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United States Patent [19]

[11] Patent Number: 5,386,689

Bozich et al.

[45] Date of Patent: Feb. 7, 1995

- [54] ACTIVE GAS TURBINE (JET) ENGINE NOISE SUPPRESSION
- [75] Inventors: Daniel J. Bozich, San Diego, Calif.; Robert Wagenfeld, Westport, Conn.
- [73] Assignee: Noises Off, Inc., White Plains, N.Y.
- [21] Appl. No.: 961,612
- [22] Filed: Oct. 13, 1992
- [51] Int. Cl.⁶ F02G 1/00; A61F 11/06; H04R 3/02
- [52] U.S. Cl. 60/39.33; 415/119; 381/71; 381/73.1
- [58] Field of Search 60/39.33; 415/119; 381/71, 73.1

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Assistant Examiner—Howard R. Richman
Attorney, Agent, or Firm—Gottlieb, Rackman & Reisman

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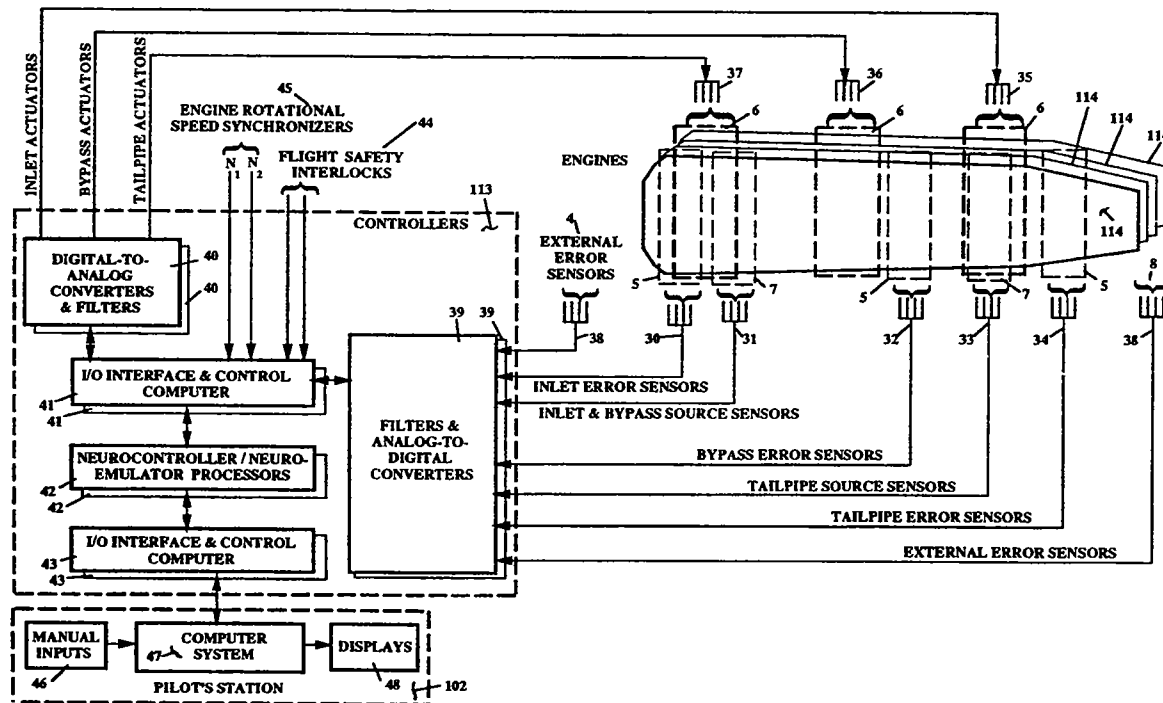
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[57] ABSTRACT

A method and a system for reducing the acoustic levels of internal and external sound fields generated by gas turbine engines has several actuators to generate sound, several sensors to measure the acoustic levels, and one or more controllers. The controllers are adaptive self-learning neural networks that control the actuators to generate sound in order to effect the reduction of the internal and external sound field as measured by the Sensors.

