rarefaction or condensation may be termed a *puff*. Repeated puffs will produce a series of free vibrations.

To the eye, each bit of vibration in Fig. 1 has a special *profile*. The profiles of the same vowel are nearly, but not quite, alike; those of different vowels are different. The eye learns to recognise the profiles automatically just as it recognises the profiles and portraits of persons; it performs no analysis. No amount of mutilation by lines, blotches or omissions changes the vowel character of a profile. So long as anything can be recognised, it remains the profile of the same vowel; it never changes to the profile of another vowel.

FIG. 1.

The sense of hearing recognises vowel vibrations as the same or different according to their sense impressions, that is, according to the likeness or difference of the profiles. There is no analysis. Experiments in filtering¹ show that any frequency or range of frequency can be removed from the vowel vibrations without changing the vowel character. So long as anything is left, the vowel remains the same one; it never changes to another vowel. The law of no change of speech character by mutilation is valid here also.

The puff and profile theory agrees with that of Willis-Helmholtz-Hermann in regard to the *production* of vowel vibrations by the action of glottal *puffs* on the air in the vocal cavity. It is opposed to it in asserting that the *perception* of vowel characters depends on the unanalysed *profiles* of the vibrations and not on any special frequencies or groups of frequencies.

E. W. SCRIPTURE.

Phonetic Laboratory,
62 Leytonstone Road,
London, E.15.

¹ See NATURE, 130, 275; 1932.

Magnetism of Copper

A LARGE amount of experimental evidence has been recently put forward to show that colloidalisation of certain metals is accompanied by large changes in their magnetic susceptibilities¹. I suggested some preliminary ideas to the effect that the increased

area of surface of the metal on colloidalisation might be responsible for the observed magnetic changes. Honda and Shimizu^{2,3} have recently offered the more definite view that, in the case of tin, the lattice constant is somewhat larger at the surface layer than in the interior, and that consequently the paramagnetic component due to the free electrons decreases and the diamagnetic component due to the bound electrons increases, so that the colloidal powders become more diamagnetic than the massive metal. According to them, colloidalising a metal has the same effect as cold-working, so far as the magnetic properties are concerned.

Copper is a metal for which we have trustworthy magnetic measurements when cold-worked. Honda and Shimizu found that on reducing the density of the metal by cold-working, the diamagnetic susceptibility increased in value, after the necessary corrections were made for the presence of ferromagnetic impurities. A similar increase of the diamagnetic susceptibility was observed when metallic copper was colloidalised.

Colloidal copper was prepared by an electrical dispersion method⁴, the dispersing medium being benzene or propyl alcohol. The dispersing and centrifuging experiments were conducted in the absence of air, and hence the possibility of chemical action modifying the results does not arise. It was found that the diamagnetic susceptibility (χ) of copper depended only on the dimensions of the particles and not on the nature of the dispersing medium. The magnetic measurements were made with a Curie balance, with water as the standard substance. Measurements were conducted at different field strengths to correct for the presence of ferromagnetic impurities.

The specific diamagnetic susceptibility of copper in bulk was found⁵ to be 0.080 (all values of χ are given in 10^{-6} units). As the size of the powders decreased from 10μ to 0.8μ , the value of χ showed a small increase from 0.080 to 0.090. When, however, the diameter was reduced from 0.8μ to 0.4μ , the value of χ showed a relatively larger change, from 0.090 to 0.135. These results fully agree with conclusions of Honda and Shimizu.

It will also be noted that the critical diameter below which χ increases rapidly is 0.8μ , which is much smaller than the corresponding values for graphite (1.5μ)⁶, bismuth (1.4μ)⁶ and tin (2.0μ)¹. Since copper has a face centred cubic lattice, we have no directional variations as in the case of graphite or bismuth. It appears, therefore, most likely that the observed changes of χ in the case of copper colloids are to be attributed to causes quite different in nature from those arising in the crystals just mentioned.

An approximate calculation shows that the surface layer wherein the density is less than the density inside the metal is of the order of a few hundred atomic layers.

Full details will be published shortly elsewhere.

S. RAMACHANDRA RAO.

Annamalai University,
Annamalainagar, S. India.
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¹ NATURE, 134, 288; 1934; Proc. Ind. Acad. Sci., 1, 123; 1934.

² NATURE, 135, 108; 1935.

³ NATURE, 132, 565; 1933.

⁴ Svedberg, "The Formation of Colloids", p. 28.

⁵ Ind. J. Phys., 6, 241; 1931.

⁶ Ind. J. Phys., 7, 35; 1932.