SUPERCONDUCTIVITY

High temperatures or futile efforts

Specialists continue their running argument over the possibilities

by Dietrick E. Thomsen

Superconductivity is an example of a scientific discovery looking for a technology. It was discovered 60 years ago that certain substances will conduct electric currents without resistance and without power loss. The technical potentialities are great, but the hitch is that superconductivity exists only at temperatures near absolute zero, and refrigeration problems make technological application impracticable.

Therefore investigators have continually sought materials that would become superconducting at higher and higher temperatures. But progress has been excruciatingly slow.

In the late 50's a theory of superconductivity that gave hope of higher temperatures led to a buoyant period, and many predictions were made. Dr. W. A. Little of Stanford University went so far then as to predict that superconductivity might be found at room temperature in certain organic materials.

But years went by, and the happy predictions were not confirmed. The mood changed to caution and even pessimism. In recent years one of the prominent experimenters in superconductivity, Dr. Bernd T. Matthias of the University of California at San Diego and the Bell Telephone Laboratories, has been pouring super-low temperature water on the prospects for high-temperature superconductivity (SN: 2/15, p. 169).

Now, however, Dr. Little, who has persisted in his study of the possibilities of organic superconductivity, comes back to say he feels he is very near success.

Over the years searches among amorphous mixtures, wafers and polymers failed to find superconductivity, says Dr. Little. But he goes on, "If the work is channeled correctly, I believe substantial progress can be made."

What is needed, he says, is an ordered structure on the atomic level, and the most likely candidate he sees is a hydrocarbon macromolecule. He is engaged in a series of experiments to manufacture a hydrocarbon according to specifications that would make it superconducting.

The trick to producing superconductivity is to make electrons pair off and work together. Normally electrons repel each other and will not pair, but the introduction of a proper third element can alter the balance of forces so that there is a net attraction between pairs of electrons.

The theory of superconductivity in metals has said that vibrations of the crystal lattice called phonons did this work; the low temperatures were necessary to allow the phonons to operate.

Now certain theorists are saying that other kinds of disturbance of the material, gathered under the general name excitons, may do just as well as the phonons.

Dr. Little calculates that the presence of electrically polarizable elements at the proper locations in the structure of a hydrocarbon molecule can produce an excitonic attraction between electrons. In the presence of electric forces the charge distribution inside a polarizable element shifts so that positive charges are concentrated on one side, negative charges on the other. This formation of a dipole tends to screen the mutual repulsion of two electrons if they are nearby. Dr. Little believes that he "can get a net attraction between electrons in the presence of an electrically polarizable entity."

The research is aimed at constructing a molecule which will have polarizable elements attached to the proper corners to make electrons pair and oscillate across the molecule. Dr. Little and his associates have not yet achieved a superconducting molecule, "but we have made a precursor to the molecule we want," he says.

And, he concludes, "Prospects of high-temperature superconductivity by the exciton method are alive and well and living at Stanford."

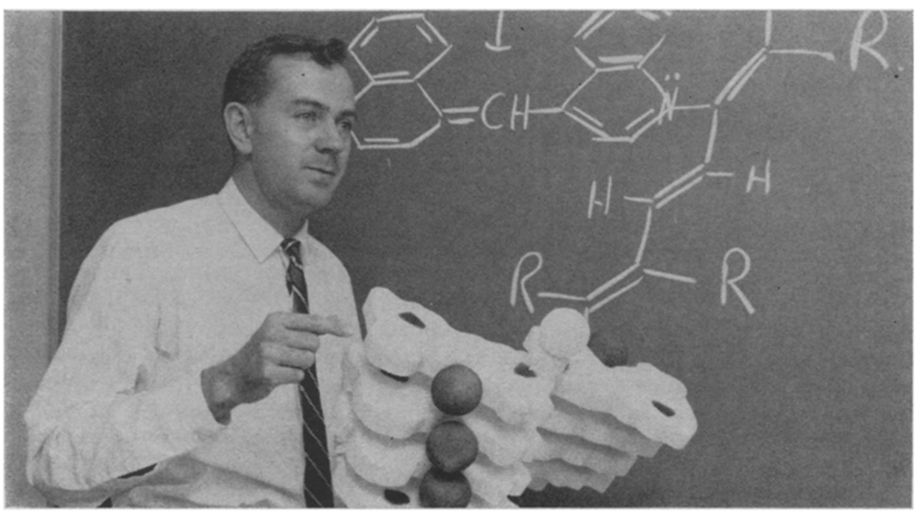
No matter what Dr. Little says, Dr. Matthias believes that such prospects are practically dead. Dr. Matthias does not believe in organic superconductivity, and he remains scornful of theoretical attempts at prediction.

"No single superconductor was predicted, no single transition temperature was raised" by theoretical calculation, he says. To theory he opposes what he calls "a very primitive empiricism" by which "we have discovered hundreds of them and raised transition temperatures."

At present the highest temperature at which superconductivity is known to appear is near 21 degrees K. "If we wait long enough we should get to 22.4 degrees," says Dr. Matthias. "I don't predict, I just extrapolate." For higher temperatures, he says, "Things really look rather dim."

"A pessimist is a well-informed optimist," says Dr. V. L. Ginzburg of the Lebedev Physics Institute in Moscow, but still he feels there is hope. He feels that specially prepared objects, like Dr. Little's macromolecules or the sandwiches of different materials that he himself suggested, may turn out to be workable.

"It is quite possible that we would never reach high temperatures," he says, "but we must pay attention to this kind of approach." ◇



Stanford

Little: For superconductivity, the very model of a modern macromolecule.