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AN AMMONIA MASER SPECTROMETER

BY

Motokazu YAMAMOTO

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ABSTRACT

The detailed description of the maser spectrometer in our laboratory is given. This spectrometer is very simple in composition but has a fairly fine performance. By using it, the spectrum on $J=K=3$ line of ammonia was observed, and its magnetic hyperfine satellites were confirmed. After having added Helmholtz coils to the apparatus, Zeeman effect was also observed.

1. Introduction

The first maser spectrometer with ultra-high resolution was constructed and operated by Gordon (**1**). Still we feel it worthwhile to report on our apparatus, because ours is simpler than his, since one-klystron-method is used.

2. Apparatus

The block diagram of the maser spectrometer is shown in Fig. 1. The respective parts are described in the following.

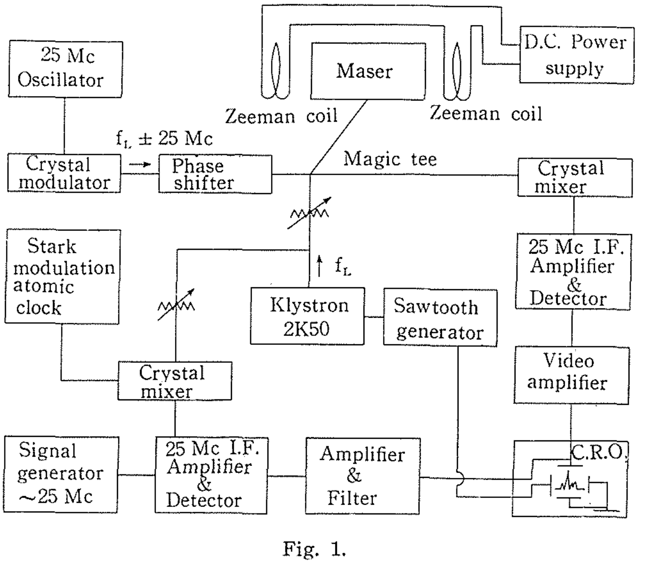

Fig. 1.

(1) The maser

The construction is the same as reported in a previous paper (**2**).

(2) The local oscillator

The heterodyne detection system was adopted, using a 2K50 klystron as local oscillator. It is air-cooled and has a sufficiently stabilized power supply, so that an observation for a short interval is not affected by the frequency drift of klystron. The circuit diagram of the klystron power supply is given in Fig. 2.

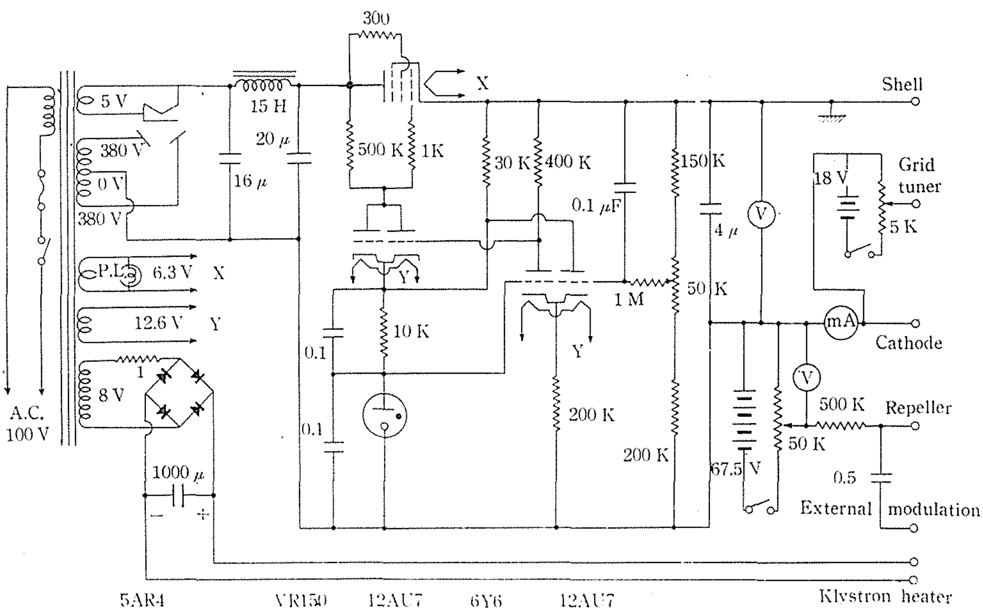

Fig. 2.

