bottle can be substituted for the lamp. This gives a more uniform temperature distribution. Different materials might be used in the construction. Dried air might be passed through the apparatus. This would be advisable if working at room temperatures. However, at 70° C. the difference between the moisture holding capacity of the air and the actual moisture content of the air of the room is so large that drying the air would hasten the evaporation only slightly.

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SPECIAL ARTICLES

THERMOELECTROMOTIVE FORCES PRODUCED BY A MAGNETIC FIELD

In studying the effects of mechanical strain and of magnetization on the thermoelectric qualities of metals, Sir William Thomson[1] saw, with characteristic insight, that these two agents affecting thermal emfs were only special cases of a more general condition. He says, "Physical agencies having directed attributes and depending (as all physical agencies we know of except gravitation appear to do) on particular qualities of the substance occupying the space across or in which they are exerted, are transmitted or permitted with different degrees of facility in different directions if the substance is crystalline." Continuing, he enlarges upon this point of view and says, "Another very general principle is, that any directional agency applied to a substance may give it different capacities in different directions for all others."

The interpretation to be put upon these statements appears to be something like this; suppose two pieces of the same metal as in Fig. 1 are joined at A. If

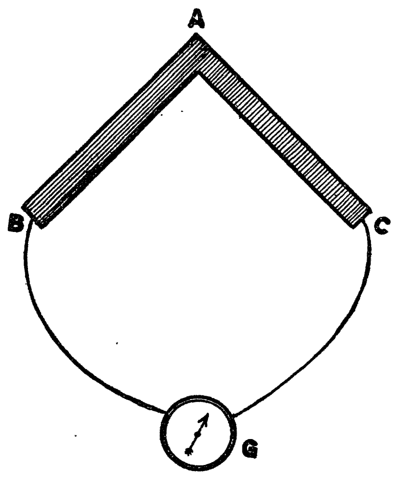

Fig. 1

AB shows properties along its length different from those along AC, they will serve as a thermocouple. For instance, if AB is crystalline with its axis extended along the length and AC has the same structure cross-wise, then if AB conducts heat, electricity or any other agent along its length differently from what AC does, these two elements will serve as a thermocouple, even though they are the same chemically.

By any means whatsoever, therefore, if we can give to AB and AC different structures so that they behave differently when placed in the path of some physical agent, we shall be able to find a thermal emf set up between the two elements. Either by stretching or by magnetizing a substance we accomplish just this effect. Thus we find a thermal emf between a stretched and an unstretched portion of a conductor.[2] We also discover a thermal emf between a permanently magnetized and an unmagnetized section of the same piece of ferromagnetic wire.[3]

A variation of this is shown in Fig. 2 where a con-

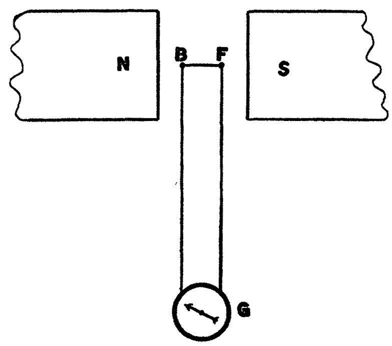

Fig. 2

tinuous iron or nickel wire is bent into a U-shaped form and placed between the poles of an electromagnet. Let one bend of the wire B be kept at the temperature of steam while the other F is maintained at freezing temperature. When the electromagnet is excited an emf occurs and a deflection of the galvanometer ensues. One may look upon this arrangement of the thermocouple as a condition in which the two elements consist of longitudinally and transversely magnetized portions. While the transversely magnetized sections, due to the very large demagnetizing factor, are not so strongly magnetized as the longitudinally magnetized portion, yet there is developed in each element a structure different from that of the other. They may, therefore, serve as a thermocouple. This was all clearly set forth by Sir

[1] Mathematical and Physical Papers, 2: 267.

[2] *Phys. Rev.*, 12: 243, 1918.

[3] *Math. and Phys. Papers*, 2: 286.

