THE M8 AND M9 HYDROGEN MASERS AS THE NATIONAL FREQUENCY STANDARD AT THE NATIONAL INSTITUTE OF METROLOGY - BUCHAREST

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Our paper describes the performances and characteristics of the M8 and M9 masers; which are part of the frequency standard at the Romanian National Institute of Metrology, in Bucharest. We have outlined the original solutions, which we have used.

The Frequency and Time Standard at the Romanian National Institute of Metrology, in Bucharest, consists of two Hydrogen Masers (M8 and M9) together with a GPS standard (SATSYNC II 425).

The maser frequencies are continuously compared (on 100 kHz) with the GPS standard frequency, then monitored and recorded every 3 minutes with a 10^{-11} sensibility, very inferior to the maser stability (10^{-14} for 100 s).

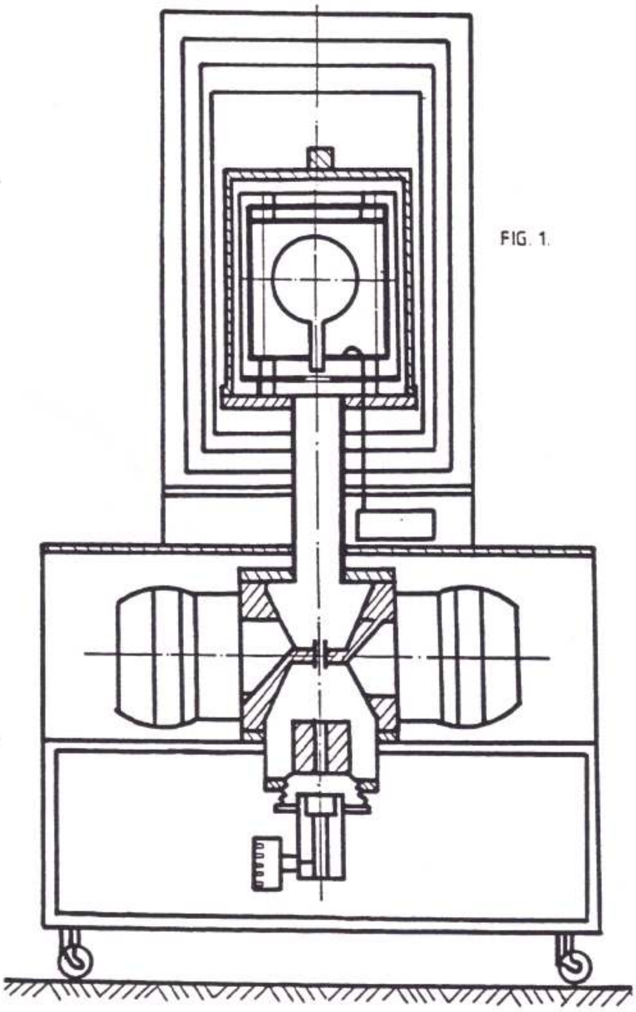

FIG. 1.

In the present paper, we describe a few of the features characterizing our masers.

Figure 1 shows the general arrangement. There are three ionic pumps mounted around an inox cube.

Four Permalloy shields (1.5 mm thick) form the magnetic shielding. On the aluminium Bell jar is situated the degaussing connection (max 1000 A). The receiver is under the magnetic shields.

The thermostatation is made with five heating windings. The cavity thermal isolation is increased by means of a thermal shield. The thermistor C in fig. 2 allows the cavity temperature determination.

The cavity temperature thermal fluctuations are $\pm 2 \times 10^{-5}$ Kh^{-1} /1/.

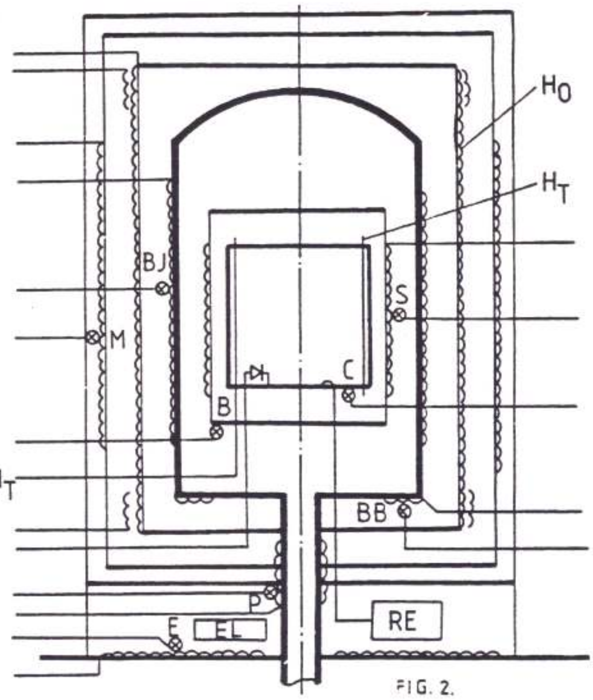

FIG. 2.

