change of distance was made in steps from test to test; for each distance the sorting system and the source were realigned.

In this method of measurement it is essential to ensure the reproducibility from test to test of the operating intensity of the beam (the reproducibility of the sorting potential is easily ensured). For this, a second auxiliary beam source, ammonia, was used in parallel with the primary working source. The length of the ammonia lead-in tube was kept the same for all experiments which ensured in all cases identical resistance to the flow of gas. The auxiliary source was led aside and directed on to an inonization gauge, from the indications of which the beam was controlled. This region was protected by cooling screens so that the indications of the gauge depended only on the flow of molecules from the auxiliary source, and not from the primary source (which was checked with the auxiliary source cut out). Behind the sorting system a cooling diaphragm was mounted, as well as a cooling copper tube about 7 mm diameter through which the beam of molecules was passed. The ammonia was purified by chilling in both experiments. A repetition of the tests from one day to the next for the same distance between the sorting system and the resonator (with the installation realigned each time) showed very good reproducibility of results. When using the second method it was possible to obtain less attenuation of the beam of active molecules in relation to distance than in the first case, while retaining the general form of the relationship. The results obtained by the second method are given below.

The relationship $\chi(l)$ obtained experimentally for system No. 1 are given in Fig. 1; curves I, II, III were obtained with sorting potentials U = 26, 18 and 12 kV, respectively. During the experiment χ was also measured at intermediate potential points (in steps of 2 kV). The figures obtained lie between the curves given, and are of the same order of increase; they are not shown in the figure. With a voltage approaching U = 26 kV the dependence of χ on the voltage becomes slight. (The figures give, essentially, normalized relationships. The absolute number of active molecules increases with an increase in voltage.)

For the No. 2 sorting system the form of the function $\chi(l)$ given in Fig. 2, remained unchanged over the voltage range from 22 to 49 kV. The accuracy of the values of χ was determined fundamentally by the accuracy of measuring the gain. As control experiments showed, the error over the major part of the curve does not exceed 10–15% and only at large distances, when it was required to measure a small gain in the presence of noise, did it reach 25%.

A comparison of Figs. 1 and 2 shows that the No. 1 sorting system forms a less dispersed beam of molecules and therefore greater preference is given to this in the two-resonator systems, despite the fact that system No. 2 gives a greater absolute number of active molecules. By means of the experimental relationship $\chi(l)$, the maximum possible gain in the effective Q of the line was calculated from (1) for two-resonator molecular generators compared with the usual molecular generators with a single resonator 10 cm long. This gain was found to be 3.5 and corresponded to a distance of about 27 cm between resonators. The relationships obtained for $\chi(l)$ can also be used for calculating other modes of these generators [3, 4].

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RESOLUTION OF THE STRUCTURE OF THE CENTRAL LINE J = 3, K = 3, ΔF = 0 OF AMMONIA $N^{14}H_3$

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The structure of the most marked transition J = 3, K = 3 of the inversion spectrum of ammonia has been investigated by a number of authors (see, for example, [1]). A substantial step forward was made by Gordon [2], using an ammonia beam maser as a radiospectroscope. This made it possible to increase the resolving power by an order (from 70 to 7 kc) compared with a gas-cell spectroscope, and to resolve a number of components of quadrupole and magnetic hyperfine structure. However, the central component, J = 3, K = 3, ΔF = 0 which is extensively used in molecular generators [3] has remained unresolved. This present note reports on the resolution of the quadrupole structure of this line which was achieved by increasing the resolving power of a Ramsey type maser spectroscope [7].

The beam radiospectroscope used was similar in design to that described earlier [4, 5]. Work which had been carried out on increasing the sensitivity of the beam radiospectroscope [6] and, on obtaining a long beam of active molecules [5], enabled us to increase the beam length to two: the width of the separated maximum in this way was 240 cps. This was approximately 25% greater than the width of the maximum calculated for a Maxwellian distribution of molecules according to velocity [7]. Observation of the line with a fivefold reduction in the power of the transition-inducing signal showed an absence of broadening due to saturation. The broadening referred to above may be explained by the selection of molecules in the sorting system according to velocity, which, according to [8], leads to an enrichment of the sorted beam by fast molecules in the case of long beams. The flight path and the resonator positions are carefully screened against electric and magnetic fields. The effectiveness of the magnetic screening is checked by observing the line under differing protective conditions, as well as by the line remaining unchanged when a magnet is brought up to the equipment. The effectiveness of the screening of the flight path from the field of the sorting system is checked by the consistency of the results when the sorting potentials are varied by a factor of ten.

