It appeared that in this entire range the expansion coefficient of $Nb_3Sn$ was slightly greater than that of niobium—the difference in the coefficients decreases from $3 \times 10^{-6}$ at 300°K to $2 \times 10^{-7}$ at 2.4°K (being $1.8 \times 10^{-6}$ at 70° and $6 \times 10^{-7}$ at 16°K). This indicates that the thermal properties of $Nb_3Sn$ and Nb are very similar, i.e., the Debye temperatures are also close. The closeness of the elastic constants of these substances agrees with this also.

As has been made clear earlier,[2] a bimetallic spiral is also very sensitive to volume changes in its components under hydrostatic compression. For example, even 0.1 atm sufficed to rotate a copper-tin spiral enough to enable the difference in the compressibility coefficients of these metals to be determined at this pressure. The spiral of $Nb_3Sn$–Nb showed that the compressibilities were equal throughout the entire temperature range, within the accuracy of the experiment (± 5%).

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## *INTRAMOLECULAR ENERGY TRANSFER AND QUANTUM GENERATORS*

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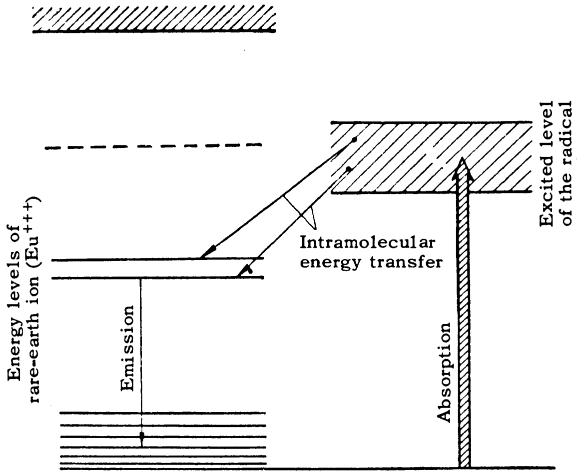
THE most efficient among the many quantum generators (lasers) developed so far to operate in the visible and in the infrared regions is the ruby laser. Its high efficiency is due for the most part to the location of the energy levels of the chromium ion. The energy spectrum of the $Cr^{+++}$ ion, which isomorphically replaces the $Al^{+++}$ ion in the corundum lattice, comprises a system of broad and narrow excited levels, of which the most important to laser operation is $^2E$, the transition from which to the unexcited state $^4A_2$ is accompanied by luminescence, and the broad level $^4F_2$ which lies somewhat above it. The transition from the unexcited state $^4A_2$ to the $^4F_2$ level ensures absorption of the pumping light in a broad spectral interval (5300—6000 Å). On the other hand, because of the small width of the $^2E$ level, the emission is in a narrow spectral line, so that the oscillation conditions are easier to satisfy[1]. The closeness of the levels $^4F_2$ and $^2E$ results in high luminescence yield, so that high laser efficiency is feasible in principle.

In most other luminescent substances, the levels are not so located. As a rule, in substances with narrow luminescence lines the broad absorption band lies too high. It is known, for example, that the ions of rare-earth elements exhibit photoluminescence, with narrow luminescence lines. The luminescence of these ions is due to transition between the excited levels of the inner 4f shell of the ion. All these levels are very narrow, since the 4f shell is well screened against external perturbations by the 5s and 5p shells. The broad levels connected with the excited 6s and 6p states lie very high. Thus, in the trivalent europium ion the luminescence levels lie not higher than 20,000 $cm^{-1}$ whereas the broad absorption level is at 40,000 $cm^{-1}$.

We wish to call attention to one yet-unused possibility. As was shown by Weissman[2] and confirmed by Sevchenko and Trofimov[3], in molecules of some complex compounds energy transfer is observed from some atoms of the molecule to others. These investigations pertained to europium and samarium compounds of the type $EuR_3$ and $SmR_3$, where R is an organic radical. In some cases these states lie near 25,000 $cm^{-1}$, which is sufficiently close to the luminescence levels of the rare-earth ions.

The luminescence of the investigated compounds is determined by the 4f shell of the rare-earth ions. This shows that the energy absorbed by the organic radical can be transferred to the rare-earth ion.

The level system of such a compound (see the figure) is thus similar to that of the chromium ion in ruby and is more suitable for use in lasers than the level system of the rare-earth ion proper. Another advantage of these compounds is that the screening action of the surrounding radicals causes a strong change in the probability of the nonradiative transitions in the 4f shell of the rare-earth ion, and consequently the quantum lumines-



cence yield increases and approaches unity in some cases.

At the present time there are no grounds for assuming that the phenomenon of intramolecular energy transfer is limited to the ions of the rare-earth elements or to organic radicals. Apparently we can choose for any ion capable of luminescence a molecule that has an absorption level in the most suitable place and to which intramolecular energy transfer is possible.

The phenomenon of intramolecular transfer of energy allows us to revise our opinion concerning substances previously regarded as offering little promise for use in lasers. This principle makes feasible lasers more efficient than those with ruby and an extension of the range of generated wavelengths.

I am grateful to Academician P. L. Kapitza for interest in this problem.

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Translated by J. G. Adashko

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# *NONSTATIONARY PHOTOMAGNETIC EFFECT IN GERMANIUM SINGLE CRYSTALS*

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THE time behavior of the photomagnetic effect (PME) when the specimen under study is subjected to pulsed illumination remains almost unstudied, if the papers of Bulliard[1] and Lashkarev[2] are disregarded. In these papers very important phenomena accompanying the nonstationary PME remained unnoticed.

The results are given below of a study we have undertaken of the nonstationary PME under pulsed illumination. The photomagnetic emf was measured as usual in the direction perpendicular both to the magnetic field and the direction of the light flux. The specimen was placed in a magnetic field which could attain 30,000 Oe. The illuminating pulse was provided with the aid of a Kerr cell, through which was transmitted the light from a 750 W incandescent lamp. Individual rectangular voltage pulses ($\approx$ 7 kV) were applied to the Kerr cell. The pulse length could be changed from 5 to 2,000 $\mu$sec; the time constants of initial rise and decay were equal, and did not exceed 1.5 $\mu$sec. The maximum light flux proceeding through the Kerr cell was approximately $10^{17}$ quanta/sec. According to our measurements the modulation depth of the visible light was 98%. The Kerr cell left the infrared region of the spectrum almost unmodulated, and the resulting modulation depth of the light (determined with a thermopile) was, therefore, 40% when a water filter 5 cm thick was placed in the light path in front of the Kerr cell. The measured PME emf and the voltage pulse on the Kerr cell were recorded simultaneously by an OK-17M double-beam oscilloscope synchronized by the voltage pulse generator.

Single crystal specimens of n type (30 ohm-cm) and p type (60 ohm-cm) germanium cut in the shape of discs approximately 30 mm in diameter were studied. The specimen surfaces were treated by standard methods. The reliability and stability of the apparatus was verified by comparing the anisotropy of the PME curves taken on the pulse apparatus with curves taken in steady-state conditions.[3-6]

The photographs of oscilloscope traces in Fig. 1 show the variation of the odd PME emf with time