14 Claims, 28 Drawing Sheets



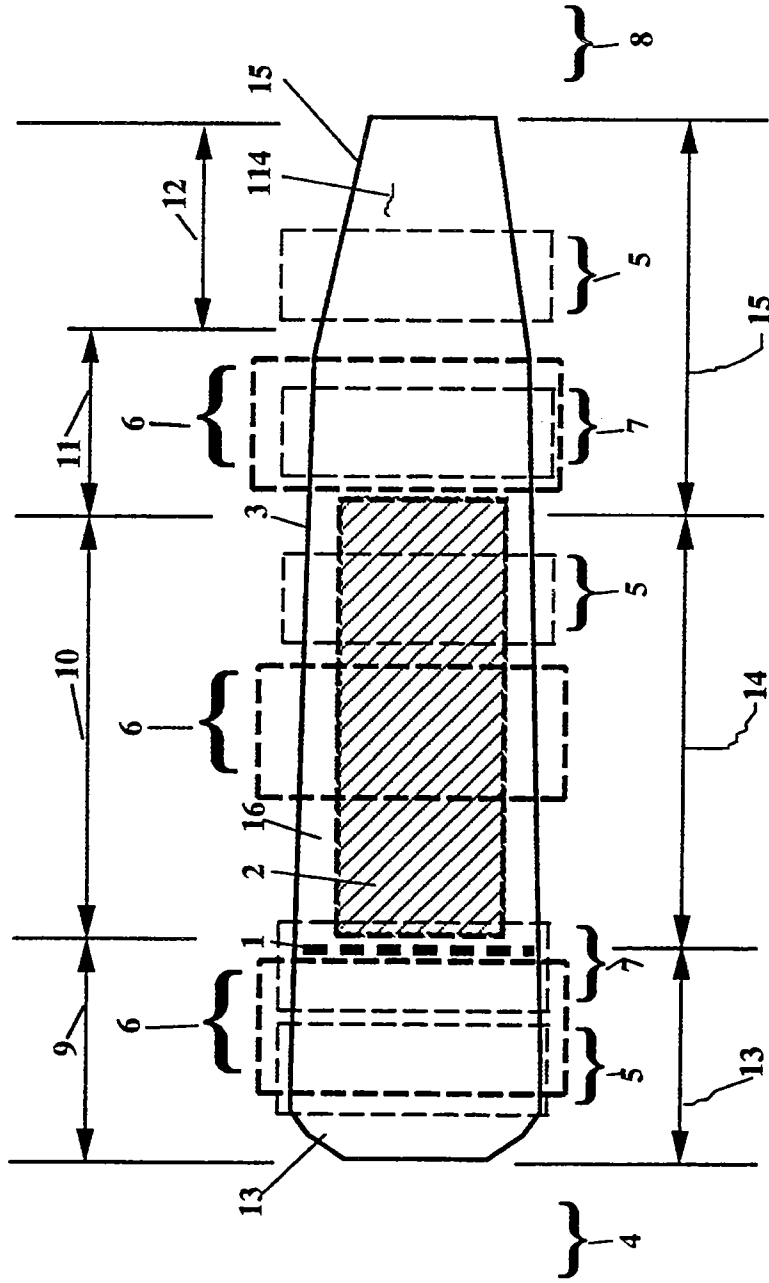


FIGURE 1A

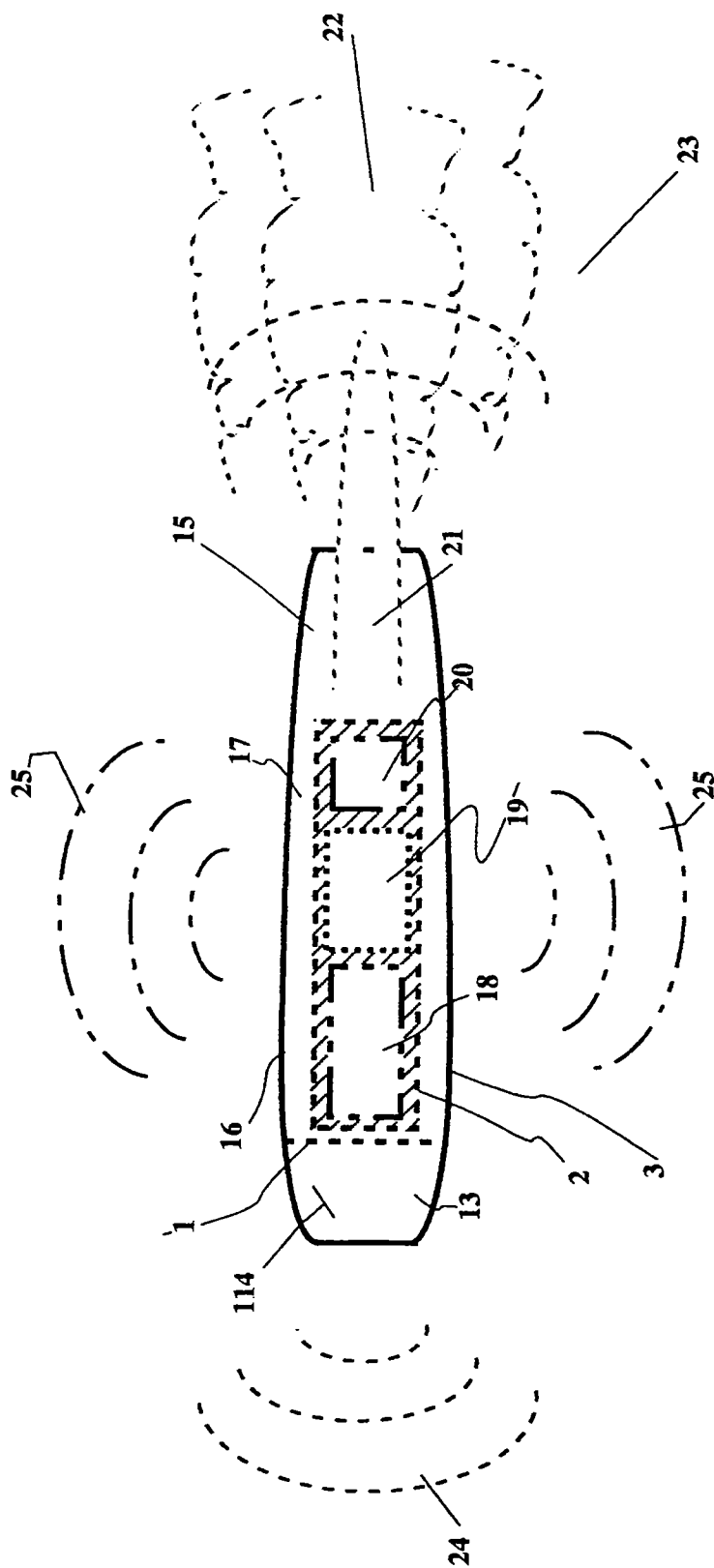


FIGURE 1B

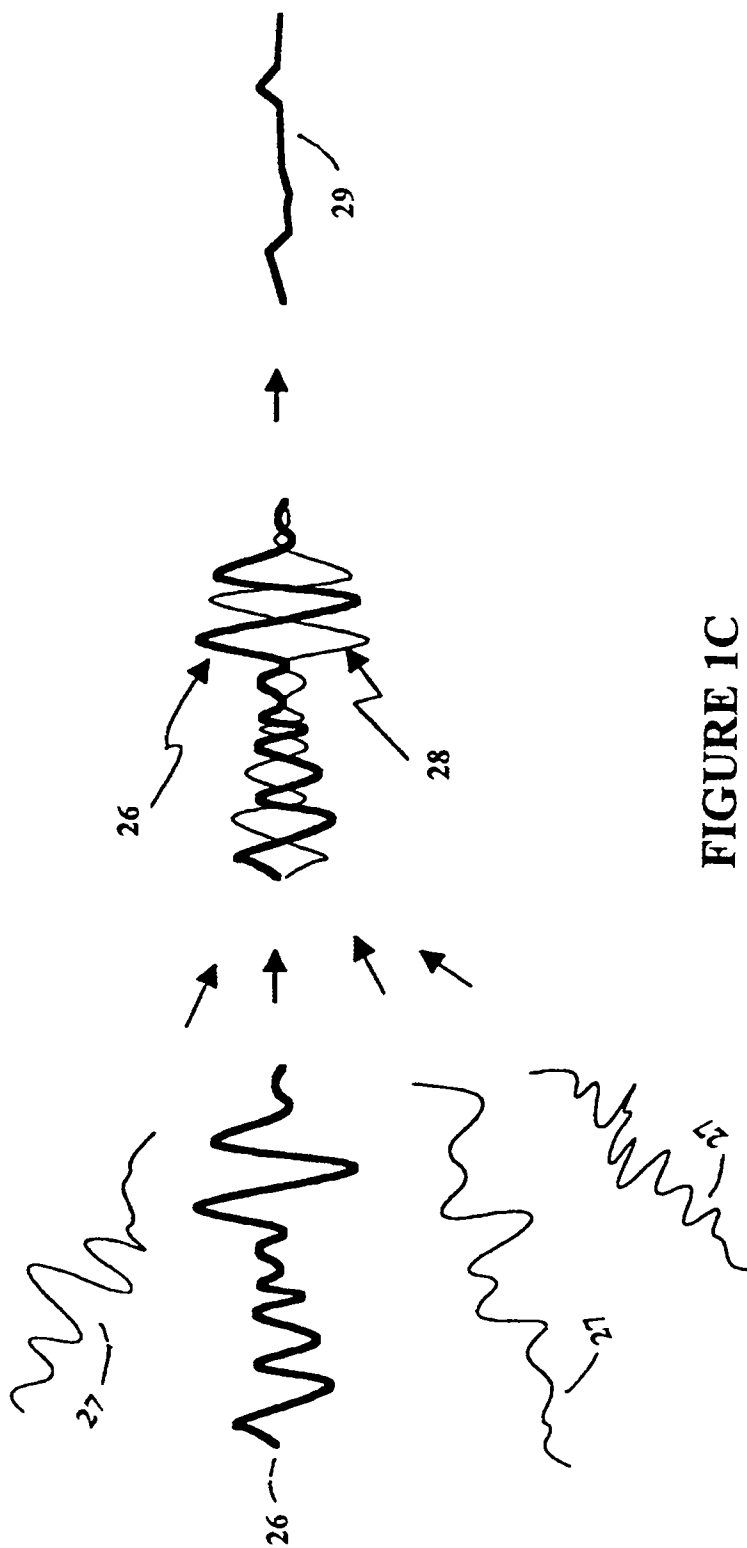


FIGURE 1C

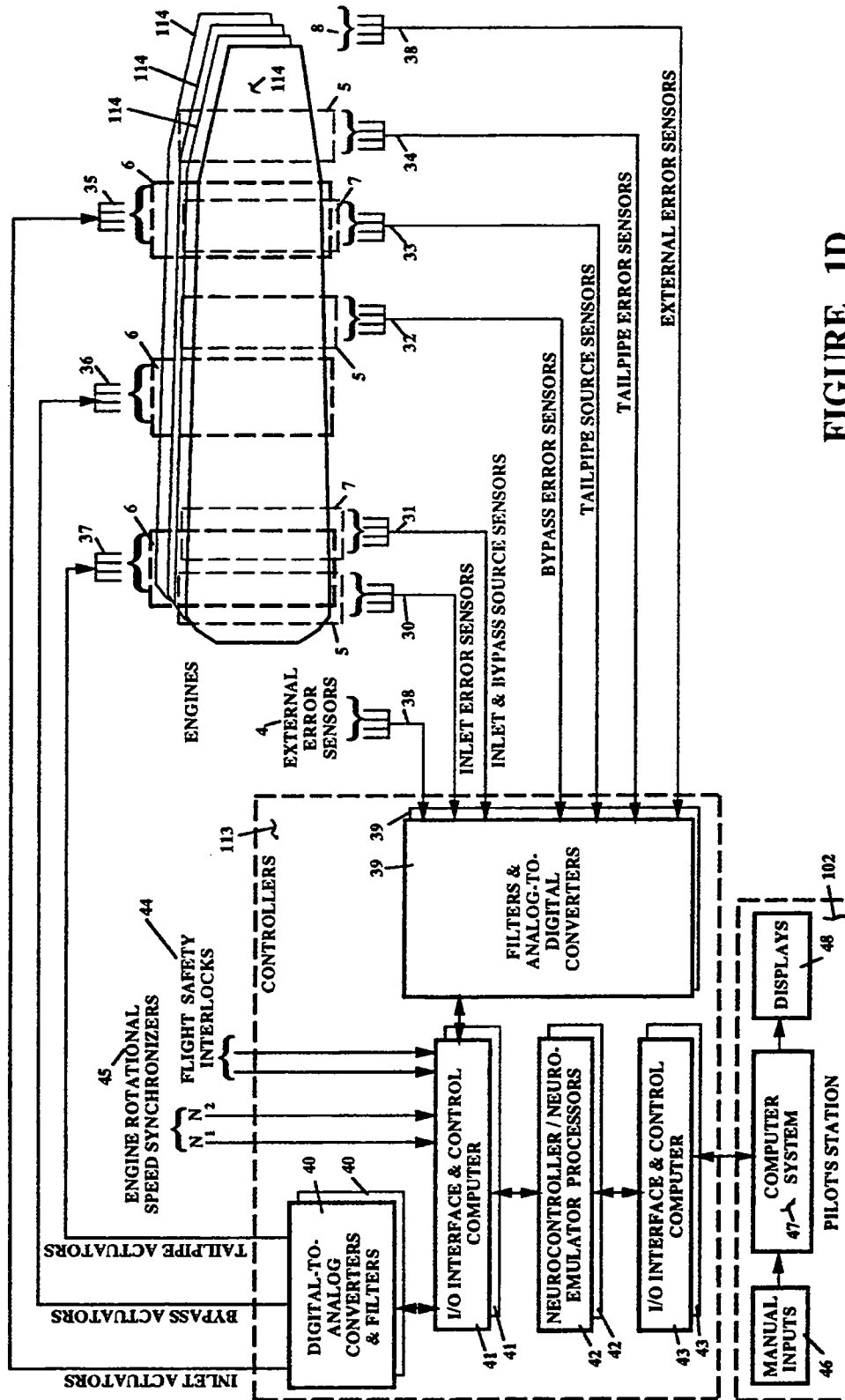


FIGURE 1D

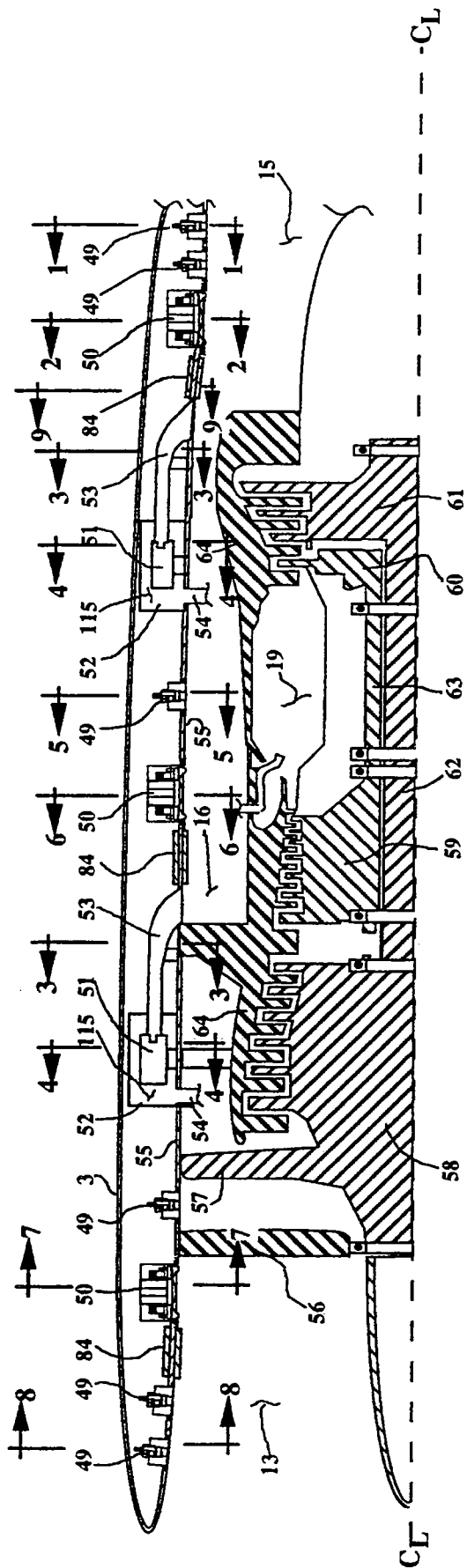


FIGURE 2A

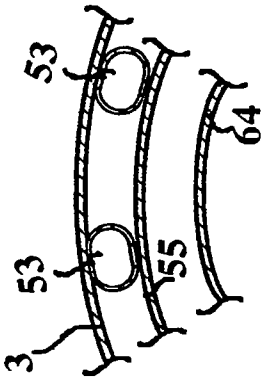


FIGURE 2D

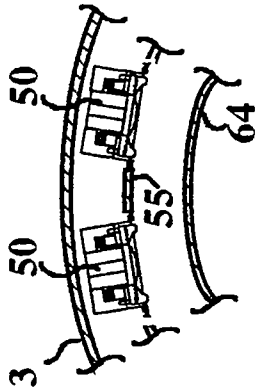


