NEWSLETTER NUMBER 8

JULY 1979

FORCE PLATFORM GROUP

INTERNATIONAL SOCIETY OF BIOMECHANICS

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Newsletter Edited by

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(The Newsletter is circulated free to members of the Force Platform Group.
Membership enquiries to the Secretary.)

Contents

The Force Platform Group of the ISB

The Group first formed in 1973 at the Fourth International Seminar on Biomechanics at the Pennsylvania State University, U.S.A. with an ad hoc committee of Peter Cavanagh (U.S.A.) and Don Grieve (England). Howard Payne (England) became 'catalogue editor' and produced two editions of "A catalogue of force platforms used in biomechanics research".

At the 1977 Sixth International Congress of Biomechanics at the August Krogh Institute, Copenhagen, Denmark, the Group re-formed itself, and elected Howard Payne as chairperson with Barry Wilson as secretary.

A biannual newsletter is produced by the Group and is sent to all members, who are asked to pay a US $5 subscription to cover the costs of producing and mailing the newsletter.

The biannual newsletter was initiated with the following objectives:

(a) To provide a bibliographic service to Group members on a regular basis.

(b) To publish original articles on topics related to force measurement in human biomechanics.

(c) To provide a forum for questions and answers on related subjects.

In this 'Message' in the Newsletter No. 1 the Chairperson urged: "Firstly, please let the editor of the newsletter have any ideas that you might generate concerning material to be included in future editions. The newsletter is a far stronger means of communication than one meeting of the Group every two years, and in such a small group, we shall need input from almost every member. Secondly, if you are aware of force platform users who are not members of our group, please encourage them to get in touch with us so that we can benefit from their input."

Editor's Note

In response to a number of enquiries a list of persons who receive the Force Platform Newsletter is printed in this Newsletter. Financial membership stands at 92 members as of June 1979.

Back issues (Xerox copies) of the Newsletters 1-7 are available at a cost of \$2.00 per issue. Airmail delivery from Australia is an additional \$2.00 per order (Delivery time would be approximately 1 month from receipt of order).

A number of letters have been received. Details of these are included in the "Additions to the Force Platform Register" and in the "Additions to the Bibliography". However, more contributions to the Newsletter are invited.

Studies submitted for publication in the Newsletter should be submitted in a form suitable for publication in English with a maximum of 8 pages typed double space and art work as black on white line drawings or photographic prints of black on white drawings of $3\frac{1}{2}$" x 5" size.

Details concerning (1) the problem, (2) the platform, (3) the peripherals, and (4) how the platform can aid in solving the problem, would be appropriate for submission. Editorial changes will be minimal and should not require correspondence between the author and editor before publication. Papers should be submitted to the Newsletter editor by December 1 and June 1 for the January and July Newsletters respectively.

Finally, to those persons who have contributed to this Newsletter, thank you.

Barry D. Wilson.

ADDITIONS TO THE FORCE PLATFORM REGISTER

Mr. Y. Ehara,
The Kanagawa Rehabilitation Center,
Nanasawa 516 ATSUGI CITY,
Kanagawa 243-01
JAPAN.

SHINKOH (Made in Japan) 600mm x 600mm. X, Y, Z and C. of P. outputs
Strain gauges,
AD converter, PDP-12, XY plotter.

Video X-Y trackers for 3D Analysis.

Gait analysis for rehabilitation.

Dr. M. Gagnon,
Department D'Education Physique,
Cepsum 2100 Blvd Edouard Montpetit,
Universite de Montreal, Montreal,
Quebec,
CANADA.

Own design, force and bending moment
Strain gauges.

Honeywell 2208 A Visicorder.

Cine camera (Locam)

Sport skills (Hockey).

Dr. R.J. Gregor,
Biomechanics Laboratory,
Department of Kinesiology,
University of California,
Los Angeles, CA. 90024
U.S.A.

Kistler, 200mm x 400mm.
6 channel, F_x, F_y, F_z, a_x, a_y, M_z.

F.M. Tape, Grass Chart recorder.

Cine cameras, E.M.G.

Sport Medicine and Technique analysis.

Mr. R.N. Marshall,
School of Physical Education,
University of Otago,
Dunedin,
NEW ZEALAND.

Own design, 610mm x 610mm.
Strain gauge, Kyowa DPM 110-A, Strain Amplifiers.