William Thomson in 1856 and has been theoretically discussed by Bridgman.[4]

Iron and nickel wires, both annealed and unannealed, have been studied in this laboratory by Wm. Ross. His arrangement of apparatus was that shown in Fig. 2. This work will appear shortly giving the details of the work. A modification is now being carried out by Stewart Seass in which the section BF of the iron and nickel wires is transversely magnetized

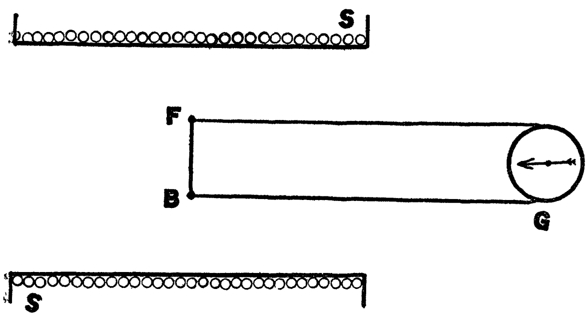

FIG. 3

by a solenoid as in Fig. 3. As was to be expected the direction of the current is opposite to that found by Ross. In the preliminary experiments by Seass it appears that if the wire is transversely magnetized all along the portion containing the junctions B and

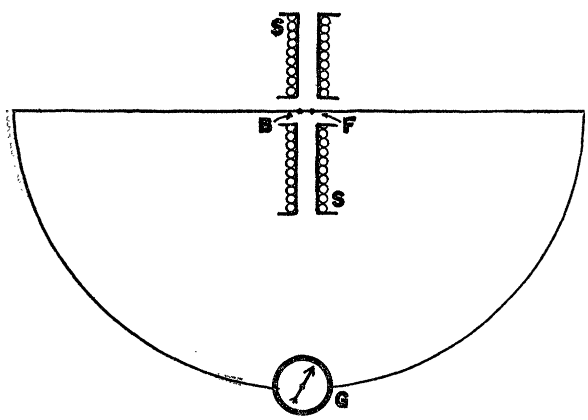

FIG. 4

F, as shown in Fig. 4, little or no emf is set up between B and F. Structurally all parts of the wire are the same, and therefore no emfs are developed. This is an important point.

In 1886 Ettingshausen and Nernst,[5] in studying the thermomagnetic effects in bismuth, came upon what they considered a new effect. If a plate of bismuth is heated at one end and kept cool at the other, as shown in Fig. 5, a magnetic field normal to the plate

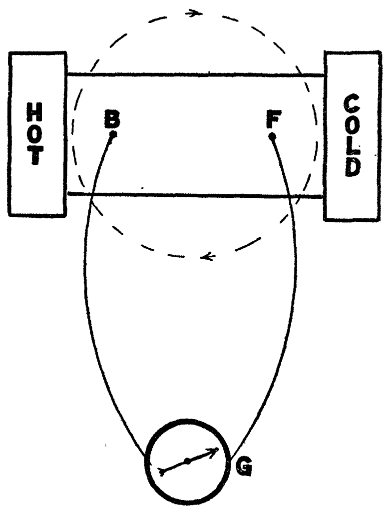

FIG. 5

and to the direction of heat flow, sets up a longitudinal emf between the points B and F. This has been called the thermomagnetic longitudinal potential difference.

If one regards carefully the disposition of the leads from the points B and F to the galvanometer, it will be seen that the Ettingshausen-Nernst effect appears to be a phase of the effect discovered by Thomson, a quarter of a century earlier.

Thomson's point of view gives some reason for the emf development in his discovery. An explanation is not so apparent when one considers the problem from the standpoint of thermomagnetic longitudinal potential difference. It would seem to the writer that this relation between Thomson's discovery and the later one by Ettingshausen and Nernst had not been sufficiently emphasized in the work which has been done on this subject. In the papers bearing upon the thermomagnetic longitudinal potential difference there seem to be a great many discrepancies. Little or no attention has been paid to the way in which the leads have been carried from B and F to the galvanometer. This is highly important and accounts for many of the discrepancies between various investigators. If there are two distinct effects present, at least one thing is very apparent, the majority of those who have studied the so-called Ettingshausen-Nernst effect have hopelessly confused it with the effect found by Thomson.

From whatever point of view one takes this phenomenon there appear to be several factors which enter to produce the resultant emf. This is a field which needs a great deal of careful investigation, both from the experimental and the theoretical sides. As Campbell[6] says, it is "a vast and fascinating

[4] *Phys. Rev.*, 31: 221, 1928.
[5] *Wiedemann's Annalen*, 29: 343, 1886.
Journal de Physique, 6: 292, 1887.

