should be freshly ignited.[2]) The solution remains clear for some time and on standing, more rapidly after agitation, crystals of ammonium magnesium phosphate make their appearance.

Titrate with 5/N HCl to a reaction of approximately pH 7.0–7.6 and add an equal volume of distilled water.

Procedure and results.—This decalcifying fluid is apparently efficient in softening bone after it has undergone the action of any of the common fixing agents, but it is perhaps better to fix and harden the specimen in formalin. The latter must be well washed out from the tissue, first in running water for 12–24 hours according to the size of the specimen, and then in two or three changes of distilled water. It is then ready for decalcification. The citrate solution should be changed fairly frequently, since it will otherwise dissolve the calcium salts to saturation and the reaction will then retard. It has seemed best to replace the solution every other day. Decalcification proceeds relatively slowly as compared with solutions of the strong acids such as hydrochloric or nitric but it is much more rapid than Muller's fluid, picric or chromoacetoosmic acid, for example. The rib of a dog split through the center is freed of lime salts by this solution in about fifteen days. Swelling of the tissues is not induced by the fluid and there is no apparent shrinkage of such cells as those of the bone marrow. Stains are taken up without difficulty and sections stained with haematoxylin and Eosin colored in tints much more pleasing to the eye than those obtained when the application of the stain has been preceded by decalcification with strong acids. Magnesium citrate solutions are not so satisfactory as is Muller's fluid, however, if determination of the amount of uncalcified osteoid tissue present in the bone during the life is requisite. Unlike Muller's fluid, magnesium citrate allows decalcification to go on to completion and removes all possibility of distinguishing the osteoid tissue from bone which in life contained deposits of lime.

Conclusions. 1. Bone may be completely and rapidly decalcified by means of a reagent which is neutral or alkaline and is free of acids. 2. This process leaves the remaining tissues in a satisfactory degree of preservation.

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SPECIAL ARTICLES

E.M.F. INDUCED IN A STRAIGHT WIRE BY A CURRENT IN A PARALLEL STRAIGHT CONDUCTOR

In Figure 1, let A be a cross-section of a tubular conductor of practically infinite length, and let a current, i, in this conductor flow "in," as shown by the crosses. Another long conductor, B, of small cross-section, is placed along the geometrical axis of A, and the ends of B are left open. It is required to compute the e.m.f. induced in B, per unit of its length, when the current in A varies with time at the rate di/dt.

Reasoning I. The magnetic lines of force outside the tube A are concentric circles, such as H. Within the wall of the tube they are also concentric circles. Inside the tube, the magnetic flux density is zero at any value of i. Consequently, no flux cuts B or collapses on it when the current i is varied, and no e.m.f. is induced in B.

Reasoning II. Consider two diametrically opposite filaments of current, such as f and f′, and determine the e.m.f. which a varying current in these filaments would induce in B. The three conductors are shown separately in Fig. 2. Let h be a line of force due to f, and h′ a line of force due to f′. Let the currents in f and f′ decrease; the motion of the two fluxes is then as shown by the horizontal arrowheads, each flux "collapsing" towards its own conductor. With

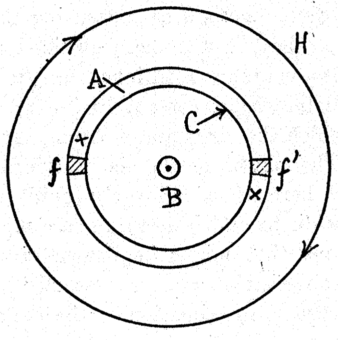

Fig. 1.

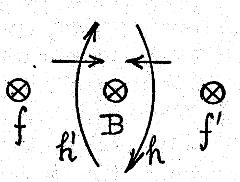

Fig. 2.

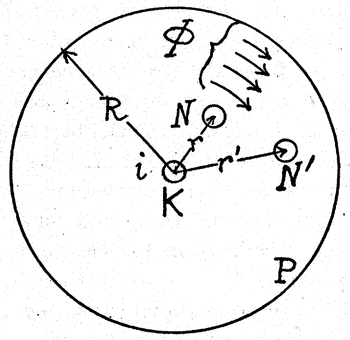

Fig. 3.