FIGURE 2G

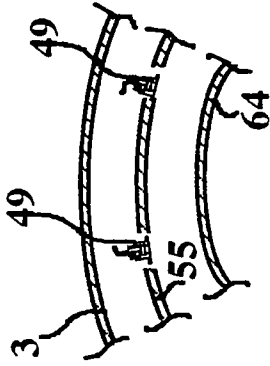


FIGURE 2F

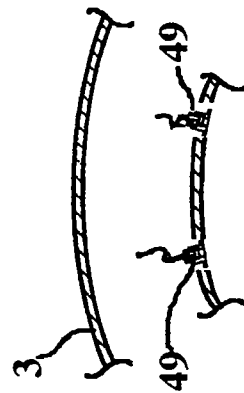


FIGURE 2B

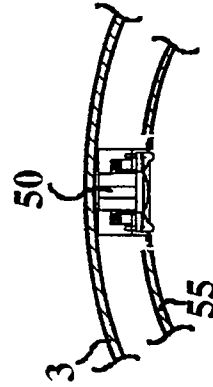


FIGURE 2H



FIGURE 2I

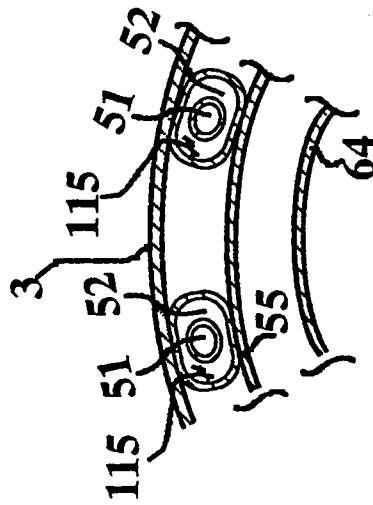


FIGURE 2E

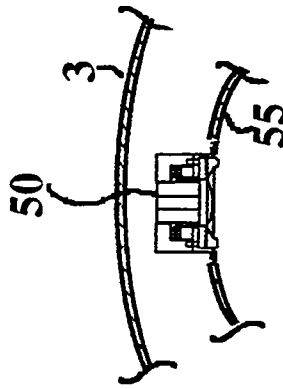


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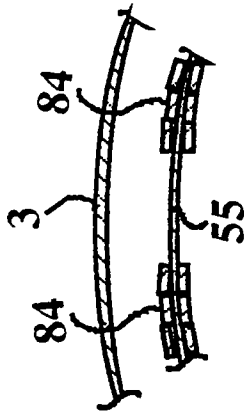


