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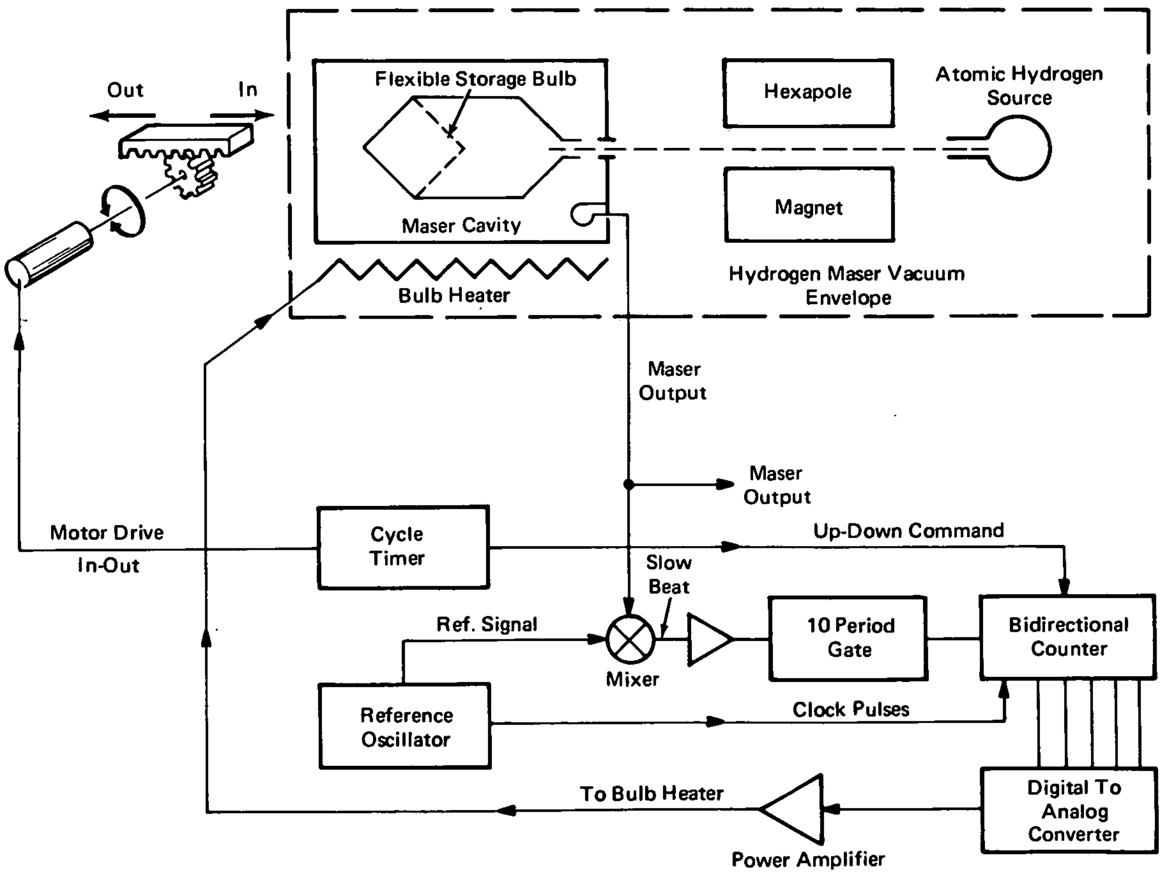
A Method of Eliminating Hydrogen Maser Wall Shift

The problem:

In an atomic hydrogen maser, hydrogen atoms in the storage bulb collide with the bulb walls causing an unwanted shift (wall shift) in the maser output frequency.

The solution:

The storage bulb is kept at a temperature at which the wall shift is zero, and the effects of bulb size, shape, and surface texture are eliminated.



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How it's done:

The wall shift may have positive or negative values with respect to the acceleration frequency of the free-hydrogen-atom dipole-moment. Since the wall shift is temperature dependent, there is a temperature at which the shift crosses from a positive to a negative value, and at that temperature the shift is zero. The particular value of this zero-shift temperature is a chemical property of the wall, and the choice of a suitable bulb coating will give a zero wall-shift temperature at which the maser may be conveniently operated. It has been found that a high molecular weight homopolymer of polytetrafluoroethylene can be used to coat the storage bulb to give a zero-shift temperature around 355K.

In order to accurately maintain the desired bulb temperature, a flexible bulb and servo system are used. At the zero-shift temperature the bulb geometry does not affect the maser output frequency; at any other temperature a change in bulb size or shape changes the output frequency. In this temperature control system, a cycling timer moves the flexible end of the bulb in and out every five minutes. If the bulb wall is not at the zero-shift temperature there will be a difference in the maser output frequency between the high- and low-volume bulb configurations. If the bulb is too cold, the frequency difference (high-volume frequency to low-volume frequency) will be positive, if too low, negative.

The figure shows the servo system used. A bidirectional counter measures the period of a fixed number of cycles (10) of the slow beat between the maser and the reference oscillator. The beat signal operates an electronic gate which allows a number of steady "clock" pulses to be counted by the bidirectional counter. When the bulb is in its low-volume configuration, the gate will be open during the ten cycles of the beat, and the counter counts up. When the bulb is in its high-volume configuration, the gate opens for ten cycles, and the counter counts down. The difference is a measure of the frequency difference between the two configurations and is used to operate a digital-to-analog converter which produces a control signal to adjust the bulb temperature.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
NASA Headquarters
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Washington, D. C. 20546
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Patent status:

NASA has decided not to apply for a patent.

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