(3) The crystal modulator

An IN26 crystal is used as modulator. Part of the local oscillator power of the frequency f_L and the power from the 25 Mc oscillator are fed to this, so that the side bands are generated at $f_L \pm 25$ Mc. Either of the side bands is then amplified by the maser.

(4) The crystal mixer

An IN26 crystal is used as mixer. Thus the signal (f_L+25 Mc or f_L-25 Mc) is mixed with the local oscillator power (f_L) and converted to 25 Mc.

(5) The I.F. amplifier

The resulting 25 Mc signal is amplified by a 6AU6 four-stage stagger-tuned intermediate amplifier with a band width of about 1 Mc. The output is detected by a germanium diode detector, amplified by a video amplifier and led to an oscilloscope. The circuit diagram is given in Fig. 3.

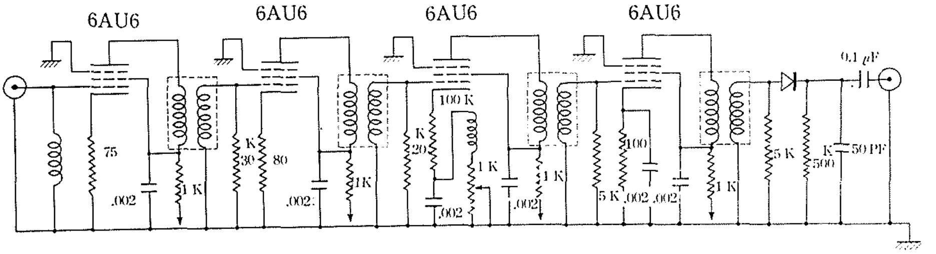

Fig. 3.

(6) The Helmholtz coils

Helmholtz coils 25 cm in diameter were used for observing Zeeman splitting. These are arranged so as to set the magnetic field perpendicular to the cavity axis.

(7) The frequency measurement

The frequency measurement was carried out as follows. Part of the local oscillator power was fed to the IN26 crystal and mixed there with the power from the Stark modulation atomic clock (**3**). The resulting beat note is amplified by the broad band amplifier whose center frequency is 25 Mc. And a signal from the calibrated signal generator was also added at a later stage of this amplifier to be mixed in a germanium diode, and the resulting beat pip was amplified by the audio amplifier and applied through filter circuits to the vertical axis of the oscilloscope. The frequency was directly measured on the oscilloscope screen by changing the frequency of the calibrated signal generator.

3. Experiments

The klystron 2K50 was frequency-modulated by applying to it's repeller the sawtooth voltage at the rate of 20 c. First the maser oscillation signal was detected under the usual operating conditions (**2**). When the focuser voltage was reduced down to the threshold voltage, the oscillation signal disappeared. Just then, the 25 Mc oscillator was switched on, and the sawtooth voltage was reduced until the emission line appeared. Typical patterns of the ammonia inversion spectrum on $J=K=3$ line are shown in Photos. 1, 2, 3 and 4. Table 1 gives the results of the frequency measurement. Other ammonia inversion spectra and their Zeeman effects, such as $J=K=1$, 2 and 4 lines, are expected to be observed by using the present spectrometer.