FIGURE 2J

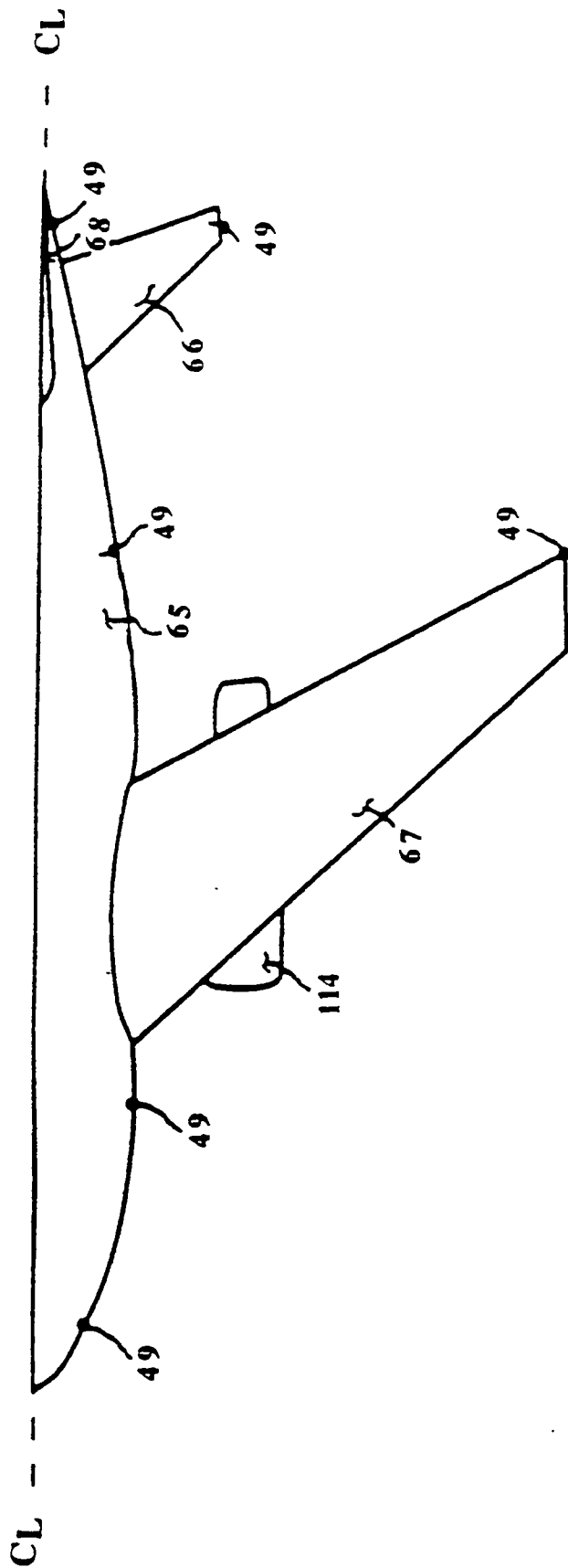


FIGURE 3

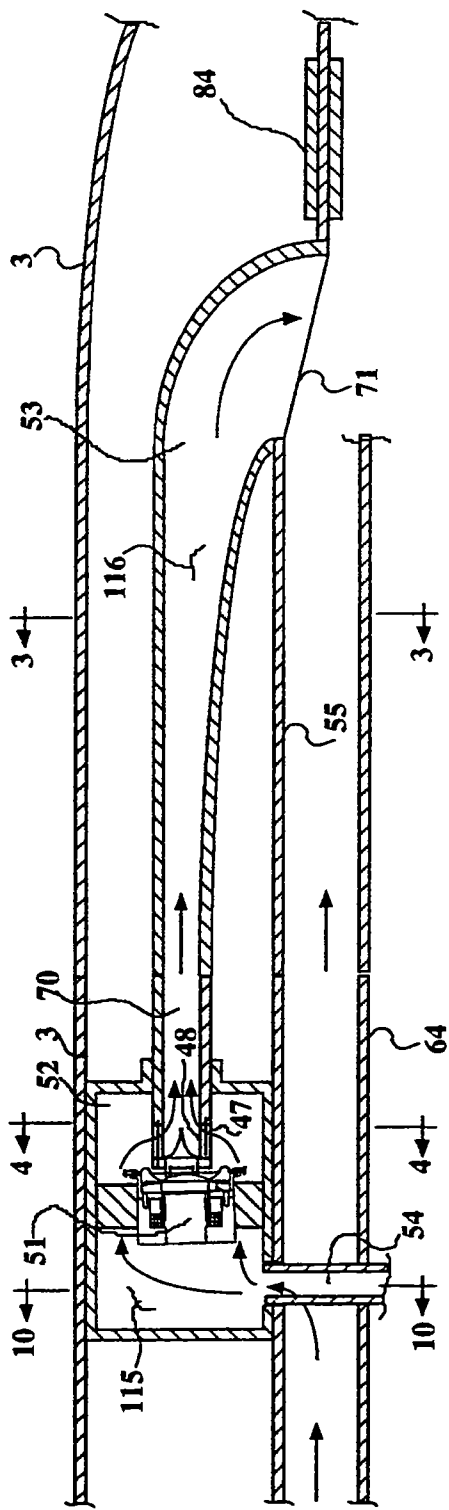


FIGURE 4A

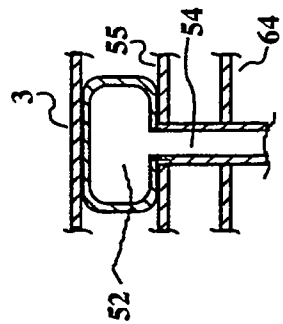


FIGURE 4C

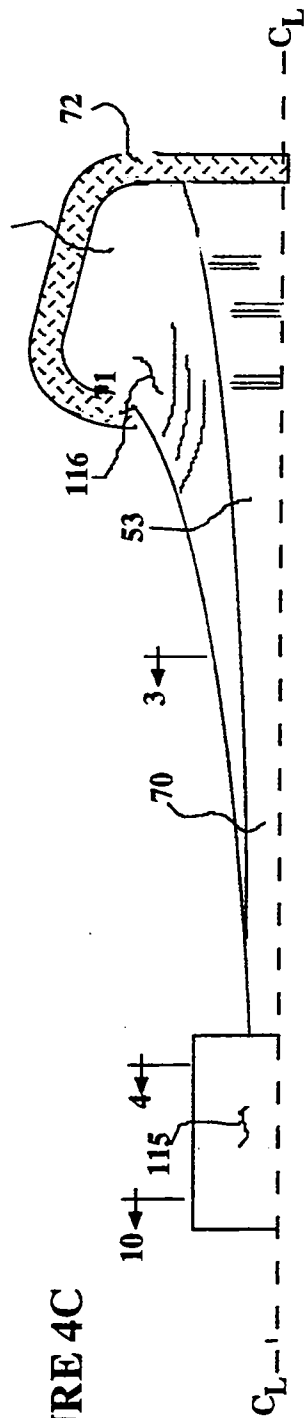


FIGURE 4B

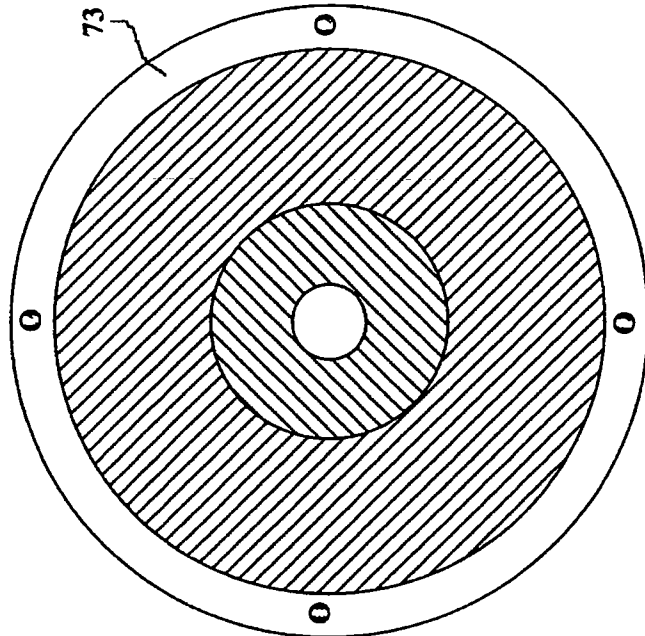
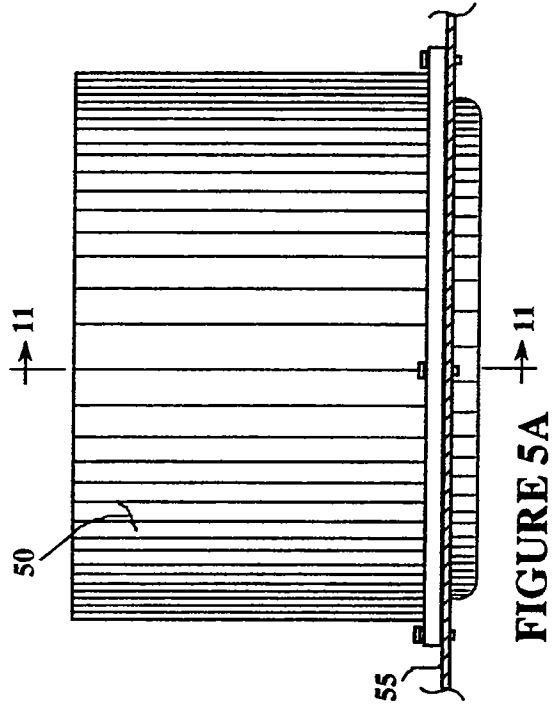
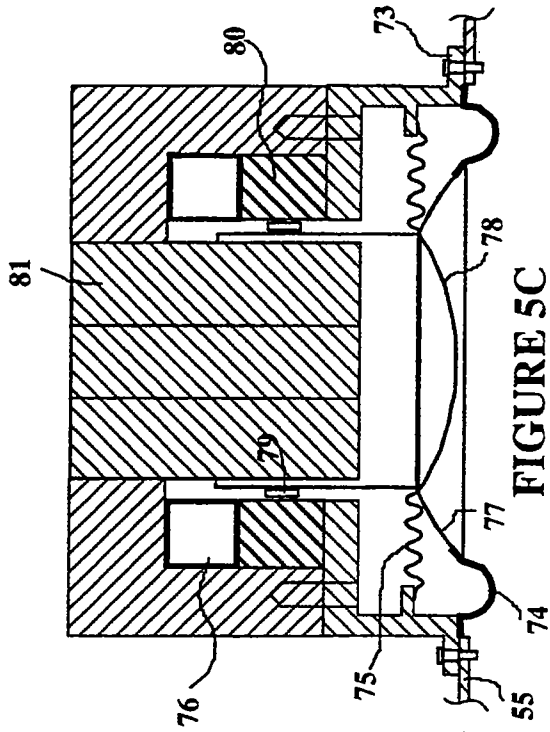
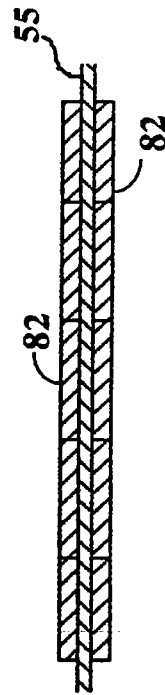