In the molecular hydrogen source, the Palladium leak is located very close to the discharge tube. Due to the pressure thermistor gauge and Palladium leak reduced time constant, the pressure servo loop time constant is very short (about 3,5 s) /2/.

The molecular dissociator is a discharge tube located at the end of a coaxial cavity tuned on 400 MHz (Fig. 3) /3/. Due to the system high efficiency, only 5 W of power is sufficient for the maximum possible dissociation degree /4/.

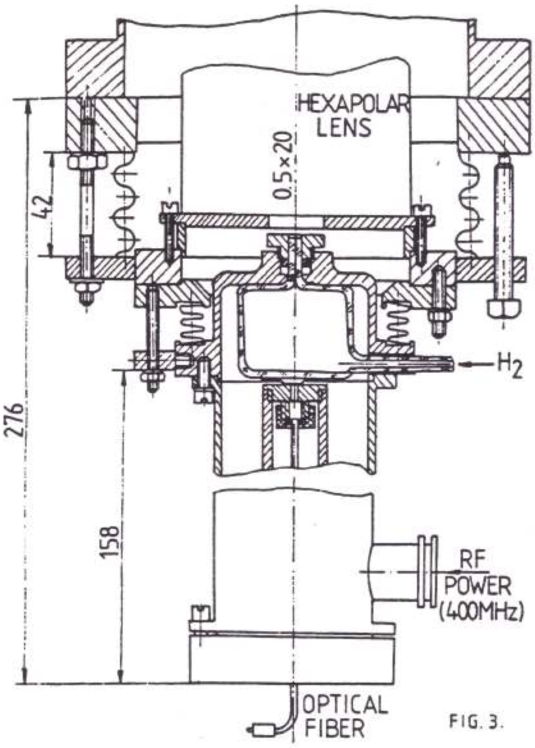

FIG. 3.

The coaxial cables for the coupling to the resonant cavity and thermal control loops (Filotex TU 165) together with the thermistors and transversal magnetic field wires, are isolated towards the vacuum vessel by nonmagnetic passages made of brass with teflon isolation (Fig. 4).

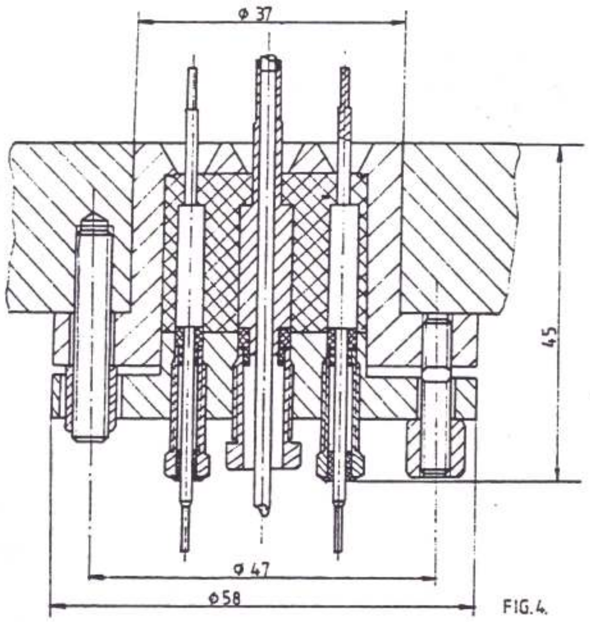

FIG.4.

In the receiver there are four frequency changes. The synthesized signal for the phase comparator γ = 6A, BCD [Hz] is obtained by frequency divisions of the 10 MHz quartz signal (Fig. 5).

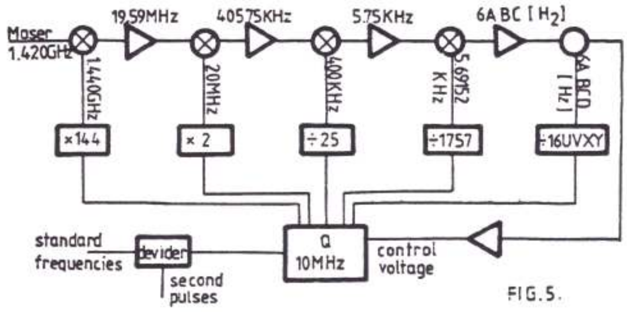

FIG.5.