A small relative width for the Ramsey component of the spectral line ($\Delta f/f \cong 10^{-8}$) calls for an adequate relative stability of the signal frequency which induces the transition. In order to stabilize the signal

frequency, an automatic phase tuning system with a molecular generator was used and the change of frequency was obtained by tuning this molecular generator [6], having calibrated it for frequency beforehand.

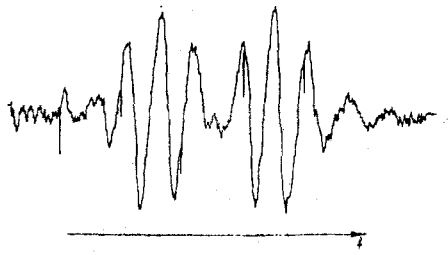

Fig. 1

Molecular modulation was used in order to increase the sensitivity of the radiospectroscope, and this was done by superimposing a nonuniform electric field on a section of the flight path in front of the second (beam) resonator. This combined the phases of polarization of the various molecules and eliminated molecular 'ringing' in the second resonator [3]. The signal is received by a superheterodyne stage, amplified and passed to a phase detector, an integrating RC circuit and an automatic recorder. A sample recording with linear tuning of the signal frequency by a motor and an integrating time constant of 1 sec is given in Fig. 1. The symmetrical form of the spectral line which corresponds to a relative difference in phase of the microwave resonator oscillations of 0 or π was achieved by using phase rotation.

The quadrupole structure of the $\Delta F = 0$ line is caused by the small difference between the constants of quadrupolar reaction for the upper and lower inversion levels which leads to splitting the line into three components, $F = 2, 3$ and 4, respectively ($\vec{F} = \vec{J} + \vec{I}$, J is the rotational quantum number, $I = 1$ is the nuclear spin for nitrogen). According to one current indirect estimate (according to the asymmetry of the spectral line), the difference between the quadrupolar constants is of the order of 4000 ± 1000 cycles [2], which gives distances for the components F = 2, 3 and 4 from the center of the unexcited line of +1000, −1250 and +400 cycles, respectively.

Observation of the spectral line was carried out under varying conditions. Both annular and quadrupolar sorting systems were used.

A better differentiation of the components was obtained with the quadrupolar systems because of the faster damping of the interference pattern of each component, which can be explained by the greater spread of focused molecules according to velocity and quantum number M_J. The annular systems gave a high signal intensity. A change in the sorting potential changed the relative intensity of the components which is due to the preferential focusing of molecules with one or other value of M_J in the distant resonator. Some of the observations were carried out with the first (beam) resonator replaced by a waveguide with an orifice to allow the beam of molecules to pass through, which eliminates the possibility of regenerating the spectral line in the first resonator.

The processing of about 40 recordings showed that there are two components of the spectral line which are separated in frequency by 1586 ± 80 cycles, which are interpreted as F = 3 and F = 4.*

*This agrees with the calculations in [9] where the intensity ratios of the components with F = 3, 4 and 2 are 1 : 0.92 : 0.05, respectively, after sorting, that is, the influence of the third component is negligibly small.

The center of the line which corresponds to the maximum amplitude of the molecular generator oscillations at the same transition was found midway between the components. The difference between the quadrupole constants of the upper and lower levels was determined as 3800 cps with a means square error of ±200 cps.

The records obtained with signal/noise ratios up to 40 confirmed the possibility of further increasing the beam length in these radiospectroscopes. At the same time the possibility should not be neglected of amplifying a signal with a low noise level in the second (beam) resonator with a regenerated auxiliary beam of active molecules. The results obtained also give the possibility that for the same beam length (about 2 meters) it may be possible to observe the rotational transitions of ammonia, in which the same energy levels take part as are used in the well-known method of demonstrating these transitions by the change in intensity of the lines of the inversion transition [10, 3]. For this, we need a beam of molecules passing through a Ramsey system in the submillimeter range, directed into a conventional microwave resonator tuned to the frequency of the corresponding inversion transition. When inducing rotational transitions with submillimeter signals the population density of the corresponding inversion levels is changed, which can be detected by the changes in the gain of an under-driven maser. The use of the Ramsey system with a beam of two meters long in the submillimeter range would enable the Q of the spectral line to be increased up to about $5 \cdot 10^9$.

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