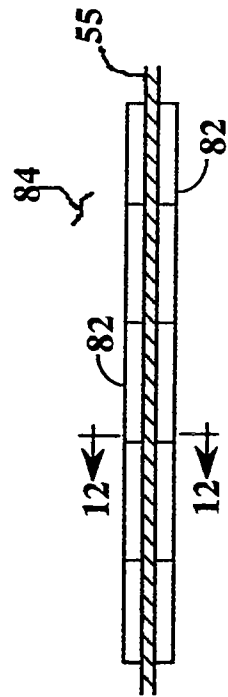


FIGURE 5C

FIGURE 5A

FIGURE 5B



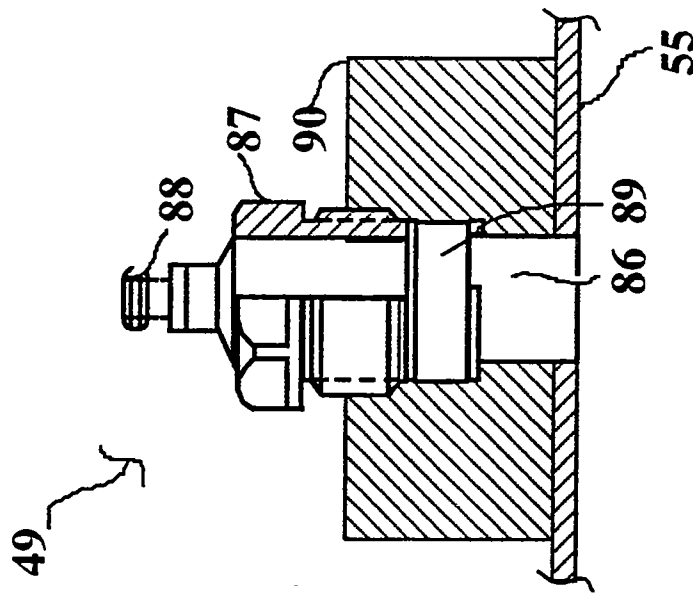


FIGURE 7

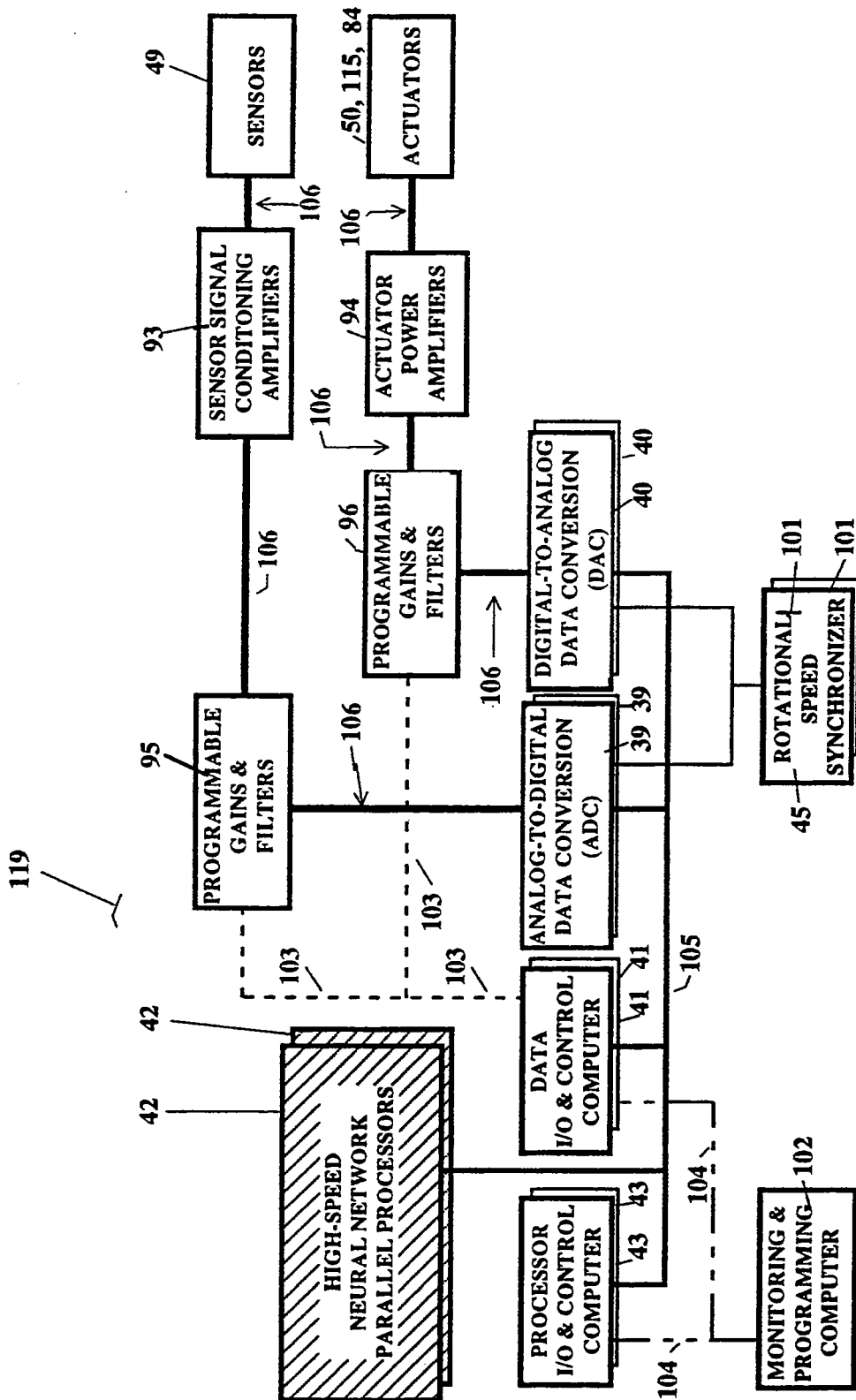
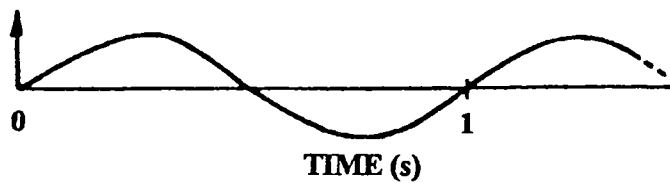


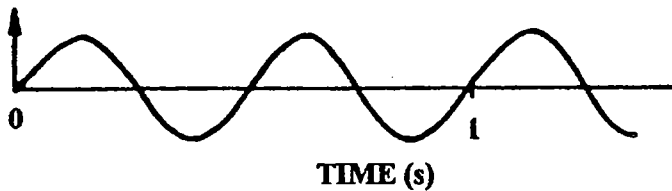
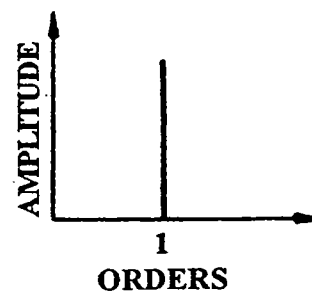
FIGURE 8

SAMPLED WAVEFORM

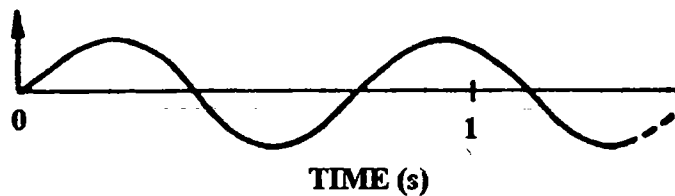
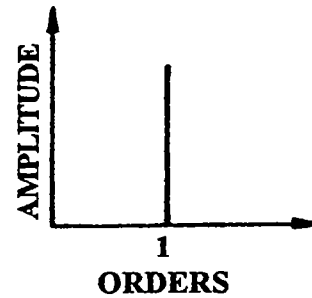


