temperature range, this contribution exceeds the weak paramagnetic susceptibility of normal metals.

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V. V. Shmidt. Critical Currents in Superconductors

1. If the current in a superconductor exceeds a certain (critical) value, then the superconducting state is destroyed. It is necessary to emphasize immediately that in the case of films and superconductors of the second kind, the destruction of superconductivity is not due to the magnetic field of the critical current, but to other causes. Only in the case of bulky superconductors of the first kind does their transition to the intermediate state occur when the magnetic field produced by the current on their surface reaches a critical value (the Silsbee rule).

When the current in the superconductor reaches a critical value, the superconducting state loses stability and a resistive state sets in.

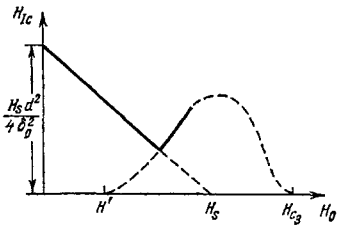
2. The critical current in a film whose thickness is $d \ll \xi(T)$ ($\xi(T)$ is the dimension of the Cooper pair or the coherence length) is determined in accordance with the Ginzburg-Landau theory[1], and the critical current density is

$$j_c \approx (c/4\pi) H_{cm}/\delta_0,$$

where H_{cm} is the critical thermodynamic field and δ_0 is the depth of penetration of the weak magnetic field. A physical explanation of the instability of the superconducting state in the case of such a current reduces to the following. An increase of the current in the superconductor means an increase of the velocity of the superfluid flow of the Bose-Einstein condensate. However, when this velocity increases, the unpairing of the electrons becomes stronger, i.e., the concentration of the Cooper pairs or the concentration of the carriers of the superconducting current decreases. There exists therefore a certain maximum current which can still flow in a stable manner in the superconductor. This indeed is the critical current.

3. Rigid superconductors are heterogeneous superconductors of the second kind. There exist several models of a rigid superconductor.

The "sponge" model: The rigid superconductor is a matrix made of soft superconducting materials, permeated by a network of thin filaments, which retain



superconductivity even when the matrix goes over into the normal state. This includes the case when the superconducting filaments run through a normal matrix. The model is applicable to certain special cases: eutectic alloys, an alloy of the type Zr + 4%Nb[2], when thin filaments of the superconducting β-Nb phase exist in the non-superconducting matrix, and synthetic superconductors obtained by pressing a superconductor through porous glass.

The critical current of the "sponge," its distribution over the cross section of the superconductor, and its dependence on the external magnetic field were calculated[3,4]. It turns out that there exists a characteristic filament density $n_0 = (3\sqrt{3}/\pi)\delta_0^2/Lr_0^3$, where L is the thickness of the "spongy" plate, r_0 is the radius of the cross section of one filament. An increase of the density of the filaments above n_0 does not lead to an appreciable increase of the critical current through the "sponge."

4. The "pinning" model[5], in which the matrix is a superconductor of the second kind. In the matrix there exist non-superconducting segregations in the form of macroscopic particles of another phase, pores, chemical compounds, etc. Superconducting vortices, which are produced in the superconductor when the latter is in the mixed state, become fastened to these segregations, i.e., "pinning" of the vortices occurs. The critical current is the one at which instability of the vortex system occurs, i.e., at which the Lorentz force produced by the current and acting on the vortices exceeds the "pinning" force. The "pinning" model in the form proposed in[5] does not describe the entire aggregate of the experimental data on critical currents in rigid superconductors, particularly the peak effect in the dependence of the critical current on the external field. This model requires refinement.

5. The dependence of the critical current on an external magnetic field in ideally homogeneous films made of superconductors of the second kind is considered in the case when the magnetic field is directed parallel to the surface of the film and perpendicular to the transport current[7,8]. The thickness of the film d satisfies the inequality $\delta_0 \gg d \gg \xi(T)$. In this case the critical current is determined by the start of the development of the vortex instability in the film, and its dependence on the magnetic field H_0 is shown in the figure. The field H′ is the minimal supercooling field of the mixed state:

$$H' = (\pi^2\delta_0^2/\sqrt{2}\varkappa d^2) H_{cm}, \qquad \varkappa = \delta_0/\xi(T);$$

the field H_S is the maximum superheat field of the Meissner state, $H_S \approx \sqrt{2}H_{cm}\delta_0/d$; the field H_{Ic} is the magnetic field produced by the critical current on the surface of the film. The results denote the existence of "pinning" in an ideally homogeneous film as a re-

sult of the interaction of the superconducting vortices with the surface of the superconductor.