The hexapolar magnet, made of ALNICO 5 and ARCO, is designed in the usual mode /5/.

The field is 0,8T at the pole tips. The diagram in Fig. 6 enables the determination of the bulb aperture ($2r_B$) focused atoms ($\mu_{ef} < 0$) velocity spectrum and also of the outward deflected atoms ($\mu_{ef} > 0$) spectrum.

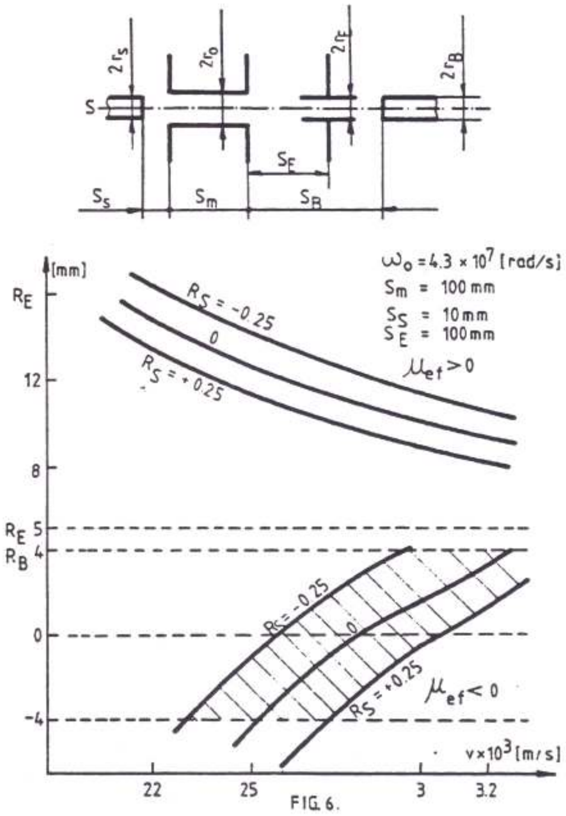

FIG. 6.

For the homogeneous H_o field measurement, a set of four rods (ϕ = 2 mm) is provided inside the resonant cavity, parallel with its axis and located near the walls. The rods are external to the cavity ends, connected as to form a two loops coil. The system is very efficient, and a signal higher as 5 mV kills the oscillation. External coils are not recommended because of the aluminium cavity walls thickness (10 mm).

The maser amplitude variation against the transversal field frequency shows a minimum at the π transition frequency (F = 0, m = 0) → (F = 1, m = 1). From the frequency minimum the H_o intensity results (Fig. 7). The minimum is thinner as the degaussing gets better /6/.

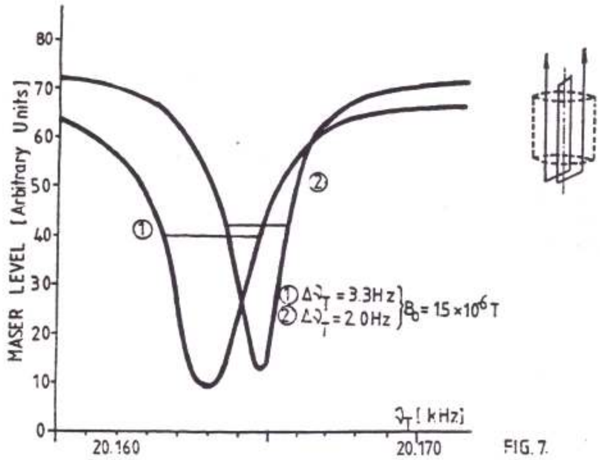

FIG. 7.

The maser frequencies biases against the ν_o = 1420405751.773 Hz /7/ unperturbed frequency are:

	M8	M9
Cavity temperature T_c	319.58K	316.54K
DOPPLER effect	-0.0625Hz	-0.0619Hz
Magnetic field H_o	+0.8668Hz	+1.2601Hz
Wall shift	-0.0279Hz	-0.0289Hz
Total bias	+0.7764Hz	+1.1693Hz
Operating frequency	1420405752.549Hz	1420405752.942Hz

In the near future the frequency standard at the National Institute of Metrology will be completed with the M3 maser submitted to a modernization process at the present time.

Within a relatively short period of time, all the masers (M3, M8 and M9) will be modified as to work, also, as passive hydrogen masers. After this process the life of the ionic pumps will be longer and we obtain an improved very long term frequency-stability.

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