A. $f_{k\phi} = 1 \text{ Hz}; f_c = 4 \text{ Hz}$

SPECTRUM



B. $f_{k\phi} = 2 \text{ Hz}; f_c = 8 \text{ Hz}$



C. $f_{k\phi} = 1.5 \text{ Hz}; f_c = 6 \text{ Hz}$

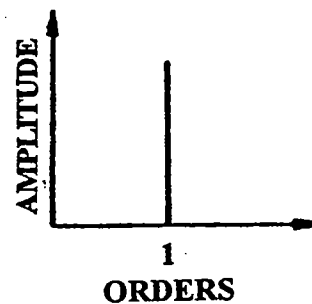


FIGURE 9A

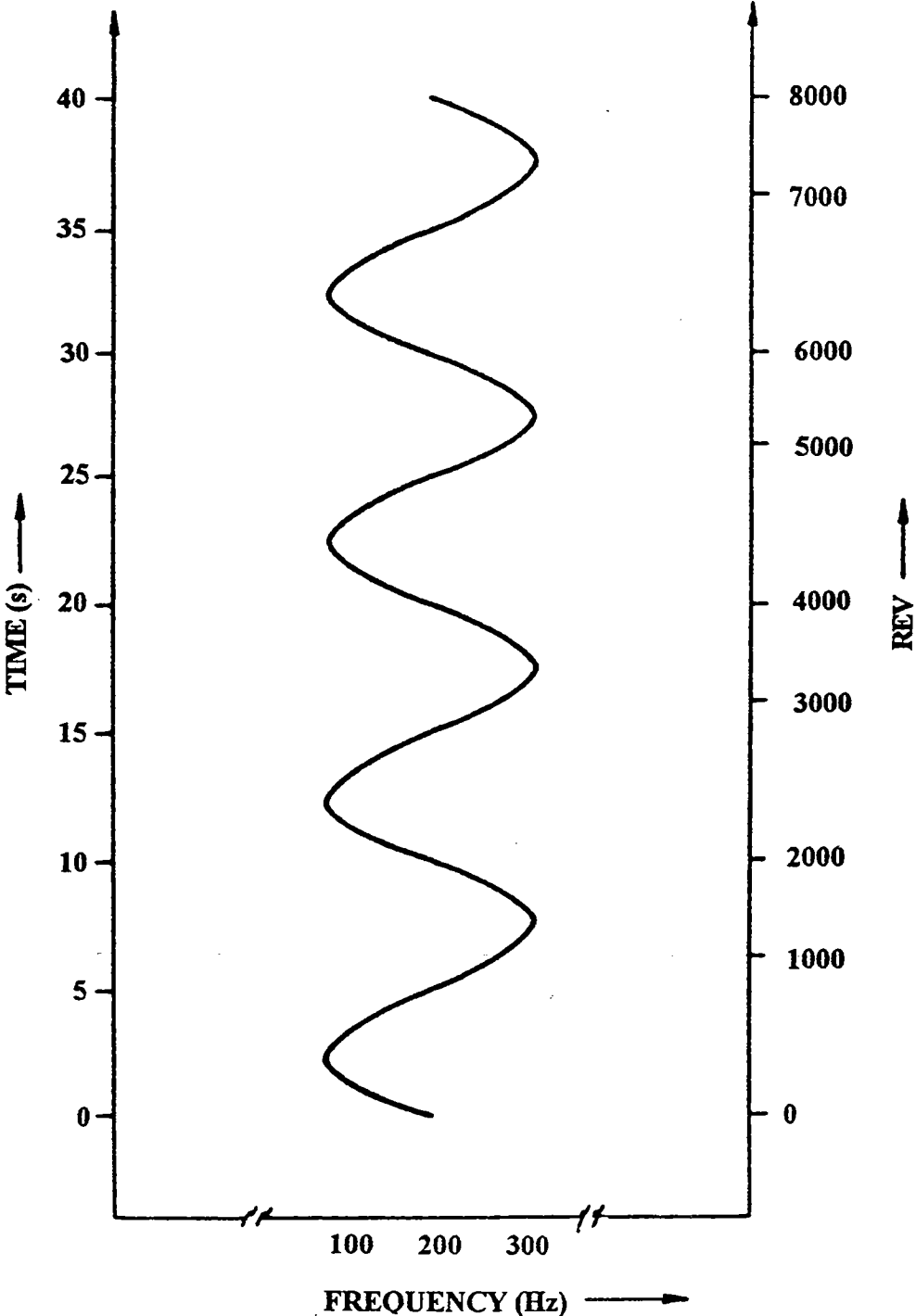


FIGURE 9B

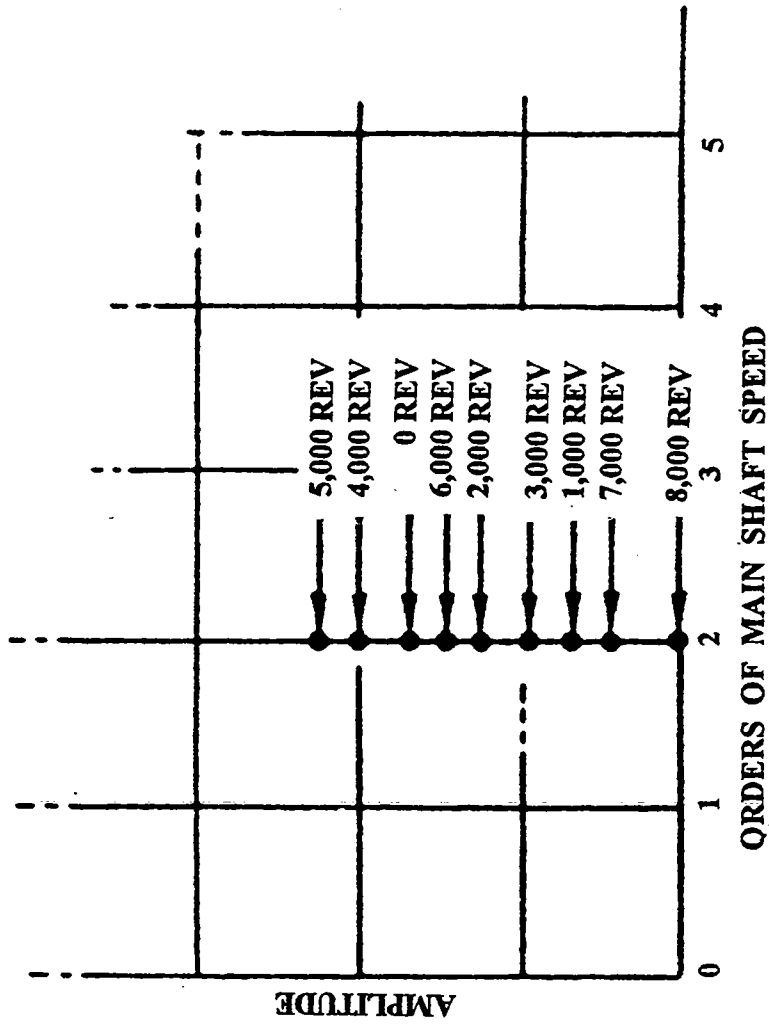


FIGURE 9C

