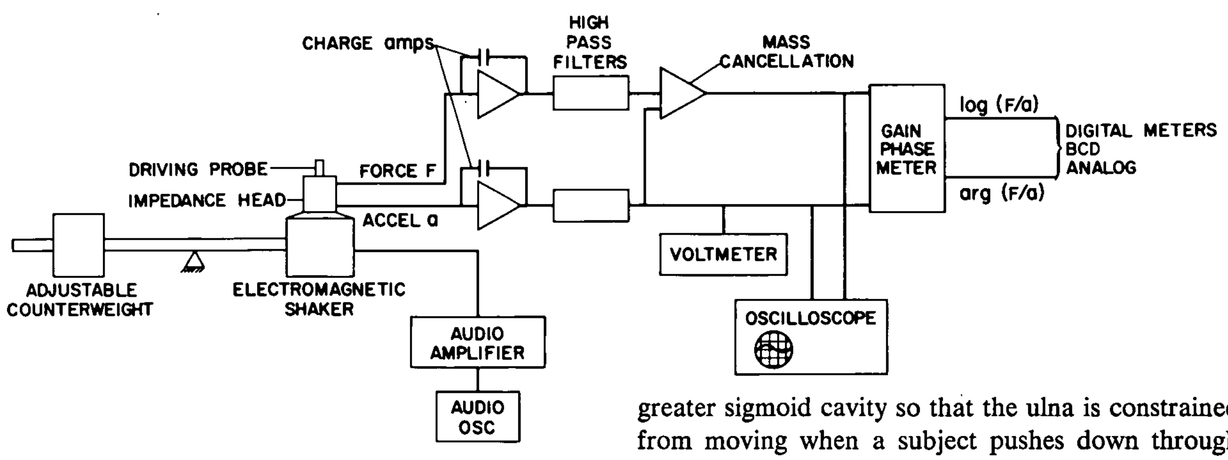
NASA TECH BRIEF

Ames Research Center

In Vivo Measurement of Mechanical Impedance of Bone

During an investigation of the factors contributing to the loss of bone strength, a method was developed for measuring the mechanical impedance of the ulnar bone in living human subjects in order to determine the response of the bone to lateral vibrations. A system of measurement was designed to provide indications of ulnar properties independent of the characteristics of surrounding soft tissue and other bones. A mechanical model made of discrete elements was constructed to approximate the ulnar response so that estimates of the static bending stiffness of the bone could be made. From the estimates of stiffness, an average bending rigidity can be determined which provides a direct index of the resistance of the bone to bending loading.



As shown in the diagram of the equipment, an electromagnetic shaker is located at one end of a balance beam; a counterweight at the other end is used to apply a constant preload force to couple the vibrations through the drive-probe to the forearm. The driving force and acceleration are measured by an impedance head; the effective end mass of the impedance head and probe are cancelled in the operational-amplifier circuit. The gain-phase meter is used to obtain both digital and analog presentations of the ratio of force to acceleration and the associated phase angle. Although the combined measuring system is capable of operating over the frequency range of 20 Hz to 10 kHz, measurements are made only below 1000 Hz because impedance above that frequency reflects largely the properties of the soft tissue lying between the probe and the bone.

The subject's forearm is placed horizontally over the drive probe in a fixture that supports the wrist and elbow. At the elbow is a small pad cast from plaster to conform to the bony prominences; it is positioned transverse to the ulna and centered under the greater sigmoid cavity so that the ulna is constrained from moving when a subject pushes down through the humerus. Motion of the ulna at the distal end is inhibited by placing a conforming plaster pad directly under the styloid process and applying downward pressure through the styloid end of the radius with a clamping fixture. By this method of positioning, measurements are relatively independent of the magnitude of the constraining forces at the elbow and wrist.

(continued overleaf)

Vibrations of the ulna are excited by the electromagnetic shaker at approximately 60 percent of the distance from the olecranon end of the ulna to the styloid process. The transverse position of the drive probe is determined by scanning across the forearm at a fixed frequency of 100 Hz until a position is found where impedance is at a maximum.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
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Reference: TSP 74-10245

Patent status:

NASA has decided not to apply for a patent.

Source: Donald R. Young
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with Gerald Thompson of
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