ROTATIONAL SPEED CONTROL

by
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■ <u>Outline</u>

- **Background**
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- **Application and Typical Solution**
- **Summary**
- **Panel Discussion**

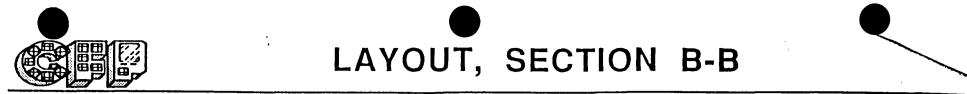# ROTATIONAL SPEED CONTROL

■ BACKGROUND

- A life sciences centrifuge is scheduled to fly aboard Space Station

- Live animal and plant specimens will be carried on the rotor and compared with microgravity specimens in racks

- The centrifuge provides both a one-g control environment and variable gravity capability

- Experimenters indicate that specimens are sensitive at the milli g level under microgravity conditions

- Centrifuge gravity level (speed) variation must be minimized

- Acute studies involving constant angular acceleration spin-up and spin-down profiles are also desired for neurovestibular research
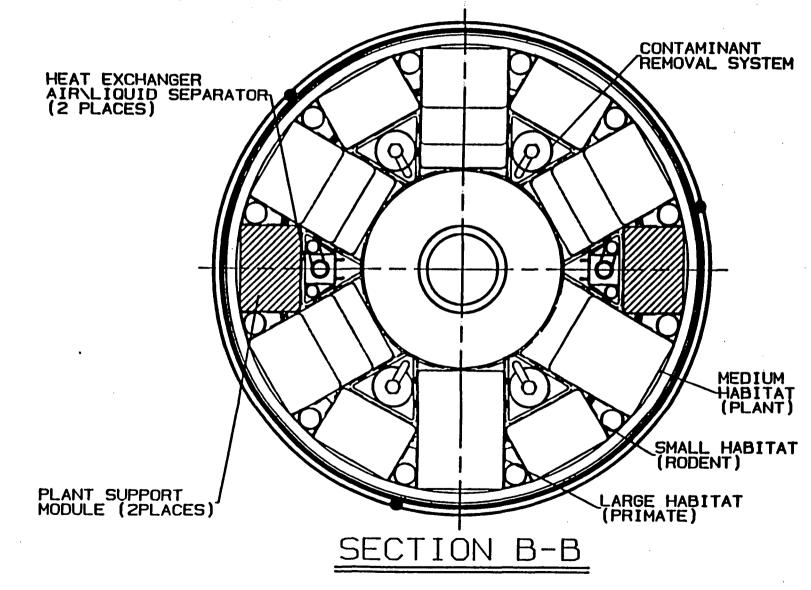
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Habitat and major subsystem accommodations on rotor:

CONTAMINANT REMOVAL SYSTEM

HEAT EXCHANGER AIR\LIQUID SEPARATOR (2 PLACES)

MEDIUM HABITAT (PLANT)

SMALL HABITAT (RODENT)

PLANT SUPPORT MODULE (2PLACES)

LARGE HABITAT (PRIMATE)

SECTION B-B

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■ **REQUIREMENTS**

● **The life sciences centrifuge holds specimens at variable gravity levels between 0.01 g and 2.0 g (approximately 2.8 to 40.0 RPM)**

● **Steady-state gravity level to be maintained constant to within 7.07×10^{-4} g RMS or 2%, whichever is greater**

● **Maximum specimen radial jerk ("g-dot") of 0.01 g/sec during spin-up, spin-down, and changes in acceleration**

● **Repeatability of gravity levels to within 1%**

● **Specimen extractor rotor to provide angular rates up to 30 deg/sec^2 with rates selectable in increments of 1 deg/sec^2 or less**
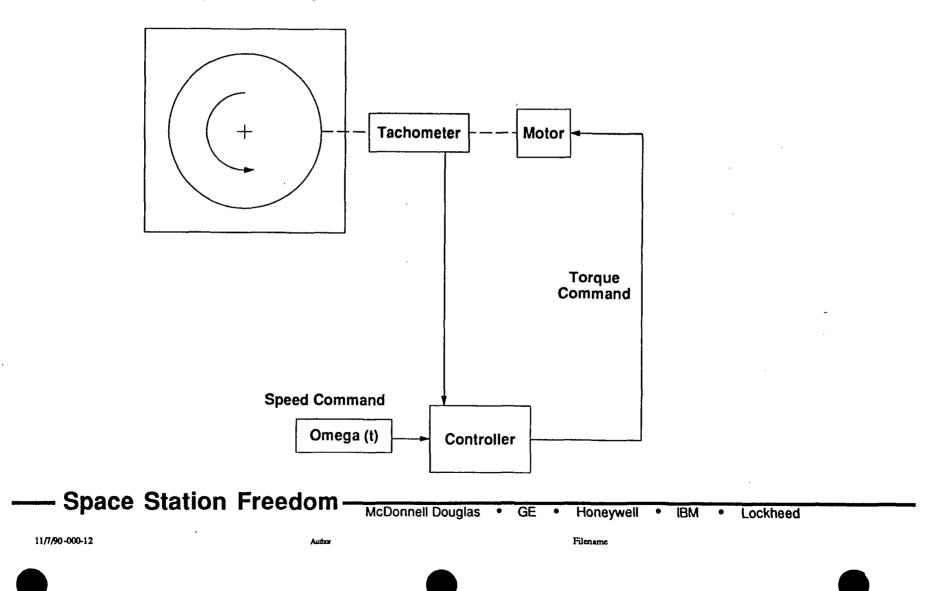

Space Station Freedom ———————————————

ROTATIONAL SPEED CONTROL

■ **APPLICATION AND TYPICAL SOLUTION**

● **Centrifuge rotor speed control**

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                    ┌──────────────┐   ┌────────┐
                    │  Tachometer  ├───┤ Motor  │◄──┐
                    └──────┬───────┘   └────────┘   │
                           │                        │
                           │              Torque    │
                           │              Command   │
                           │                        │
        Speed Command      │                        │
        ┌──────────┐    ┌──┴──────────┐             │
        │ Omega (t)├───►│  Controller ├─────────────┘
        └──────────┘    └─────────────┘
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ROTATIONAL SPEED CONTROL

■ **SUMMARY**

● **Key requirements for a case example involving rotor speed control have been identified**

● **(Opening questions for Panel discussion)**

How can fuzzy logic control be applied to rotational speed control systems to meet desired performance requirements at a lower cost or complexity than conventional methods?

What are typical tolerances that can be held using fuzzy logic? Does the particular example discussed have high suitability for the fuzzy logic control approach?

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Topic: Rotational Speed Control
Presenter: Paul Bastin

Comment: (Bastin) System is continuously running - requirement for up to 90 days operation.

Comment: (Berenji) Fuzzy logic is able to handle imprecisions and preconditions in the rules appear to have more slack. Overall, fuzzy logic system is more robust and has better adaptation with weight changes.

Comment: (Brown) The Japanese use Fuzzy logic control in applications such as in the subway trains in order to smooth the starting and stopping of the trains. The goal of this application is similar in terms of the goal of smoothness of operation; fuzzy logic can handle the large variations.

Q (Lawler):   How much "change" in the system?
A: Not alot – 5% to 10%

Q (Lawler):   How much evolution in terms of the size of experiments are being allowed for?
A: The system is able to accomodate new experiments and the current design allows for the size of the envelopes to be modified and heavier loads.

Comment: (Jani) The acceleration should be measured by accelerometers.