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10. A Most Accurate Frequency Meter for Microwave Spectroscopy

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In microwave spectroscopy, it is necessary to measure the absorption frequency of gases very accurately. A frequency meter was designed and constructed by us for this purpose.

The output frequency of 100 kc/s crystal oscillator calibrated by the signal from the standard station JJY (its accuracy being 2 parts in 10^7) is multiplied by the vacuum tube multiplier and cross-modulated with 40 Mc/s to generate 432 Mc/s and its many side band frequencies.

These output frequencies are again multiplied by the crystal multiplier up to 9,000 Mc/s region, and serve as microwave standard markers at 48 Mc/s intervals. These markers and the output of the klystron which is frequency-modulated by the sawtooth generator for microwave spectroscopy, are applied to the crystal mixer followed by the interpolation receiver. When the difference frequency between a marker and the klystron signal coincides with receiver tuning frequency, a pulse appears at the receiver output terminals. This pulse is applied to a cathode-ray oscilloscope and by adjusting the tuning frequency of the interpolation receiver, it is made to overlap the absorption line figure on the screen. Then, the absorption can be determined from the relation

$$f_x = n f_s \pm f_i ,$$

where f_x: absorption frequency of the sample,
f_s : difference frequency between two consecutive markers (48 Mc/s),
f_i : tuning frequency of the interpolation receiver,
n : positive integer.

The n is integer calculated from rough frequency measurement by cavity wave meter and the ambiguous sign was determined by the moving direction of pulse on the screen when the interpolation receiver is detuned. The following table shows the uncertainty of the frequency measurement in 9,000 Mc/s region.

Contributing factor	Uncertainty
JJY signal	±1.8 kc/s
Crystal oscillator	±0.2
Interpolation receiver	±5.0
Time lag in amplifier *	±1.0
Maximum error	±8.0 kc/s

* Estimated from data in literatures