A FORCE PLATE SYSTEM FOR STUDYING POSTURE AND GAIT

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Abstract. A general purpose force plate for use in biomechanical studies of posture and gait has been developed at the McGill BioMedical Engineering Unit. The mechanical design and load cell electronics are first discussed in some detail in this paper. The calculation of the significant force variables from the load cell outputs, the calibration of the plate, and finally, the performance characteristics of the plate are described.

To conclude the paper a brief description is given of the equipment available for use with the plate and projects currently using the plate.

Text. A method of measuring ground reactions is essential in experimental investigations of both posture and gait. This paper describes a particular force plate system designed as a general purpose instrument to fulfill this need.

The plate consists of a three-foot square magnesium plate supported by six BLH load cells, three vertical and three horizontal. The vertical cells are at the corners of a triangle, with the horizontal cells forming the sides. All six load cells are mounted on flexure rods which are stiff axially but soft in bending. These essentially eliminate any cross coupling between the vertical and horizontal cells due to large bending moments. In detail the cells do not respond to small bending moments of the size which these flexures transmit, but since these flexures are linear in bending, any forces they absorb in bending can easily be accounted for in calibrating the plate.

The load cells are energized by a 3KHz. carrier wave and the output amplified by six channels of A.C. amplification whose output is a D.C. voltage from -1.4 to +1.4 V. with a 2.8mv noise level. The amplifiers have a flat frequency response from 0 to 1750 KHz.

The amplified load cell outputs are fed through an operational amplifier network to obtain the six independent force and moment variables related to a reference axis fixed on the plate:

(i) F_x , F_y -- two horizontal orthogonal shear forces,

(ii) F_z -- total vertical force,

(iii) M_x , M_y , M_z -- net moments about the x , y , z axes respectively.

Also, but not independent

(iv) x_p , y_p -- the coordinates of the effective centre of vertical force.

The force plate has been calibrated in terms of these variables by dead weight loading. This showed both that the plate is in fact linear and that cross coupling effects are negligible. Sensitivity of the plate is better than 1 Newton (0.2 lb). Shock response tests indicate that the plate has a natural frequency of more than 100 Hz. in all modes. These characteristics are entirely satisfactory for posture and gait studies although at the higher walking speeds, the shock of heel stroke may cause a small artifact to occur.

The force plate system also includes the following auxillary equipment:

(i) Four channels of EMG amplifiers and associated rectification and filtering circuitry for use in assessing muscular activity.

(ii) A 16 mm. cine camera for use in defining total body position in space as a function of time.

(iii) Five miniature pressure transducers to permit analysis of the detailed pressure distribution on the feet during standing and walking.

(iv) An orthotic exoskeleton capable of removing most of the degrees of freedom of a subject during quiet and perturbed standing.

(v) The Unit's PDP-12 computer has been interfaced with the apparatus to allow on-line digital data acquisition and computer control of experiments.

Three separate projects have so far used this apparatus:

(i) A biomechanical study of the pathological posture displayed by muscular dystrophy patients (D.L. Burke et al[1]).

(ii) A clinical investigation of force and pressure patterns in normal and pathological subjects during standing and walking.

(iii) An investigation aimed at identifying the neuromuscular mechanism involved in the control of normal posture.

These studies have demonstrated that the force plate system is very versatile and permits accurate data to be acquired for the dynamic analysis of posture and locomotion.

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1. Posture in muscular dystrophy--the compensatory role of pseudo hypertrophy, equinus and lordosis, D.L. Burke et al, Proc. 3rd CMBES, Halifax, N.S., Sept. 1970.