UV Recorder.

Cine cameras.

Gait analysis.

Dr. E. Michaut and F. Pelisse,
Centre d'etudes et de Recherches pour l'Appareillage
et la Biomecanique de l'Appareil Locomoteur,
Cereval,
2, rue du Parc,
94460 Valenton,
FRANCE.

CEREVAL (Own design) 300mm x 800mm, 2 of 300mm x 1700mm.
Strain gauges.

Nova 3 Computer, printer and plotter.

Transducers on prosthesis and on crutches.

Gait analysis of normal and pathological subjects.

Dr. B.D. Wilson,
Department of Human Movement Studies,
University of Queensland,
St. Lucia,
Brisbane,
AUSTRALIA 4069.

Kistler 6 channel

PDP 11/34, HP graphics and printer, F.M. tape

E.M.G., cinematography, POLGON.

Gait analysis, Quantification of sensori-motor deficit, Sport Biomechanics.

ADDITIONS TO THE BIBLIOGRAPHY

Ehara, Y., Nomura, S., and Beppu, M. Development of the automatic gait measurement system. Proceedings of International Society for Prosthetics and Othotics 1977 World Congress, New York.

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Instrumentation Development and Validation for Analyzing Force Applications on the Balance Beam

By

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In any movement of the human body, exertion of force against its environment takes place. The study of the magnitude and direction of that exerted force provides researchers of human movement with valuable information. (2:83)* At the time of this study, only a small amount of information was available on the use of force instrumentation devices for collecting data in analyzing gymnastic technique. It was believed that the development and validation of a measurement device for analyzing the applications of force on the balance beam would contribute additional information about general balancing skills and balance beam performances.

The force instrument designed was composed of two mini-platforms held between the wooden beam portion of the balance beam and the supports. The basic piece of equipment was a Nissen balance beam (No. 269-E). The mini-platforms were bridged together by steel in order to stabilize the two units as a singular functioning platform. The steel bridge was composed of a light weight flexible steel material and assisted in creating a stiff suspension that had been previously suggested by Stout.(3) Stiff suspension was further enhanced by weights on the bases of support of the balance beam to ensure that there was no perceptible movement in the balance beam structure.

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* Numbers in parentheses refer to numbered references in the bibliography; those after the colon are page numbers.

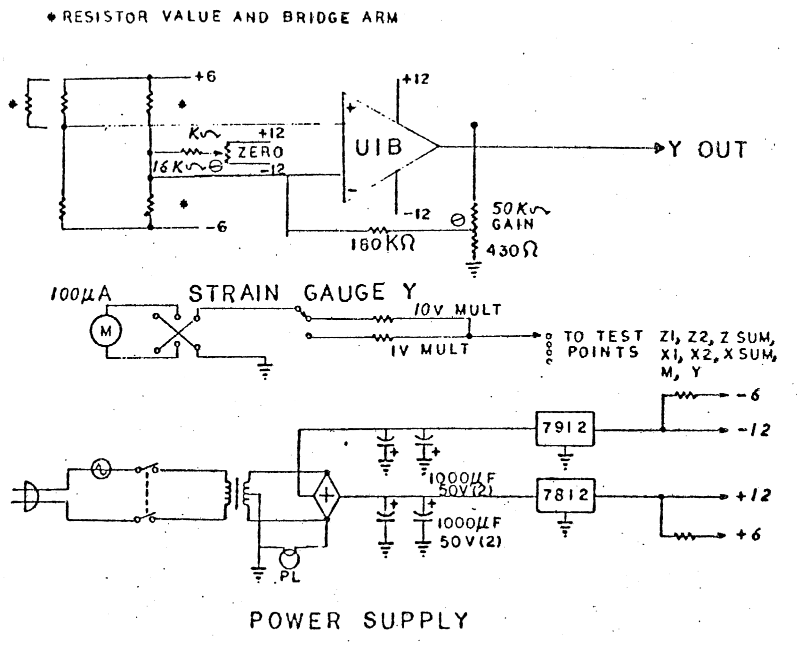

Figure 1. Electrical Circuitry for the Power Supply and Y Strain Gauge in the Beam Instrument