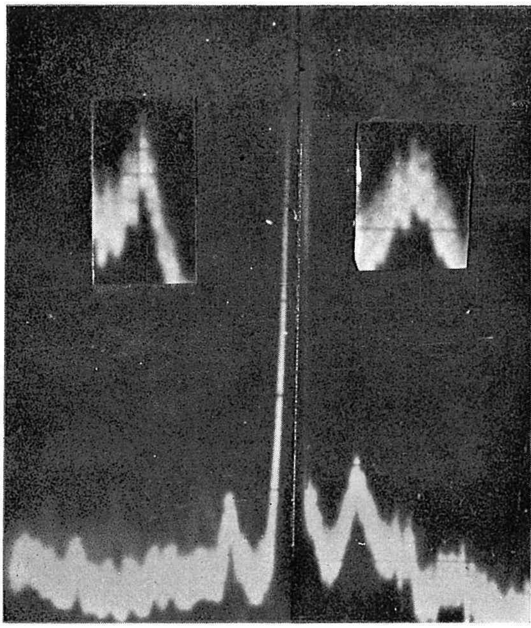

Photo. 1

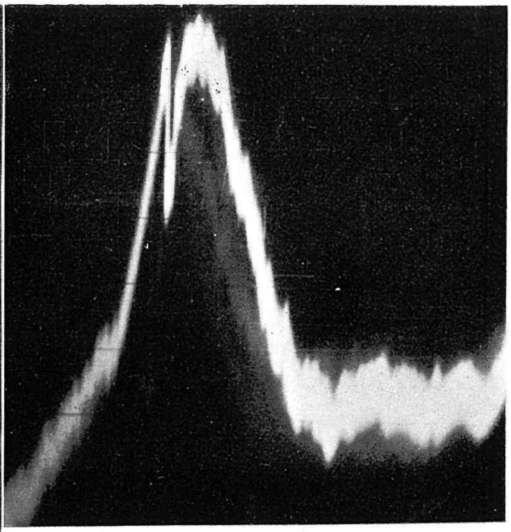

Photo. 2

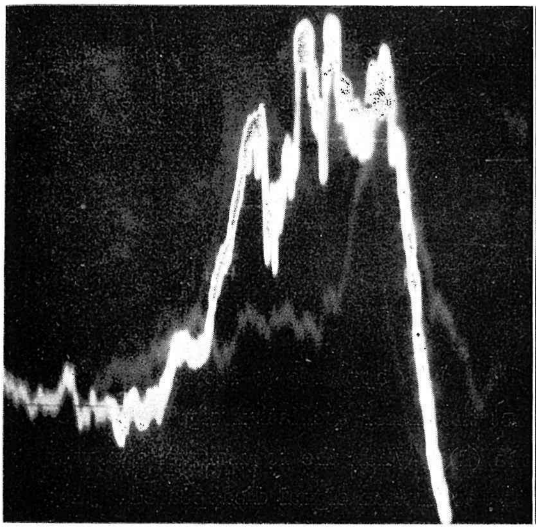

Photo. 3

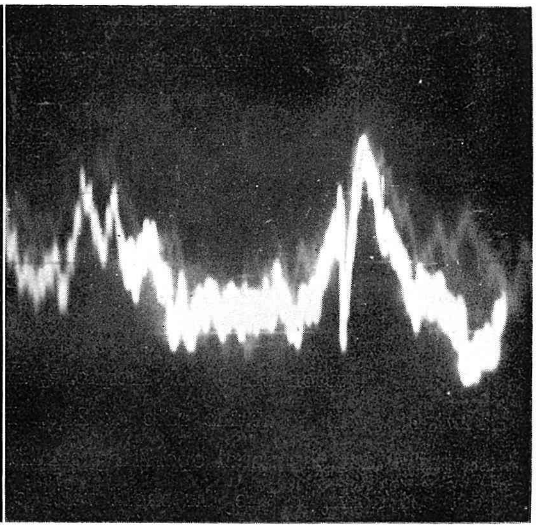

Photo. 4

Photo. 1 shows a typical oscilloscopic photograph of the $N^{14}H_3$ $J=K=3$ inversion transition at 23,870 Mc.

Below: the saturated main line with magnetic satellites.

Above left: lower magnetic satellite corresponding to the $\Delta F_1=0$, $\Delta F=-1$ transition.

Above right: upper magnetic satellite corresponding to the $\Delta F_1=0$, $\Delta F=+1$ transition.

Photos. 2, 3 and 4 show typical oscilloscopic photographs of Zeeman splittings on $N^{14}H_3$ $J=K=3$ line. The applied magnetic field was increased in this order.

Table 1.

Transition	Theoretical value (Gordon)	Experimental value	
		Gordon	Present author
$\Delta F_1 = 0$	−71.0	−71.0	−70.9
$\Delta F = -1$	−62.5	−62.5	−62.7
$\Delta F_1 = 0$	61.0	60.9	60.5
$\Delta F = +1$	70.3	70.1	70.5

(Unit in KC)

Acknowledgement

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3. I. TAKAHASHI *et al.*, Rev. Sci. Inst., **27** (1956), 739.