; and
- that the energy available for distribution is proportional to the length of time during which the sound waves have been arriving, i.e. that none of the energy entering the cochlea has been lost in eddies, friction, etc.;

the following table shows the number of oscillators in vibration and their mean amplitude:

No. of Sound Waves from Common Cement.	No. of Resonators in Vibration.	Mean Amplitude.
1	6000	·003
2	1000	·03
3	600	·08
4	450	·13
5	350	·21
6	290	·31
7	240	·44
8	200	·60
9	170	·80
10	150	1·00

It will be seen that after one sound wave 6000 resonators are in vibration with an amplitude of 0.003, whereas after 10 sound waves 150 resonators only are swinging with an amplitude of 1. The table shows that there is a rapid increase in the mean amplitude of the vibrating resonators at the commencement of a tone.

There is no pretence of any exactness in the above values. They merely illustrate the kind of results to be expected. It should be noted further that at any instant those resonators approximately "in tune" with the incoming sound waves will have amplitudes considerably greater than the mean value, others nearest to those which are coming to rest will have amplitudes less than the mean value.