6. Modern materials capable of carrying large currents are obtained as a result of complicated mechanical working and heat treatment. This produces in them a layered-filamentary microstructure. The separation of the normal-phase particles usually begins on the boundaries of the fibers. Therefore the film considered in Sec. 5 can be regarded as a certain idealization of such a fiber. This uncovers the possibility of combining the "sponge" and "pinning" models. It is possible that the peak effect in the film (see the figure) explains the peak effect observed in many rigid superconductors.

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V. L. Tal'roze. Chemical Lasers.

The present status of research and the results attained in the field of chemical lasers, compared with other existing types of lasers, are quite modest, although the very idea of chemical lasers is almost as old as the lasers in general. Non-equilibrium excitation in the associated chemiluminescence of the products of a large number of chemical reactions have been known for a long time, and have been investigated in sufficient detail. On the other hand, the formation of an inverted population of vibrational levels was apparently first observed by Polyani in 1961 in the HCl molecule produced in the reaction between atomic hydrogen and the chlorine molecule. It was this reaction which led, in final analysis, to the development of the first chemical laser in 1965 by Casper and Pimentel.

What attracts researchers to chemical lasers is apparently the following: (1) The large energy reserve per unit volume and weight of the reacting substance. (2) The practically unlimited volume in which the process of such an energy release can be organized. (3) The possibility of direct transformation of chemical energy into an energetically perfect optical form of energy and the production on this basis of laser power systems, which so far, of course, are still in the fantasy stage.

In the USSR, papers on chemical lasers were published by four groups of scientists: N. G. Basov, A. N. Oraevskiĭ, and co-workers (Physics Institute, USSR Academy of Sciences), Dolgov-Savel'ev and co-workers (Nuclear Physics Institute, Siberian Division of the USSR Academy of Sciences), R. V. Khokhlov and co-workers (Moscow State University), and the author's own group at the Institute of Chemical Physics of the USSR Academy of Sciences. So far, all the actually operating chemical lasers are based on chemical reactions in which they are elementary acts that lead to the formation of vibrationally-excited molecules HCl, DCl, HF, and DF. In 1963, the author presented the principles of the kinetic theory of the chemical laser. One of the conclusions of this theory was the advantage of chain and especially branched-chain chemical reactions as the working process in chemical lasers. There are at least two such advantages: the possibility of transferring the system from a relatively stable state into a state of rapid reaction to small changes of temperature or pressures, namely the transfer of the system to the ignition region, and the spontaneous increase of the reaction rate in this region as a result of branching of the chain to rate values at which the creation of inversion overtakes the relaxation to such an extent that generation with considerable efficiency becomes possible. The first generation with the aid of a branched-chain chemical reaction was realized in 1968 by the author together with G. K. Vasil'ev and O. M. Batovskii. The working mixture was the hitherto unused $H_2 + F_2 + O_2$ mixture. The branched-chain character of the chemical reaction in this mixture was discovered earlier by N. N. Semenov, A. E. Shilov, and co-workers at the Institute of Chemical Physics. The branching itself is here energetic ($HF^* + F_2 \rightarrow HF + 2F$). With the aid of a low-power and short electric discharge it was possible to transfer the mixture to the region of self ignition both through the first and through the second limit, and short generation pulses were obtained, lasting several microseconds, with a peak power on the order of 10 kW and a chemical efficiency up to 2%.

The constants of the rates of all the elementary acts of the reaction were measured independently, and this made it possible to construct a semiquantitative theory of such a laser; the conclusions of such a theory are in satisfactory agreement with experiment.

The published data on chemiluminescence on electronic transitions, on the basis of which no one has yet succeeded in developing a chemical laser, are analyzed in the paper. In particular, strongly luminescing reactions in liquids are considered, particularly reactions of the type that determine the luminescence of biological objects (e.g., oxidation of luciferin, where the light yield reaches 88 photons per 100 reacting molecules). The main problem, for which a solution is still unknown, is that of "rapid" realization of these reactions.

V. V. Fadeev. Ultraviolet Lasers Using Organic Scintillators

1. One of the important problems of quantum electronics is to obtain powerful radiation in the UV band and to ultimately cover the entire band. To solve this problem it is necessary to produce in the UV band sources whose frequency can be continuously varied. One of the promising methods is the method of converting the frequencies of the available sources (e.g.,