

is not changed appreciably by the space charge, which, for good conductors, certainly is justified.)

In order to calculate φ_B , consider a chain as in Fig. 2 with two opposite jumps of temperature in two different materials. This chain does not give rise to an E.M.F. As, with our assumption, simple differences of currents from both sides have to be considered at all contacts, one can remove intermediate links without disturbing the balance. At this point it is essential to neglect the back diffusion, as, otherwise, the numbers of electrons outgoing from both ends of the link $A-B$ will not be the same. Furthermore, one has to assume that the number of electrons for unit surface, which are retained by a given potential difference, does not depend appreciably either on temperature or on the nature of the metal. This condition is fulfilled, if the electrons are in a state of high degeneration, that is for all ordinary metals.

If we transpose in the above sense the 'hole' at B to the contact at A , and D to C , a symmetrical arrangement remains (one metal at T_1 , the other one at T_2 , and at both contacts a sharp jump of temperature) and, therefore, neither chain (the transposed or the original one) can give rise to any current.

If we substitute in the original chain a slow transition of temperature in solid material for the sharp discontinuities at B and D , there remains simply an ordinary thermocouple with a corresponding E.M.F. $F_{I,II}$. If we write down this balance we obtain the relation:

$$0 = F_{I,II} + \left(\varphi_D \left| \frac{T_1}{T_2} - \varphi T \right|_{II} \right) = \left(\varphi_D \left| \frac{T_1}{T_2} - \varphi T \right|_{I} \right) \quad (2)$$

or with (1)

$$- F_{I,II} = \varphi_{BI} \left| \frac{T_1}{T_2} - \varphi_{BI} \right|_{I} \quad (3)$$

Now, the E.M.F. of a chain can always be written as the difference of two functions characteristic for each of the two constituents.

$$F_{I,II} = F_I \left| \frac{T_1}{T_2} - F_{II} \left| \frac{T_1}{T_2} \right|; \quad (4)$$

and we obtain, therefore, by comparison with (3), the general result:

$$\varphi_B \left| \frac{T_1}{T_2} = F \left| \frac{T_1}{T_2} \right|; \quad (5)$$

that is, the potential of our special Benedicks chain is a magnitude which can be described as an absolute thermoelectric potential for a single material. It is, therefore, of the same order of magnitude as ordinary thermoelectric potentials.

It is to be noticed that the above result, though independent of any special model, is only valid for a suitable contact and a sharp discontinuity of temperature. It represents clearly the maximum effect possible. But as, according to our present picture, the free path comes out rather large, especially for low temperatures, where it reaches macroscopic dimensions, it should not be impossible to measure this effect.

A more complete discussion, together with a kinetic derivation and a treatment of related subjects, will shortly appear in the reports of the Réunion Int. de Chimie-Physique, Paris, 1933 ("Act. Sci. et Ind.", Paris, Hermann) and the *Nachr. Goett. Ak. Wiss.*

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¹ Benedicks, *Ergebn. d. Exakt. Natw.*, 8, 25; 1929. "Handb. Phys.", vol. 13, p. 200.

Chemistry of Cheddar Cheese-making

SINCE its introduction by Lloyd in 1895 in the south-western counties of England, the determination of the acidity of the whey exuding from the curd has been regularly used by cheese-makers as a means of timing the manufacturing operations. The acidities are generally expressed as percentages of lactic acid in the whey. During the later stages of the process, it is found frequently that there is a fall in acidity in the whey, more especially after the salt has been added. No valid explanation has been put forward for this fall in acidity, apart from the obvious ones, namely, that the whey after salting is diluted with fat and salt, and the acidity might be expected to fall.

Determination of lactic acid in the wheys at various stages in the Cheddar cheese-making process have shown that there is a steady and continuous rise in the percentage present, even through the salting stage, despite the fact that the titratable acidity at this latter stage either falls or shows no appreciable rise. The rise in lactic acid content is accompanied by a very marked rise in calcium content (already noted by Lloyd) and the lactic acid is carried out in the whey as calcium lactate which does not exert any appreciable buffer action at hydrogen ion concentrations intermediate between the normal hydrogen ion concentration of wheys and the phenolphthalein end point.

Determination of the lactose content of whey has shown that there is a sharp fall in the percentage of lactose in the water of the whey liberated by the addition of salt at the salting stage. This is due to a diffusion outwards of water from the curd, and probably to a liberation of bound water from the curd. The addition of salt to curd at any of the earlier stages of the cheese-making process produces a similar sharp fall in the lactose content of the whey, calculated on the basis of the water content; whereas the whey from the unsalted curd shows a steady fall in lactose content. That rennet curd contains a considerable quantity of bound water is indicated by the fact that the proportion of lactose to water in the whey immediately after the curd is cut is greater than the proportion in the original milk, indicating that about 2 per cent of the water in milk is bound, that is, cheese curd will contain a quantity of bound water equal to about four fifths of its casein content.

An attempt to throw some light on the action of salt on cheese curd has yielded interesting results. Sodium sulphate was added to milk to give a concentration of 0.1 per cent SO_4 radicle. The proportion of SO_4 to water in the whey showed a slight fall until the salting stage was reached; after which there was a sharp rise of about 50 per cent, despite the fact already referred to above, that there is a dilution of the whey either by osmosis or by the liberation of bound water. No well-founded explanation is submitted for this observation, but it is suggested that the curd may be acting as a membrane and that the rise in SO_4 content is a Donnan equilibrium effect.

These matters are receiving further attention at this Institute.

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