REFERENCES

1. G. A. Begiashvili and Yu. S. Monin, Izv. VUZ. Radiofizika [Soviet Radiophysics], 9, 3, 627, 1966.
2. V. V. Tamoikin and S. B. Biragov, ZhETF, 44, 1544, 1963.
3. M. L. Ter-Mikaelyan, Izv. AN Arm. SSR, 14, 103, 1961.
4. V. V. Tamoikin, Dissertation, Gor'kii, 1965.
5. I. M. Lifshits, M. I. Kaganov, and V. M. Tsukernik, Uch. zap. KhGU, Trudy fiz.-mat. f-ta, 2, 41, 1950.

1 April 1966 Cybernetics Institute AN GSSR

AN OPTIMAL VARIANT OF A TWO-RESONATOR MOLECULAR GENERATOR WITH OPPOSED BEAMS

A. F. Krupnov, V. A. Skvortsov, and L. A. Sinegubko

Izvestiya VUZ. Radiofizika, Vol. 10, No. 1, pp. 140–142, 1967

UDC 621.378.3

One of the methods of increasing the frequency stability of the oscillations of molecular generators is the narrowing of the spectral line in a Ramsey system with spaced resonators and opposed beams. The principles of such systems are theoretically based and experimentally confirmed in [1–4]. However, the problem of the optimal variant of such generators and of the maximum gain in the effective Q of a line which can be obtained under actual conditions has not been considered up to now.

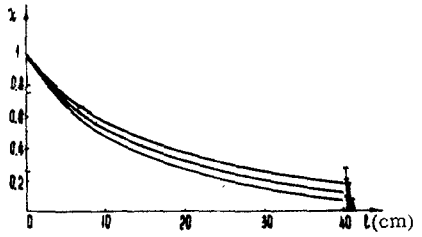

Fig. 1

The effective Q of the spectral line in such generators is defined as a rule by the rate of change of the generated frequency with a rearrangement of the resonators as $Q_{eff} = Q_p \Delta\omega_p/\Delta\omega_g$. The gain is defined as the ratio of the effective Q of the line in a symmetrical two-resonator system and the Q of the line in a generator with an indentical single resonator. For small generator amplitudes it equals [2], approximately,

$$G = \frac{1 + 7\chi + 6\chi\, T/\tau}{1+3\chi}. \qquad (1)$$

Here τ is the time of flight of a molecule for a single resonator (the length usually adopted is about 10 cm), T is the time of flight for the distance l_0 between resonators, the beam attenuation constant is $\chi = N(l)/N(0)$, where N(0) is the number of active molecules which proceed from the sorting system to the first beam resonator, N(l) is the number of molecules of the same beam which reach the second resonator, and $l = l_0 + l_{res}$, where l_{res} is the resonator length. With an increase in the distance l, on the one hand, the time of flight T increases linearly, and, on the other, χ falls because of the angular divergence of the beam of molecules.

The function $\chi(l)$ is determined by forming a beam of active molecules, i.e., by constructing a molecular beam source and a sorting system. We examined the function $\chi(l)$ in the sorting systems and sources with which we had obtained the best results in previous work [4]. A cylindrical duct, the diameter and length of which were 0.15 mm, was used as a source, and was placed at a distance of 20 mm from the beginning of the sorting system. Ring type sorting systems were used, in which the distance between rings equals the radius of the ring.

System No. 1 was 40 mm long and had an internal diameter of 3.5 mm. Originally, we were able with this system to obtain self-excitation of a molecular generator with a single resonator spaced at a distance of 50 cm from the sorting system. System No. 2 was 100 mm long and 6 mm in diameter. It was possible with this system to obtain generation with the resonator spaced at 70 cm [4].

We measured the ratio of the number of active molecules N(l) reaching the single resonator from a sorting system separated from it by a distance l, to the number of active molecules N(0) which reach a resonator presented directly to the sorting system ($l = 0$). For this, the power gains K(l), K(0) were measured in both cases with unchanged beam intensity and sorting potential, on an under-driven maser by a method described previously by the authors [5]. * In addition the excitation parameters of the maser were calculated from the gain $\eta(l) = 1 - [K(l)]^{-1/2}$; $\eta(0) = 1 - [K(0)]^{-1/2}$, which are directly proportional to the number of active molecules reaching the resonator. The ratio $\eta(l)/\eta(0) = N(l)/N(0)$, also gave the value $\chi(l)$.

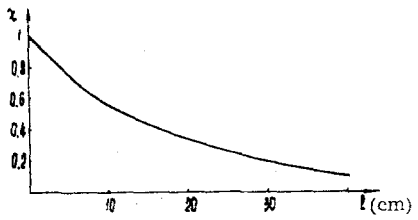

Fig. 2

Measurements were carried out by two methods. In the first of these the beam source and the sorting system were arranged to move along a guiding platform, enabling the distance from the sorting system to the fixed resonator to be varied directly under working conditions with fixed beam and sorting potentials. One merit of this method is that it is possible to eliminate any dependence of $\chi(l)$ on a single experiment, and one of its faults is the difficulty of maintaining sufficiently good alignment at large (of the order of half a meter) displacements of the sorting system.

Moreover the conditions for freezing in the beam are worse in this case. Hence the measurements were repeated using a second method, in which only one point was taken for $\chi(l)$ in each experiment, and the

*The maser resonator was 10 cm long and two coupling orifices were also included in the path. The frequency of the test signal was stabilized by a quartz oscillator in a phase-lock automatic control circuit; the receiver oscillator was stabilized by the same generator. The detector in the if receiver worked in the square-law mode.

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].

REFERENCES

1. A. N. Oraevskii, Molecular Generators [in Russian], izd. Nauka, Moscow, 1964.

2. E. M. Belenov and A. N. Oraevskii, ZhTF, 36, 557, 1966.

3. A. F. Mukhamedgalieva, A. N. Oraevskii, and G. M. Strakhovskii, Izv. VUZ. Radiofizika [Soviet Radiophysics], 9, 302, 1966.

4. A. F. Krupnov and V. A. Skvortsov, Izv. VUZ. Radiofizika [Radiophysics and Quantum Electronics] (in press).

5. A. F. Krupnov and V. A. Skvortsov, ZhETF, 47, 1605, 1964.

20 June 1966

Scientific Research Radiophysical Institute, Gor'kii University

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

A. F. Krupnov, V. A. Skvortsov, and L. A. Sinegubko

Izvestiya VUZ. Radiofizika, Vol. 10, No. 1, pp. 142–144, 1967

UDC 621.378.33 : 539.28

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