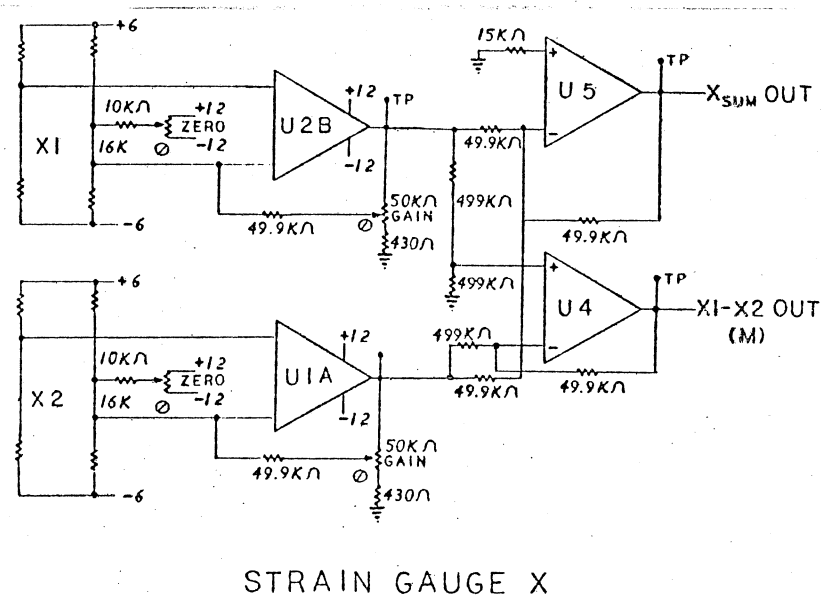

Figure 2. Electrical Circuitry for the X Strain Gauge

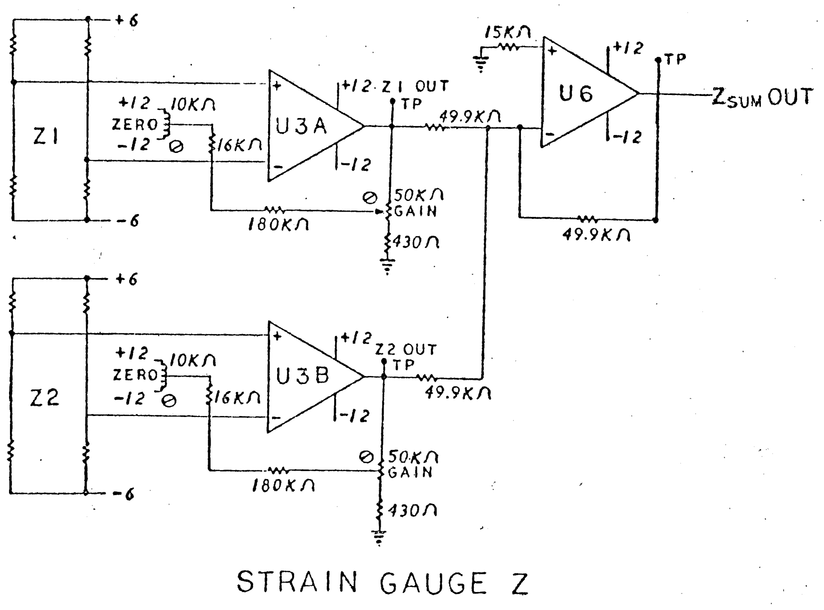

Figure 3. Electrical Circuitry for the Z Strain Gauge

Each mini-platform contained strain gauges for measuring sensitivity of pressure in all three planes. The strain gauges were constructed of ground flat stock (Brown and Sharp AISI, Type 01) steel, with four foil-type resistance units cemented to each other. The strain gauge members were identical except for thickness; 1/2 inch by 1 inch stock was used for Z component, and 3/8 inch by 1 inch stock for the X and Y axes. The foil-type resistance units were 350 OHMS with no distortion on them. A diagram of the Y strain gauge and the power supply electrical circuitry can be seen in Figure 1. The electrical circuitry for the X and Z strain gauge elements are illustrated in Figures 2 and 3 respectively.