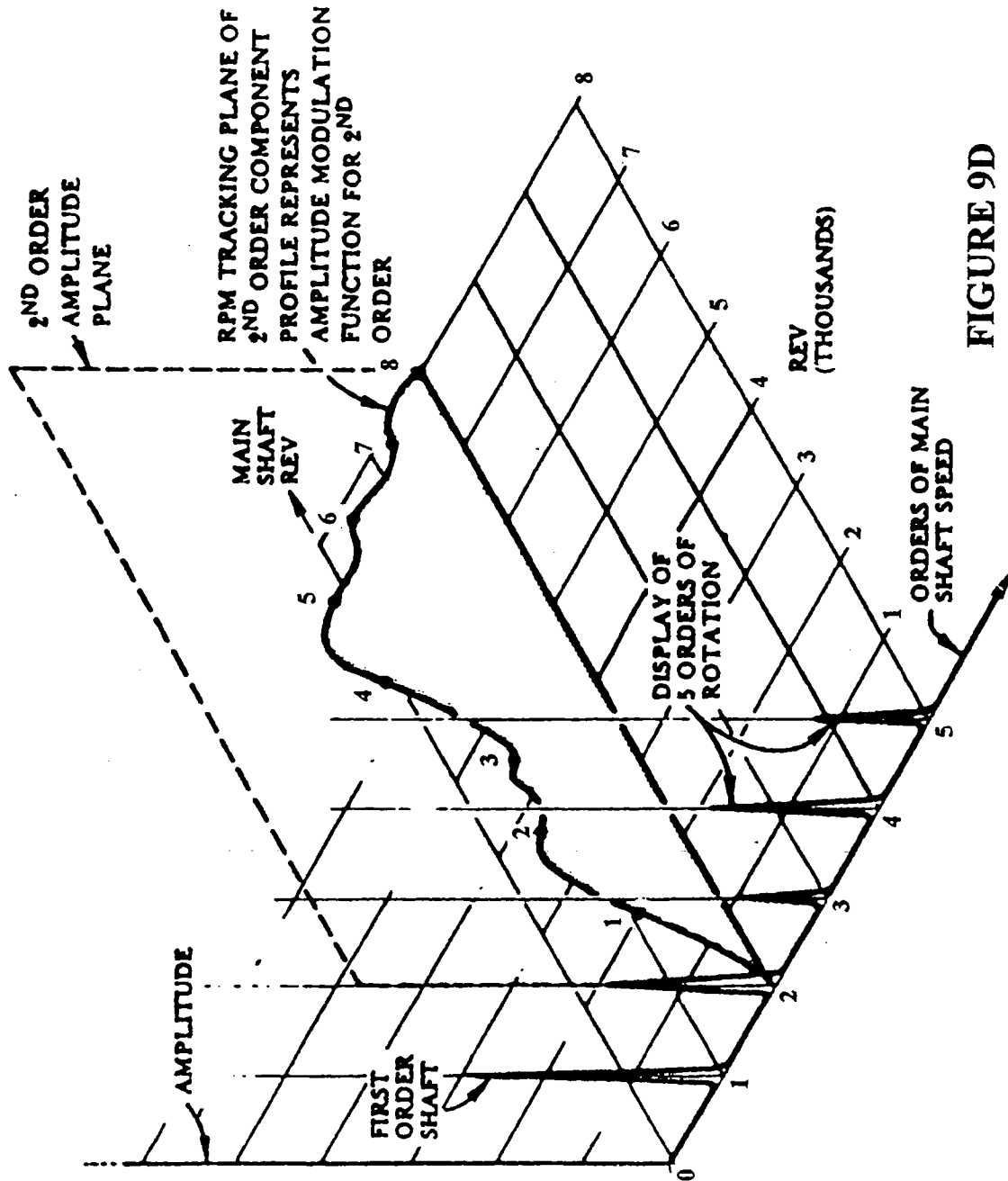


FIGURE 9D

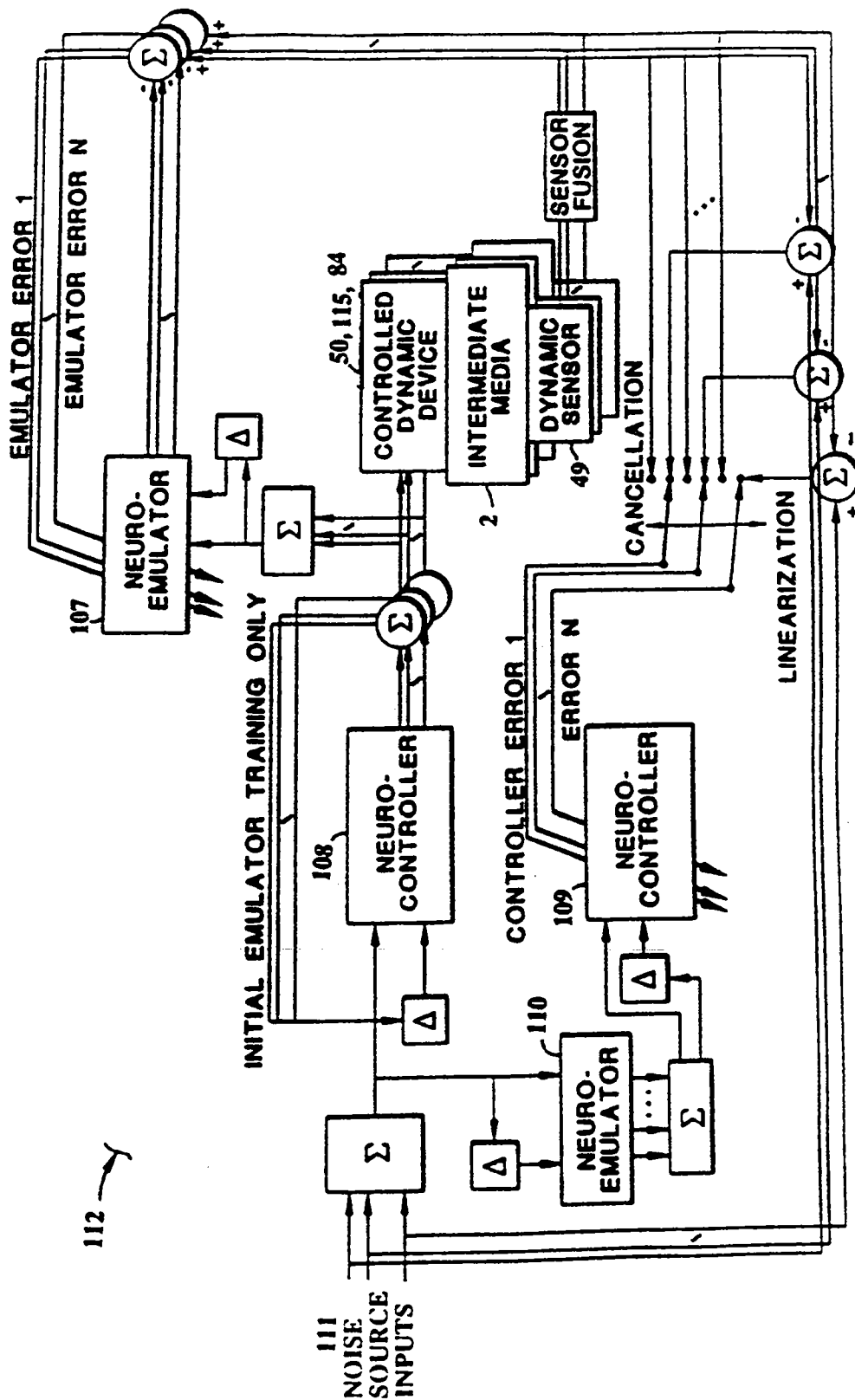


FIGURE 10A

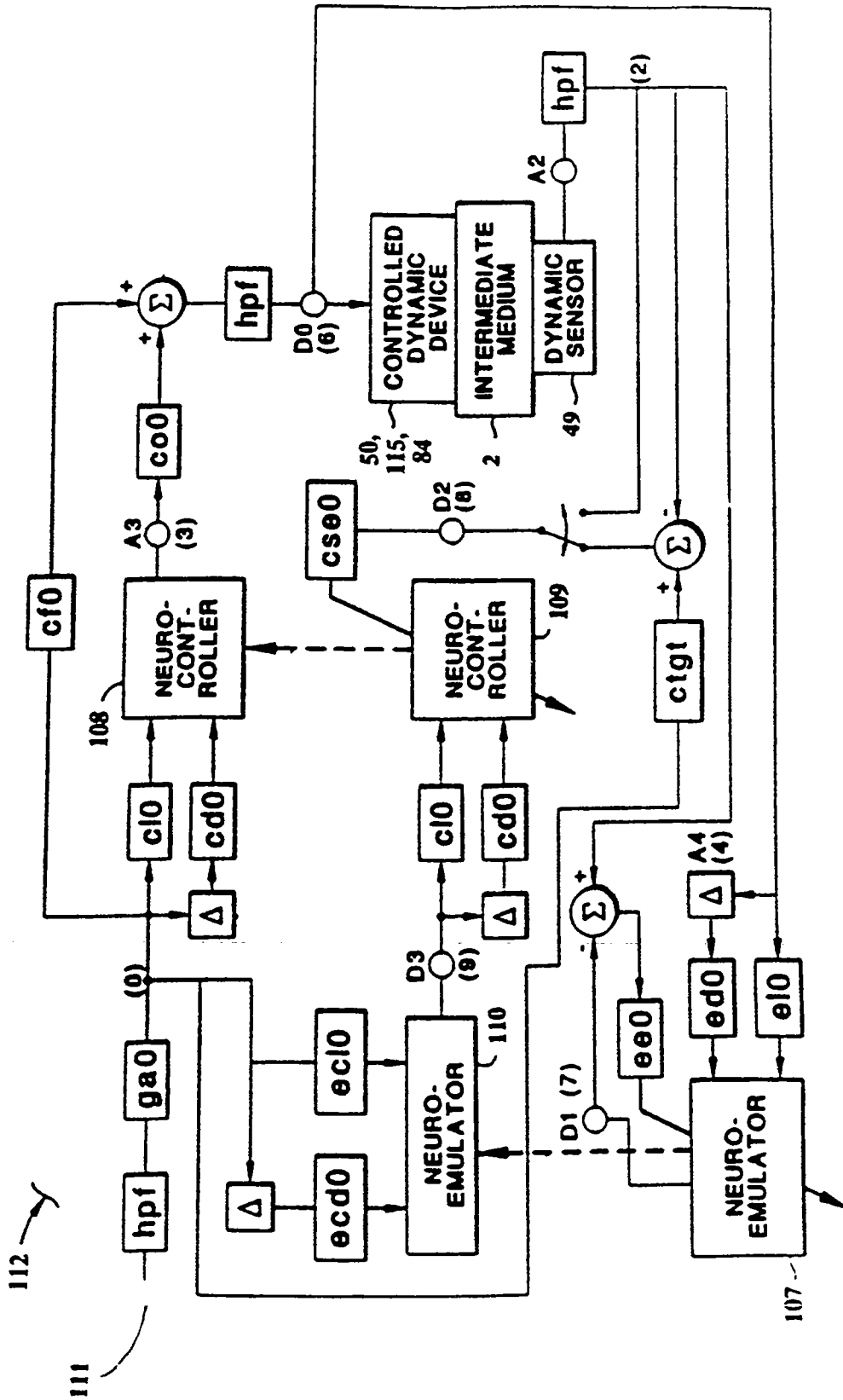


FIGURE 10B

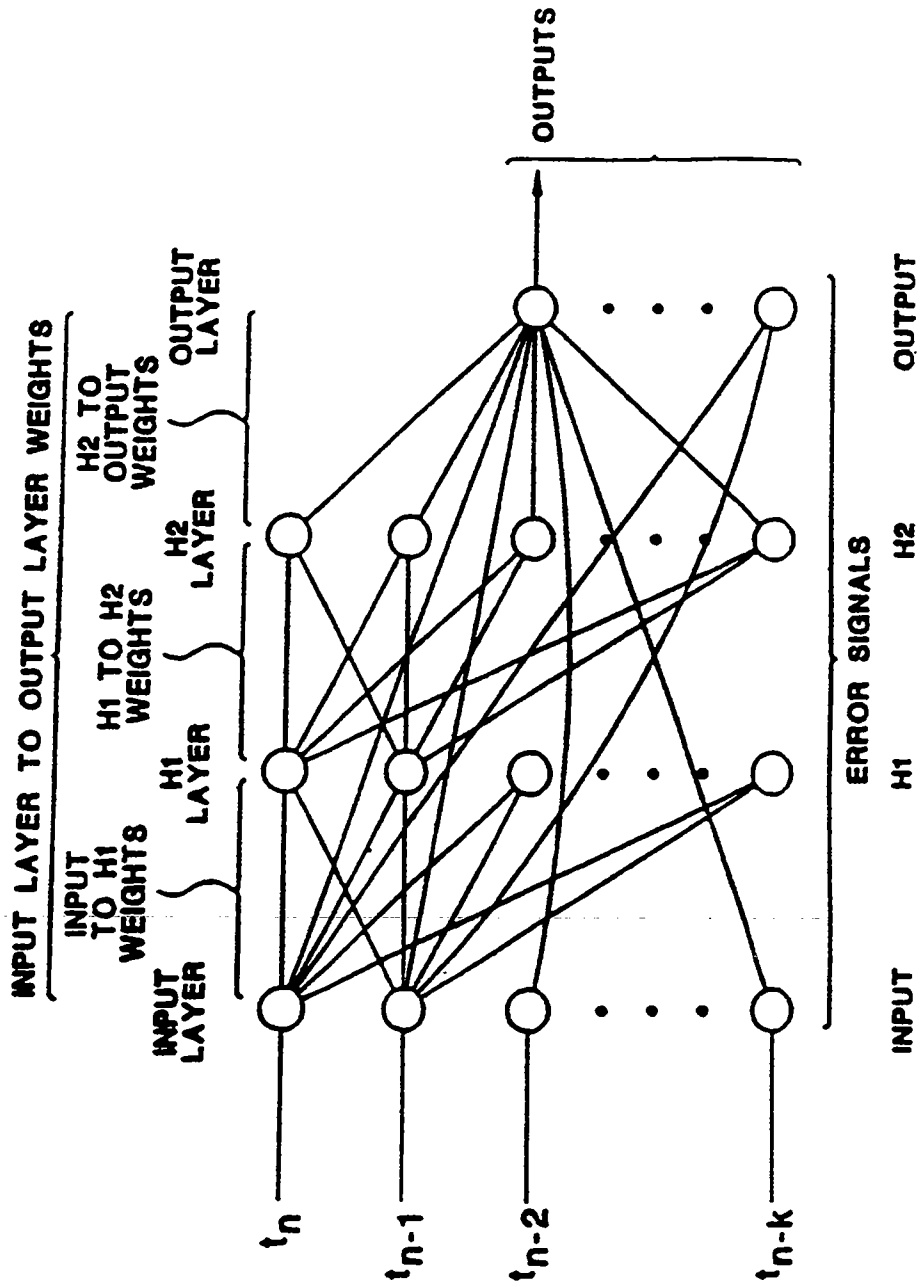


FIGURE 10C

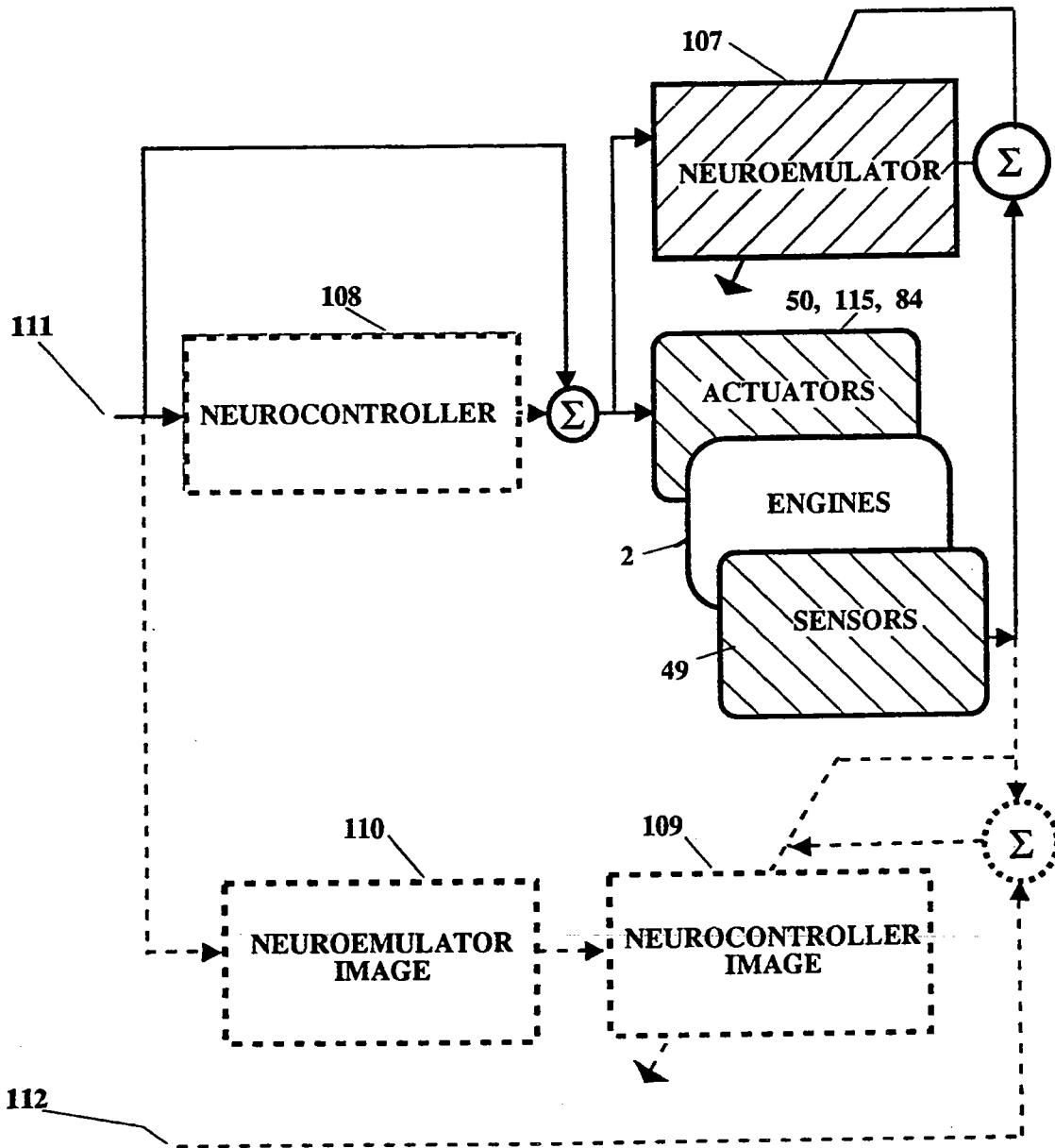


FIGURE 11A

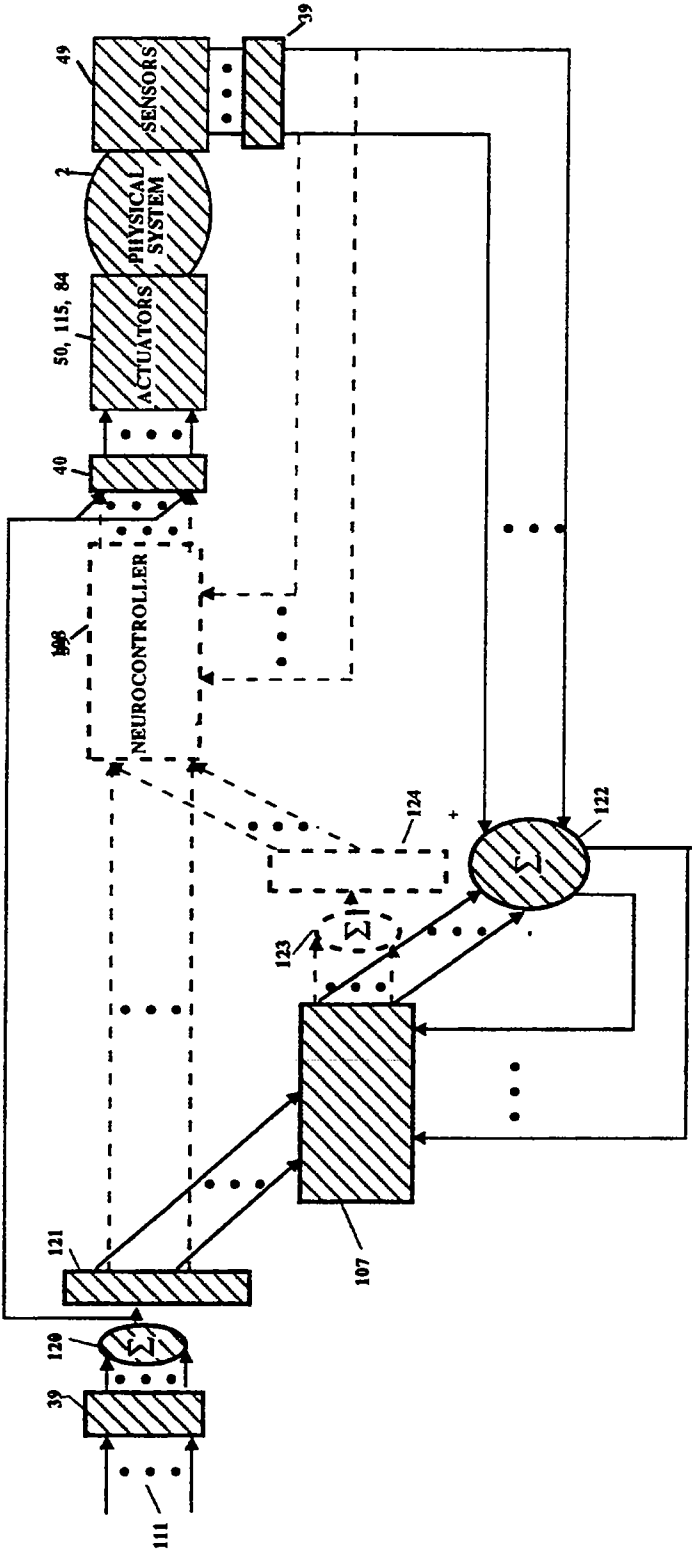


FIGURE 11B.