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[2] This reagent has been used by Mathison, G. C., *Biochem. Jour.*, 1909, IV, 237; Fiske, C. H., *Jour. Biol. Chem.*, 1921, XLVI, 289, and by others.

the polarities shown, the direction of the e.m.f. induced in B is "in," as indicated by the cross, the filaments f and f′ acting concurrently. This agrees with the general law that when the primary current decreases, the secondary induced e.m.f. is in the same direction as the primary current.

The tube A may be considered as consisting of pairs of filaments, such as f and f′. Since an elementary e.m.f. is induced in B by each pair of filaments, and the action is cumulative, a finite e.m.f. should be induced in B when di/dt in the whole tube has a finite value.

Thus, according to Reasoning I, there should be no e.m.f. induced in B, while according to Reasoning II, there should be an induced e.m.f. of finite value. Before unraveling this seeming paradox, the following propositions should be considered:

(1) Is it legitimate to speak of an e.m.f. induced between the open ends of a long straight conductor? To measure this e.m.f. it would be necessary to introduce leads to a voltmeter, thus forming a closed circuit. If an electrometer be used instead, the circuit would still be closed through electrostatic lines of force within the instrument. Should the leads and the measuring instrument be placed within the tubular conductor A, there should be no indication when the current i is varied. Should the instrument and the leads be placed outside A, a loop would be formed, linking with some of the external flux H, and the induced e.m.f. would depend upon the total flux enclosed by the loop.

(2) Careful writers do not speak of an e.m.f. induced in an open straight secondary conductor, but of the direction of the secondary current. This implies a closed secondary circuit and avoids the vexed question as to the seat and location of this e.m.f. See, for example, J. C. Maxwell, *Electricity and Magnetism,* Vol. II, p. 178; Foster and Porter, *Electricity and Magnetism,* p. 394.

(3) In Fig. 3, let K be a straight infinite conductor carrying a current i. Let N be a parallel secondary conductor of finite length, with open ends, at a distance r from K. Let the current i return through a cylindrical shell P of very large radius R.

The lines of force due to i are concentric circles, and the flux Φ, comprised between N and P, per unit of axial length, is proportional to i log(R/r). Should i vary at the rate di/dt, the e.m.f. induced in N, per unit length, would be proportional to (di/dt) log(R/r). But R is arbitrary and tends to infinity, so that the e.m.f. induced in N seems to be indefinitely large. Here again, to measure this e.m.f., the circuit of N would have to be completed, for example by means of a parallel wire N′, at a distance r′. The flux enclosed in this secondary loop has a finite value, proportional to i log (r′/r), and the e.m.f. induced in the loop (not in one of the conductors) has a definite value (finite) confirmed by experiment.

(4) If an e.m.f. could be induced in a long straight secondary conductor, as shown in Figures 1 and 3, then by grounding one end and providing the other end with a sharp point, an intense local electrostatic field should be produced. The existence of this field could perhaps be demonstrated by some delicate ionization experiment, Stark effect, etc. On the other hand, grounding one end would give a closed circuit, through displacement currents along lines of force between the sharp point and the ground, so that the experiment may not be conclusive.

Thus, on the whole, it seems as though the foregoing paradox is based on the impossibility of either computing or measuring an e.m.f. induced in an open conductor, without considering a return circuit of some kind, either conducting or through a dielectric. In view of the very fundamental nature of the phenomena and laws involved, it is hoped that other points of view will be contributed to this discussion.

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RATE OF VIRUS SPREAD IN TOMATO PLANTS

WHEN a plant is inoculated at one point with a virus disease, at what rate does the infective principle diffuse itself to other stems, leaves or shoots? Assuming that the incubation period is constant—that symptoms will appear in a given time after the infective agent has reached any point—the appearance of symptoms in a succession in other portions of the plant distant from the point of inoculation ought to provide a measure of the rate of virus spread from the original inoculation point. This observational method, however, relies on uniformity of growth in all parts of the plant and such uniformity may not exist; it further depends on the detection of symptoms at the same stage in their development, which is by no means a certain procedure.

The more direct method of measuring the progress of virus in a plant system here outlined appears to avoid the disadvantages mentioned and to provide a means, accurate within certain limits, of measuring the rate at which the virus moves from part to part of the plant. The results of the short series of preliminary tests are here recorded largely for the purpose of calling attention to and illustrating the method, since the conclusions that might be drawn from the few cases under observation must necessarily be accepted as only a rough approximation to the truth.

Eight tomato plants in pots were grown in such a manner as to develop several horizontal branches, each