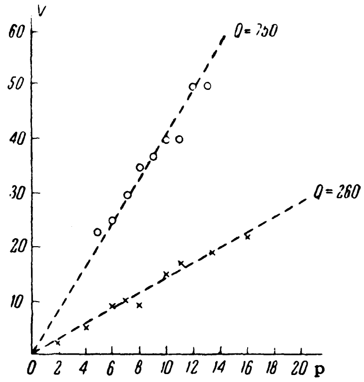

FIG. 1

i.e. barriers up to 10^4 v may be realized. However, in experiments with reflection of fast particles, it should be taken into account that the time of motion of the particles along the slope of the barrier should comprise a sufficiently large number of high-frequency cycles, or else the potential picture itself would lose its sense and the particle could jump the barrier at favorable phases (some kind of "tunnel effect") even though its velocity satisfies condition (2).

Boot and Harvie[3] described an experiment to demonstrate the presence of a potential barrier in a multicavity magnetron. The electrons that appear close to the anode block as a result of ionization (high-frequency discharge) roll down the slope of the barrier to the cold cathode. This effect was detected by the appearance of current in the external circuit and by cathode heating caused by electron bombardment. Experiments with magnetrons conducted by us previously have shown that for unambiguous interpretation of the effect it is necessary to remove the electrodes from the high frequency field, i.e., to avoid a sharp slope of the potential distribution in the whole interaction space.

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52

NUCLEAR MAGNETIC RESONANCE SHIFT IN MOLYBDENUM

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We have investigated the shift of the nuclear magnetic resonance, due to the paramagnetism of the conduction electrons (Knight shift)[1] in metallic molybdenum. The spectrometer was similar to the one used before.[2] An electromagnet with a pole diameter of 300 mm and a gap of 42 mm made possible work in fields up to 14,000 gausses, stabilized with deuteron resonance as reference. The frequency was measured with a type 528 wavemeter.

In order to avoid the influence of skin-effect on the resonance line,[3] we worked with a powder prepared by filing a molybdenum sheet and sifting the filings through a sieve of 150 mesh. The molybdenum content in the sheet was not less than 99.9%, and the paramagnetic impurities not more than 0.008%. To relieve the internal stresses, the powder was annealed at 1250°C for two hours in a vacuum of 10^{-4} Hg.

Resonance caused by both odd isotopes of molybdenum was observed in the powder thus obtained. The amplitude ratio of the resonance lines of Mo^{95} and Mo^{97} was 3 : 1, whereas the isotope-content ratio was only 1.5 : 1. An even bigger difference was obtained in the unannealed metal, where the Mo^{97} line was not observed at all, although the Mo^{95} resonance exceeded the noise level by 5 to 6 times. The Mo^{95} signal in the powder immediately after filing was nearly one order lower than in the annealed one. All this points to a strong effect of the interaction between the nuclear quadrupole moments and the gradient of the electrical field, an interaction due to the disturbance of the lattice structure. The quadrupole interaction was noticed to be greater for Mo^{97}. This agrees with the data of W. G. Proctor F. C. Yu on nuclear magnetic resonance of molybdenum in an aqueous solution of K_2MoO_4.[4]

Bloembergen and Rowland[5] showed that a shift of the resonance lines becomes possible at a quadrupole interaction big enough for second-order quadrupole effects to appear. The shifted line should be asymmetrical. For molybdenum, comparison of the amplitudes of the resonance lines of Mo^{95} and Mo^{97} with the ones expected, taking into account the sensitivity of the measuring apparatus, shows that, at least for Mo^{97}, the weakening of the line is caused to a considerable extent by second-order quadrupole effects. At the same time, both resonances in the annealed molybdenum are symmetrical and, in spite of a noticeably different influence of the quadrupole interaction, they have approximately the same width. This brings us to the conclusion that the observed part of the resonances corresponds to nuclei weakly exposed to the influence of quadrupole effects. Because of the sharp dependence of second-order quadrupole effects on the distance, the resonance caused by other nuclei closer to points of structural disturbances becomes so blurred as to be unobservable.[5] The effect of quadrupole interaction on the shift in molybdenum can thus be neglected.

The Knight shift was measured relative to the resonances of Mo^{95} and Mo^{97} in an aqueous solution of K_2MoO_4, i.e., with an accuracy up to the value of the chemical shift in this compound. From a series of successive measurements with metallic and nonmetallic samples in a field of 12600 gausses, we obtained the following values of the shift

$$\frac{\Delta H}{H}(Mo^{95}) = (0.582 \pm 0.005)\%,$$

$$\frac{\Delta H}{H}(Mo^{97}) = (0.586 \pm 0.005)\%.$$

Analogous results were obtained in a field of 8300 gausses.

The fact that the same shift was obtained for both isotopes at two values of the field also proves the assumption that the influence of the quadrupole interaction upon the shift can be neglected.

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53

STIMULATED R.F. AMPLIFIER WORKING ON HYPERFINE LEVELS OF PARAMAGNETIC ATOMS

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THE idea of using a paramagnetic crystal as an active element (substance) in stimulated microwave amplifiers was expressed by Bloembergen.[1] Such an amplifier was realized with crystals of salts containing Gd^{3+} ions, by using the dipole transitions between the energy levels of the electron spins of paramagnetic Gd^{3+} ions.[2] In the work of Itoh[3] it was shown that diamagnetic crystals, containing atoms with substantial quadrupole splitting of nuclear spin levels, can be employed in amplifiers at low frequencies (10^6 cps). Abragam and others[4] have pointed out the possibility of the appearance of a stimulated radiation in transitions between the energy levels of proton spins in liquid solutions of paramagnetic ions. We would like to call attention to the possibility of obtaining amplification of signals in the frequency range of 10^8 to 10^9 cps by employing transitions between hyperfine levels of paramagnetic ions.

As an example let us consider crystals of salts containing bivalent ions of the Cu^{64} isotope (ground state $^2D, S = 1/2, I = 1$) (obviously, the conclusions reached here are applicable to other paramagnetic atoms). The scheme of the spin levels of Cu^{++} ions in a strong magnetic field is shown in the figure. The relaxation transition probabilities, the ratio of which determines the possibility of creating negative differences of populations between adjacent hyperfine levels at temperatures of liquid helium and fields of about 5000 oe, have the following values: $W_{a'a} = 10^3$ to 10^4 sec^{-1} (for electron transitions) and $W_{a'b'} = 0.1$ to 1 sec^{-1} (for nuclear transitions). The stationary populations of hyperfine levels that appear upon saturation of the electron transitions, were calculated in our work[5] devoted to the polarization of Cu^{64} nuclei.

Thus, upon saturation of the electron transition $a \rightarrow a'$, the populations of the hyperfine levels are characterized by the following relations:[5]

$$a'/b' = 1 + 3\Delta/2, \quad b'/c' = 1, \quad c/b = 1,$$

$$b/a = 1 + \Delta/2, \quad \Delta = g_e\beta H_0/2kT.$$

We see that the upper of the two adjacent levels a'b' (or a,b) is much more populated than the