in vitro the effect of acidity should be studied, particularly when the amœbicides are to be administered orally, and that tests should be carried out at a pH value of 6·2 or 6·3.

Under these conditions T.A.D.D. is three to five times as efficient as emetine. Moreover, when blood is added to the medium even at pH values otherwise favouring emetine, T.A.D.D. and emetine are of very similar amœbicidal value, the former at times showing a definite superiority.

The toxicity of T.A.D.D. to mice has been compared with that of emetine, with the following results:

	Median Lethal Dose (mgm./gm.)		
	Oral.	Subcut.	Intraven.
ακ-Tetra-*n*-amyldiaminodecane dihydrochloride	0·45	0·35	0·04
Emetine dihydrochloride	0·04	0·06	0·013

It has thus only one tenth of the toxicity of emetine when administered orally to mice and one sixth on subcutaneous injection. Its therapeutic index is therefore much more favourable than that of emetine, and it appeared to be an exceptionally promising compound for clinical trial in conditions of ill-health due to infestation with *Entamœba histolytica*. At this point, it was recommended to and accepted by the Therapeutic Trials Committee of the Medical Research Council for clinical trial. It was tried clinically by Prof. Warrington Yorke, who has kindly allowed me to state his results. He finds that T.A.D.D. has some action in amœbic dysentery, when administered orally, but is not sufficiently active to be of any real value. Unfortunately, it cannot be given intramuscularly, subcutaneously or intravenously, as it is intensely irritating.

It appears, therefore, that the comparison of the amœbicidal values of emetine and T.A.D.D. with a faintly alkaline medium gives a better indication of their relative clinical value than the comparison in a slightly acid medium. This knowledge will be of value in further work on the subject.

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A New Conception of Supraconductivity*

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5. According to these conceptions, *there cannot exist any magnetic flux 'frozen' in the interior of pure supraconductors*; a permanent flux should only be found confined to the *hollows of supraconducting rings*. The topological connectivity of a supraconductor, therefore, is a property extremely characteristic of its behaviour: the multiplicity of its connectivity, diminished by one, immediately indicates the number of independent conservative quantities, that is, of independent invariant magnetic fluxes.

Actually, however, in the classical experiments of Kamerlingh Onnes, already there have been found magnetic fields 'frozen' in even simply connected supraconductors. It was these permanent fluxes which seemed at that time directly to indicate the elementary phenomenon: an *infinite conductivity*. We, on the contrary, do not consider these experiments as representing the elementary case of the phenomenon, but rather as a relatively complicated affair which can be reduced to a still more elementary phenomenon.

According to our conceptions, we interpret these magnetic fluxes 'frozen' in the interior of the supraconductors as follows[6]: One knows that the presence of a magnetic field exceeding a certain critical value H_T (depending on the temperature T) destroys the supraconductivity. Now it can happen that some magnetic fluxes are confined in certain regions of the metal in such a manner that the critical magnetic field is there exceeded, whereas in the supraconducting regions the supraconductivity is maintained. Thus the appearance of the permanent fluxes should be conditioned by the formation of a complicated structure of the supraconducting and the normal phases in the metal in such a way that the supraconducting regions constitute rings embracing the magnetic fluxes in their non-supraconducting hollows.

6. It is easy to see that, even in very simple experiments, such a *mixed structure of the two phases* must automatically arise. This can be shown by considering, for example, a supraconducting sphere which is brought into a homogeneous magnetic field.

The sphere pushes back the magnetic lines of force and compresses them in the region near the equator. An elementary calculation shows that the intensity of the field immediately on the

*Continued from page 796.

equator (H_e) is one and a half times greater than that (H_∞) at great distance from the sphere :

$$H_e = \frac{3}{2} H_\infty$$

With an external field $H_\infty = 2/3 H_T$, therefore, the field on the equator attains just the critical value H_T, whereas everywhere else it is smaller than H_T. When we now intensify the field a little, the supraconductivity will be destroyed in the sphere immediately behind the equator. But then the magnetic field can enter this region and the magnetic lines of force will be less compressed. As a consequence the magnetic field at the equator will be a little less than H_T, and the supraconducting state will here reappear. If now we intensify the field a little more, the supraconductivity will be destroyed anew immediately behind the equator, whilst the supraconducting layer just formed will move farther into the interior of the sphere.

7. At first sight it seems extraordinarily difficult to make such a microstructure of layers accessible to theoretical treatment. To do this it would be necessary to solve a very complicated boundary problem for which the shape of the boundaries has still to be determined, whilst even their number is not yet known. It is possible, however, to avoid this practically insoluble problem, if one abstains from determining that microstructure in detail and rather restricts oneself to considering the *mean values* of the field strengths taken over this microstructure of the phases. Actually it is these mean values of the fields which are above all the object of the experimenter.

The theory of this mixture of the two phases[7], sometimes called 'intermediate state' is, therefore, nothing but a consistent application of the theory of the 'pure supraconducting' phase ; but formally it forms for itself an independent whole[8]. Here we will only give some of the results.