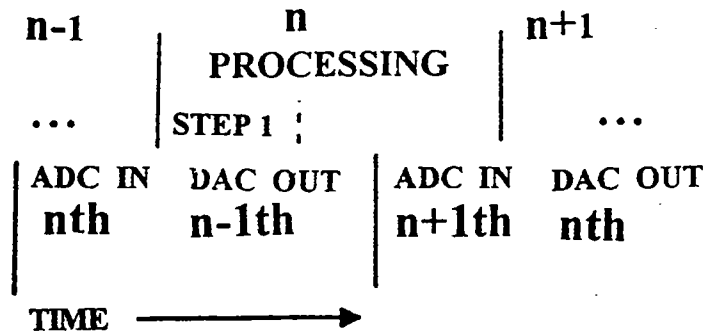


FIGURE 11C

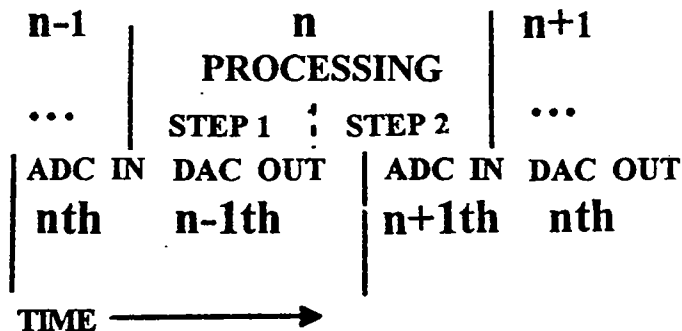


FIGURE 12D

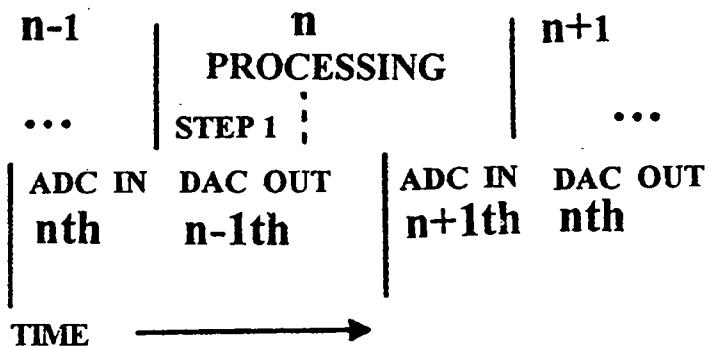


FIGURE 13C

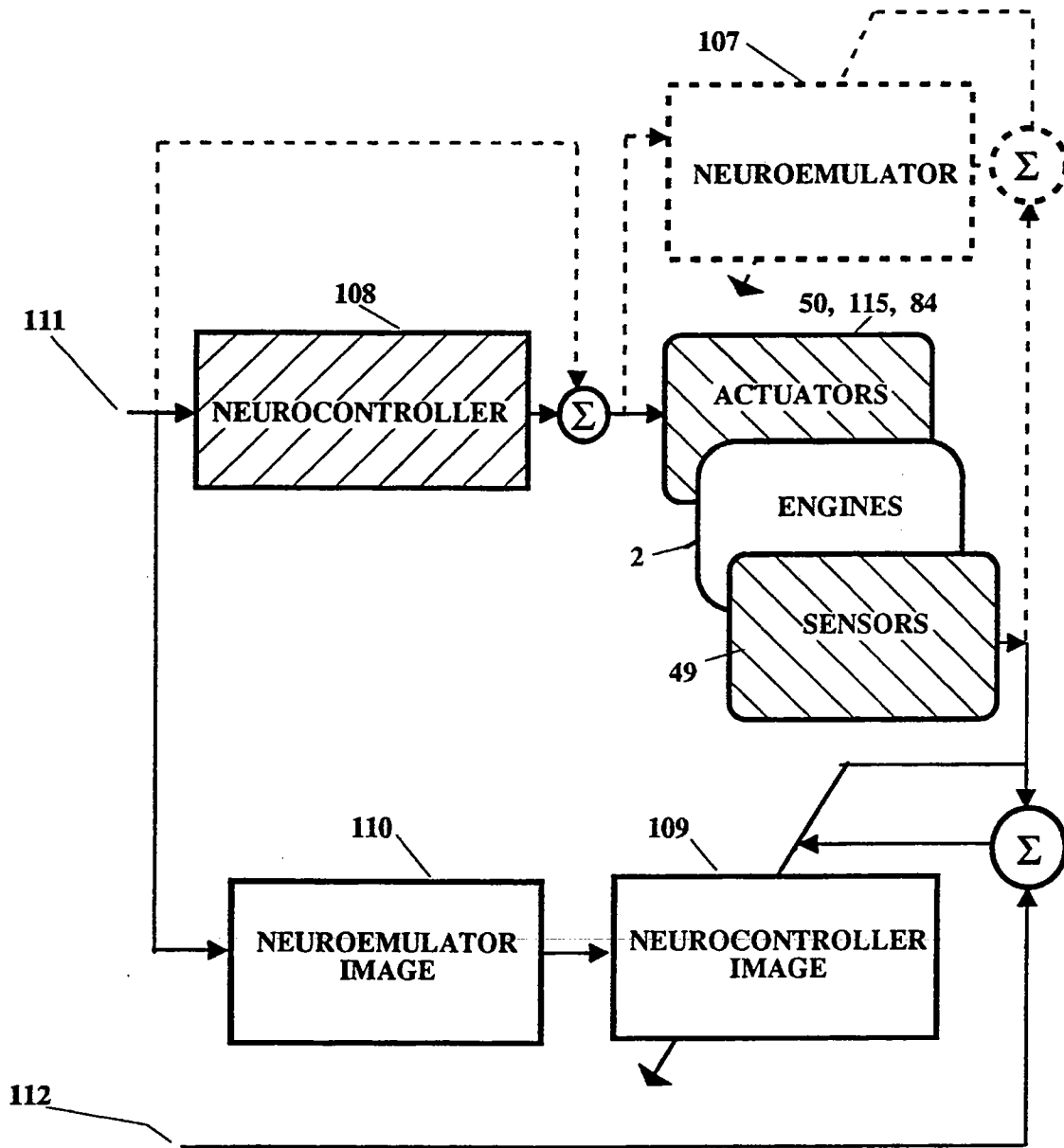


FIGURE 12A

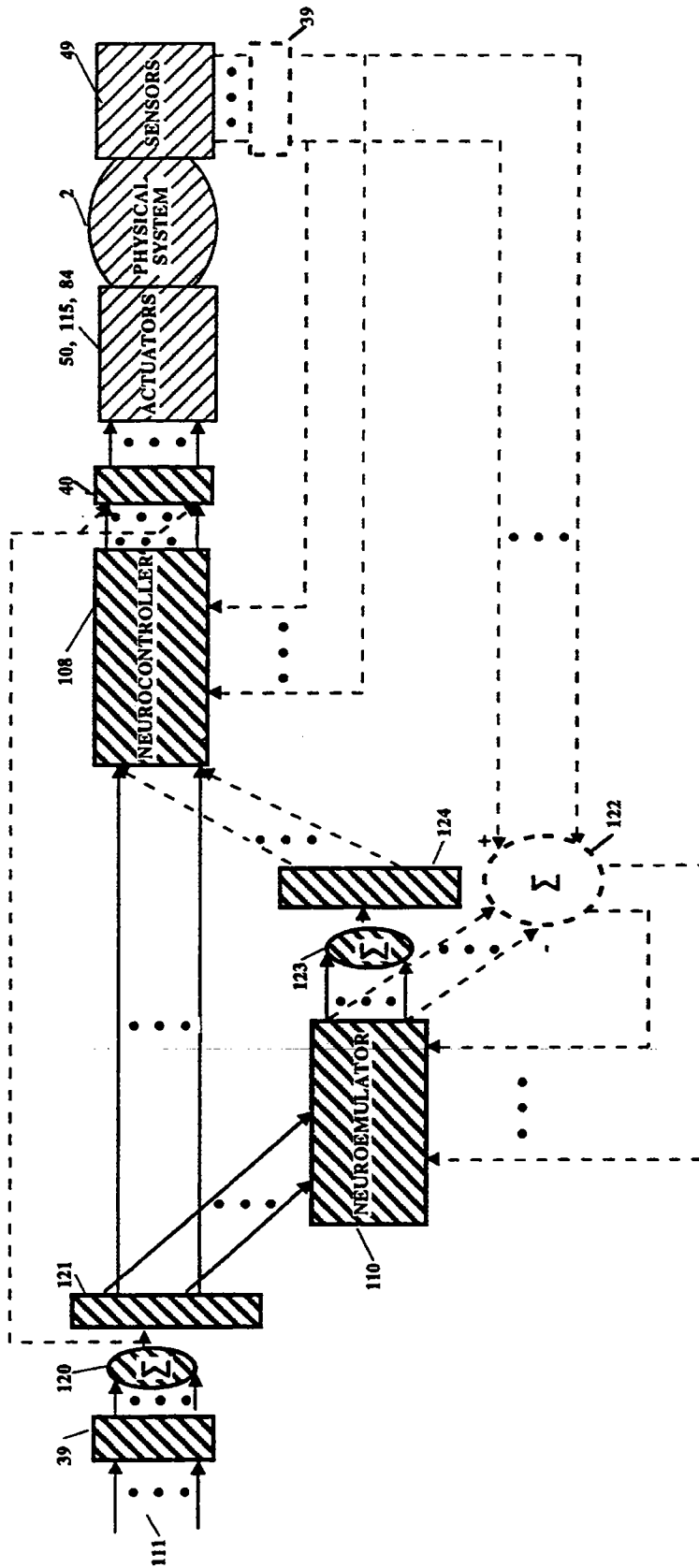


FIGURE 12B.

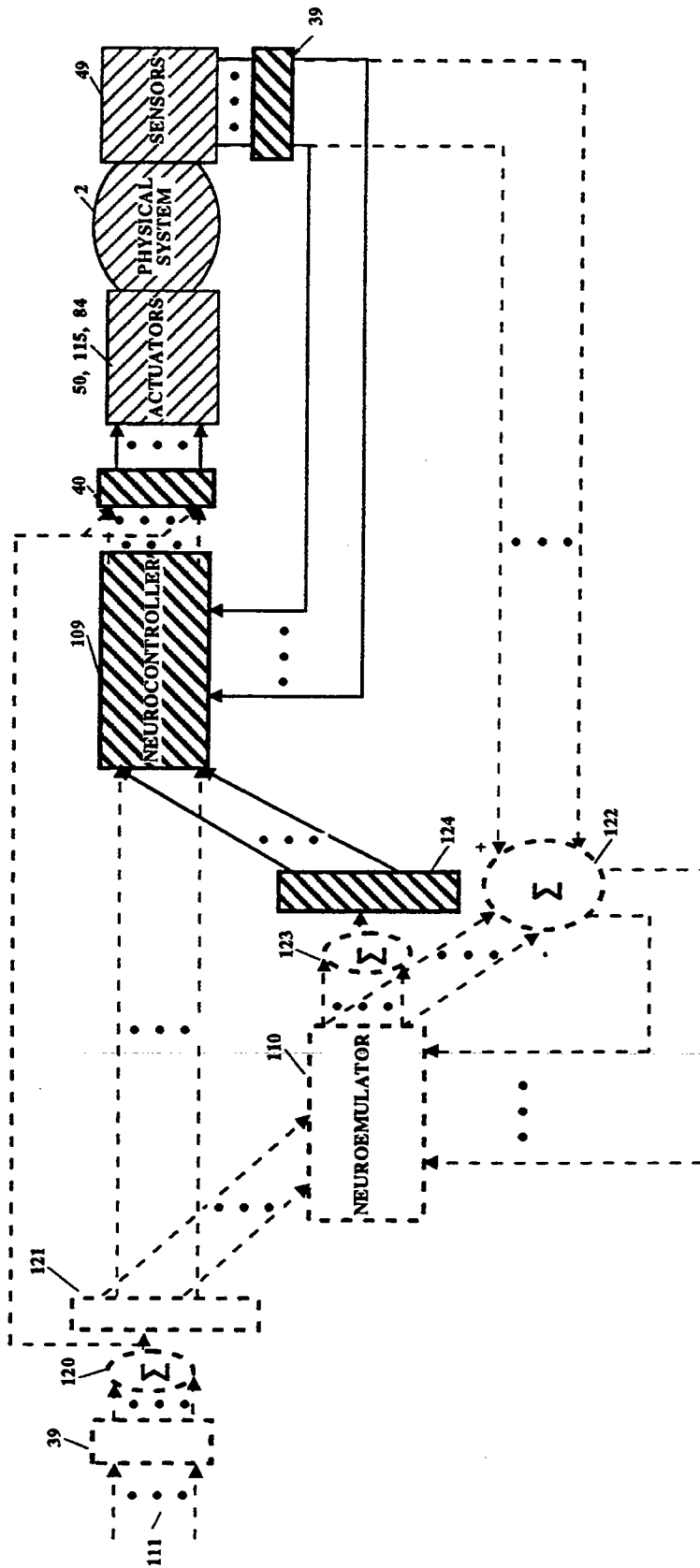


FIGURE 12C.