The force instrument recorded the vertical (Z) downward force exerted on the balance beam on three separate channels of an oscillograph. Two of the vertical channels (Z1 and Z2) recorded the separate force applications from the two individual mini-platforms supported on the ends of the balance beam. Comparisons of Z1 and Z2 permitted the exact calculation of the point of application of vertical force between the ends of the balance beam. A third vertical channel (Zsum) recorded the sum of Z1 and Z2. This instrument also recorded the horizontal forces (X and Y). Finally, the instrument was capable of recording the turning horizontal moment (M) around the vertical axis.

A force platform should have a natural frequency that would not be excited by the application of forces on that instrument. The two simultaneous frequencies could result in resonance that would make the interpretation of forces difficult. The natural frequency of the instrument developed in this study was determined by applying an intermittent non-variable force on the platform and accomplishing this over a range of frequencies. This was best accomplished by mounting a brush electrical motor to the top of the balance beam. This motor weighed ten pounds and had the capability of varying speeds through the adjustment of a veriax. The motor had a two and one half inch flywheel mounted on it. A strobotac faced the motor and flashed a light on the flywheel. A throw cam of one half ounce was mounted on the face of the flywheel. The use of the strobotac provided an intermittent flash of light which made the revolving cam on the flywheel appear stationary. When the stationary effect had been obtained, a direct RPM reading was taken from a dial indicator on the strobotac. The setting of the strobotac to a preselected RPM, and the adjustment of the veriax on the motor permitted the motor to be adapted to the desired RPMs.

The oscillograph was used to test and record the vibratory behaviour of the balance beam at various RPMs. The counting of cycles per second (CPS) was possible directly from the oscillograph recordings. The range of RPMs were from 400 to 3000 RPMs. The multiple of the reciprocal action of the mounted motor through the range of RPMs was the interpreted natural frequency. The natural frequencies for the balance beam were 50 CPS for the X axis and 30 CPS for both the Y and Z axes. The natural frequencies were considerably lower than those indicated by Payne. (2:84) The higher natural frequencies were impossible with this instrument due to complexities created by the increased mass, unusual dimensions, and additive frequencies from the separate individual force platforms and the beam itself.

A static validation was accomplished through the use of techniques that are standard in calibration procedures for force instruments. Comparisons were made of known static loadings with the strip chart recordings from the oscillograph. Static loadings were accomplished through the utilization of weights for the Z axis and an electronic cable tensiometer for the X and Y axes. The static validation was evaluated through the use of the Pearson product-moment correlation coefficient technique. The deflected value was recorded as the static constant for the particular known force applied. Numerous trials of various static loading weights on a variety of locations on the instrument were tested, and a composite correlation coefficient was calculated for each plane.

The correlation coefficients were .9938, .9957, and .9949 for the X, Y and Z respectively. The correlation coefficients for all three planes indicated sufficient accuracy for the instrument with regard to static loadings. Limitations were imposed on the range of loadings used due to the physical possibilities of the experimental situation. The static validation indicated that the force instrument responded and performed the same as other conventional force platforms.

An important characteristic of the force platform that should be evaluated was the predictable behaviour or the linearity of that behavior in dynamic situations. The irregular physical size of any force platform would be an indication of possible irregular behavior dynamically. The balance beam was not symmetrical in physical size, and a test of linearity was therefore indicated. The physical characteristic of concern was the extreme length of the balance beam. The length of the balance beam made the horizontal (X) axis of special concern.

Two tests of dynamic nature were performed on the force instrument device. These tests were performed through the application of a simple pendulum type of apparatus. The simple pendulum provided a means of dynamically controlling force applications. These tests were accomplished by swinging a steel ball of known weight through a predetermined arc against the balance beam. The oscillograph recorded the harmonic oscillations of the known force applications. This was done on both sides of the balance beam, and at various selected points along the length of the balance beam to determine if the oscillations were linear.

The swinging apparatus was constructed of a wooden ladder with a rod mounted to the top of the ladder by clamps. A steel cable connected the rod with the steel ball. The steel ball weighed 3.62 kilograms and was swung through an arc of 75 degrees. The arc was measured prior to each trial with a protractor mounted on the rod. The radius of the arc was 73.66 centimeters, which was the length of the cable from the rod to the center of the steel ball.

The data to be evaluated for validation were in the form of sinusoidal waves on the strip chart recording paper taken from the oscillograph. The sinusoidal wave forms were compared at various points along the entire length of the balance beam. The amplitude of the sine wave was measured at various points in time preceding the initial application of force. The Pearson product-moment correlation coefficients were used to determine linearity of the oscillations.