[6] "Galvanomagnetic and Thermomagnetic Effects," p. v.

domain, wherein dwell some of the mysteries of matter."

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THE PRODUCTION OF DENTAL CARIES IN RATS FED AN ADEQUATE DIET

ONE of the difficulties encountered by those who have been engaged in dental research has been the production of caries in experimental animals. In spite of the fact that diets have been fed known to be deficient in one or more of the dietary factors considered essential for normal dental development, there has been a striking absence of caries. This fact alone is impressive and suggests strongly a lack of correlation between the adequacy of the diet from a chemical point of view and the tendency of the diet to produce dental decay.

In a study made with rats on the effect of diet on dental development, we were surprised to find caries present in the normal control animals that were receiving the stock ration used in our laboratory. This ration (yellow corn 60, whole milk powder 30, linseed meal 6, alfalfa meal 3, sodium chloride 1) has given excellent results over a period of three years and is believed to be adequate for normal dental development and dental maintenance. In contrast to this, groups of rats receiving diets characterized by a high oatmeal, low calcium and low vitamin content, gave no indications whatsoever of dental decay, even though the dental structure was relatively soft. When oatmeal was substituted for cornmeal in the stock ration, caries failed to develop. Apparently, then, the cornmeal was responsible for the decay of the teeth.

In making periodic examinations of the teeth, it was observed that impactions of cornmeal particles occurred usually in the lower molars. This was followed in a few weeks by the formation of a small cavity which encouraged more impactions and subsequently more extensive decay. In many cases a complete destruction of one or more of the lower molars has been observed. The upper molars were rarely involved and then to a much lesser degree than the lowers.

The tendency for cornmeal to become impacted has been found to be primarily a function of the size of the particle. Cornmeal passing through a sixty-mesh screen appeared to have little or no tendency to become lodged in the crevices of the molars. Accordingly, when a group of rats received the stock ration containing cornmeal of this degree of fineness, there was no evidence of decay at six months. Another group receiving cornmeal that passed through a forty-mesh screen showed slight decay at three months, and at six months the crowns of the central molar teeth were destroyed. In the case of the rats which received the fairly coarse meal as supplied by a milling concern, caries was initiated at about eight weeks and at six months practically all the lower molars were involved in extensive decay.

Attempts to prevent decay of the teeth by the addition of cod-liver oil or orange juice, supplying liberal amounts of vitamins A, D and C, or by fortifying the ration with calcium carbonate or tricalcium phosphate have been of no avail. In view of these results it is difficult to accept the theory that dental caries is due primarily to a vitamin or mineral deficiency of the diet. The results rather are in strong support of a not at all modern point of view; namely, that the cause of dental decay is the decomposition, most likely by aciduric and acidogenic bacteria, of certain foodstuffs held by the teeth in some way or other.

Those who in recent years have emphasized the importance of the diet from the standpoint of vitamins and minerals as a means of preventing caries or of checking the progress of caries in human teeth have overlooked or perhaps have ignored the fact that in changing from a deficient to an adequate diet there have no doubt been marked changes effected besides the increase in vitamin and mineral content of the diet. The inclusion in the diet of greater quantities of fruits, vegetables and dairy products necessarily reduces the consumption of those foods which, because of their consistency and chemical make-up, have a tendency to be retained by the teeth and upon subsequent decomposition probably cause decay of the teeth. That the quantity of these particular foodstuffs consumed is an important factor is indicated by the fact that in a series of experiments in which various mixtures of cornmeal and oatmeal were used in compounding the stock ration a gradual increase in the frequency and severity of caries was observed as the amount of cornmeal was increased. Similar observations have been made in the case of other experimental diets in which different amounts of cornmeal were used. The increase in the diet of the so-called "protective" foods is no doubt also accompanied by a change in the physical properties of the food mixture as it exists in the mouth, resulting possibly in a marked decrease in the tendency of food to be retained by the teeth. There is also the possibility that the consumption of certain fruits, fruit juices or vegetables is accompanied by a definite cleansing of the teeth comparable perhaps to the conscientious use of a tooth brush in conjunction with an effective tooth paste.

In view of the results of the experiments described