The variables of the theory of this intermediate state are the *averages* of **h** and of **e** taken over the microscopic structure. These are the quantities which Lorentz identifies with the quantities **B** and **E** of Maxwell's theory :

$$\mathbf{B} = \overline{\mathbf{h}} \quad \text{and} \quad \mathbf{E} = \overline{\mathbf{e}}$$

Here we will restrict ourselves to the pure magnetostatic case. The theory can be completely characterized by indicating the free energy F which, it has been calculated, is given by :

$$F = H_T \left| \sqrt{B_x^2 + B_y^2 + B_z^2} \right| - \tfrac{1}{2} H_T^2 \qquad (10)$$
$$(\text{for} \, |\mathbf{B}| \leqslant H_T)$$

By its derivatives with respect to B_x, B_y, B_z, the free energy defines the quantities H_x, H_y, H_z of the macroscopic Maxwell equations. One gets :

$$H_x = \frac{B_x}{\left|\sqrt{B_x^2 + B_y^2 + B_z^2}\right|} H_T, \text{ etc.} \qquad (11)$$

This equation can be simply interpreted by stating that in the intermediate state there is a diamagnetic permeability dependent on **B** which for $\mathbf{B} \leqslant H_T$ is given by

$$\mu = \frac{|\mathbf{B}|}{H_T}.$$

Moreover, one has the equations

$$\text{curl } \mathbf{H} = 0 \qquad \text{div } \mathbf{B} = 0$$

and the usual boundary conditions.

Although on account of equation (11) this theory is not a linear theory (like the theory of the pure supraconducting state or the ordinary Maxwell theory), it is nevertheless of extreme simplicity; (11) simply states that the magnetic field strength **H** is always parallel to the magnetic induction **B**, but that it has always the absolute value H_T, independently of the value of **B**. From this, among other things, it follows that, in the domain of the magnetostatics of the intermediate state, the magnetic lines of force are always straight lines.

For $\mathbf{B}=0$, however, according to (11) the field **H** is not defined as to its intensity or as to its direction. This comes from the fact that for $\mathbf{B}=0$ the pure supraconducting regions become unlimitedly large, which signifies that the description with the mean values **B** and **H** can no longer be legitimate and that one has now explicitly to apply the equations of the pure supraconducting state to the supraconductor as a whole. Obviously the case $\mathbf{B}=0$ cannot simply be considered as a limiting case of the non-linear theory.

8. We cannot enter here into a detailed discussion of the relation between theory and experiment. On the whole, one can say that the results of the theory agree fairly well with the experiments. With respect to the pure supraconducting state there is full agreement. Practically there exist three phenomena only : (1) the permanent current in a ring ; (2) the current without electric field in an open supraconducting wire, which is fed by normal conducting leads ; (3) Meissner's experiment. The consistent representation of these experiments was the basis of our theory. The greater part of the experiments (actually the Meissner effect also) concerns the transition between the normal and the supraconducting state and deals therefore with the intermediate state. Particularly striking in this respect are recent experiments of De Haas and Guinau, of Mendelssohn and of Shoenberg[9] as to the transition, qualitatively discussed above, of a sphere in a magnetic field. These experiments are in very

good agreement with the statements of our theory of the microstructure. In many cases, it is true, the experiments[10] of the transition phenomena seem yet to be obscured by hysteresis and other retardation effects, which prevent the realization of thermal equilibrium and render difficult the theoretical discussion. The theory can also account qualitatively for these disturbing effects[11], though there still remains something to be done. But for a reasonable discussion of these questions we would have to occupy ourselves with much more detail than could be given here.

The macroscopic theory we have discussed shows that it is possible to interpret the phenomena in a way which avoids the paradoxes that seemed hitherto to render impossible any theory of supraconductivity. The new interpretation includes, moreover, a very simple description of the phenomenon in the language of wave kinematics. The next stage will have to be the development of the electronic basis of this theory. One might presume that the new aspect here presented of supraconductivity may also give an indication for the construction of a molecular model of the supraconductor[12].

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[8] The magnetostatic part of this theory has also been developed by Peierls, R., *Proc. Roy. Soc.*, A, **155**, 613 (1936), quite independently of our conceptions, as a pure phenomenological description of a new 'intermediate' state, different from both the pure supraconductive and the normal state. But it can be shown[7] that, thermodynamically speaking, the intermediate state has not to be considered as a further independent phase but as a *mixture* of the two phases.

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Bicentenary of the Birth of Galvani

Celebration at Bologna

THE great contribution of Luigi Galvani to the advancement of the sciences of electricity and electro-physiology has been fittingly celebrated by a scientific congress held on October 17–20 at the invitation of the City and University of Bologna, the historic centre of learning where Galvani worked.

Galvani was born on September 9, 1737. In his early years it is recorded that he wished to enter the Church, but that on the insistence of his family he took to the study of medicine, and at twenty-five years of age had become lecturer in anatomy in the University of Bologna. Here his work lay in the field of anatomy and physiology until his great electro-physiological discovery made in 1791. It has been stated that the discovery arose from an observation that when animals were suspended on iron railings by copper hooks, a twitching of the muscles resulted. His published work states, however, that he observed the twitchings in the dissected muscles of a frog's leg whenever a spark was passed from a neighbouring electric machine to some other object, the only condition being that the animal should be in contact with some metal or other good conducting substance. A further experiment showed that the same convulsions could be obtained by the "sole application of some conducting arc", of which one extremity touched the muscles and the other the nerves or spine of the frog. The motion was believed by Galvani to result from a union of the negative charge of the muscle with the positive electricity proceeding along the nerve.

The discovery attracted the attention of Volta, working in Como, who thereupon made an extensive series of experiments. He showed in particular that convulsions could be excited in the legs or other members of the animals by "metallic touching either of two parts of a nerve only or of two muscles" provided only that an arc consisting of two metals was employed. He ascribed the effects seen to the electricity produced by the contact of dissimilar metals, and showed also that the electric current acted not on the muscles directly but through the medium of the nerves. These results, which were communicated to the Royal Society in 1793 by his countryman Cavallo, led directly to his construction in 1800 of the voltaic pile.

At the opening session of the recent Congress, attended by the King and Queen of Italy and members of the Government, Prof. Q. Marjorana delivered a commemorative address on the life and work of Galvani. Later in the day the delegates were invited to a formal opening of a library and collection of records of Galvani. For these sessions, Bologna made public holiday. The streets were lined with troops ; girls from the villages paraded