Measurements of the amplitude of each peak were taken every fourth cycle for two seconds of oscillation for each of the three planes. The application of force produced by the simple pendulum was measured at the center of the balance beam, the extreme right and left ends of the balance beam, and two feet to the left and right of the center of the balance beam. Each application of force was compared against the other trials of force application in each plane.

The range of correlation coefficients for the X axis was .9432 to .9945, .9751 to .9933 for the Y axis, and .8956 to .9934 for the Z axis. The results of this test indicated a high degree of linearity for the balance beam force instrument.

Granger (1) indicated that added mass to the force platform in his investigation had no effect on the sensitivity or linear behavior of the force platform. A second dynamic test was used regardless of Granger's findings due to the unusual dimensions and characteristics of this instrument and therefore to ensure linearity. This test used exactly the same procedure as indicated in the first dynamic test, but the vertical (Z) plane was statically loaded. The presence of weight on the vertical axis had a dampening effect on the frequency cycles of all the planes. Weight on the vertical (Z) axis was representative of the actual situation of a performer on the balance beam. A weight was placed on top of the balance beam, or on the vertical axis, with the oscillograph recording the dynamic action of the steel ball. This made it possible to measure the dampening effect of the static loading and establish the linearity of oscillations under these conditions. The results of the second dynamic test indicated that the force instrument was also linear under these conditions. The range of correlation coefficients for the X axis was .8715 to .9727, .9727 to 1.0 for the Y axis, and .9920 to .9971 for the Z axis.

The balance beam force instrument had the same predictable behavior as a spring with a measurable spring constant. All the force curves created due to movement on the balance beam were directly measurable with the exception of the period of impact immediately following a flight from the balance beam. After the period of impact, the balance beam was a reestablished loaded spring with directly measurable force data. The difficulty in making precise force measurements occurred only during the period of impact.

The results of the static and dynamic tests validated the accuracy and linearity of the force instrument. The results of such tests could also be used to clarify force data which has undesirable oscillations. Force recordings of the immediate impact taken after a subject returns to the force platform following a flight of some nature may be contaminated due to oscillatory motion of that instrument. If this situation existed, the screening tests suggested here and general experimental information would provide the necessary information to make the force data more reliable and valid.

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The CEREVAL dynamic measurement force-platform

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Introduction

The cereval force platform enables measurement of three orthogonal components of force resulting from applied forces. The resultant moment and other parameters may be calculated from this information.

The platform is supported by 8 transducers, with strain gauges linked to form Wheatstone bridge circuits. The testing bodies of the transducers have been calculated to give an insignificant displacement of the entire equipment when the maximal force is applied.

The natural frequency of the platform which has been observed to be appropriate for the measurements made in biomechanical research, or, for monitoring rehabilitation or athletic training.

I. Selecting a reference system

Figure 1 shows the positions of the 3 dimensional origin of reference with respect to the platform. The origin O coincides with the angle 4 on the support.

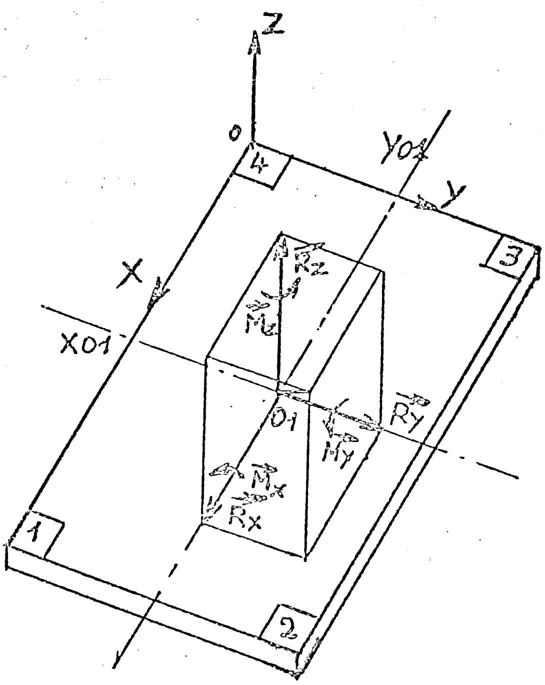
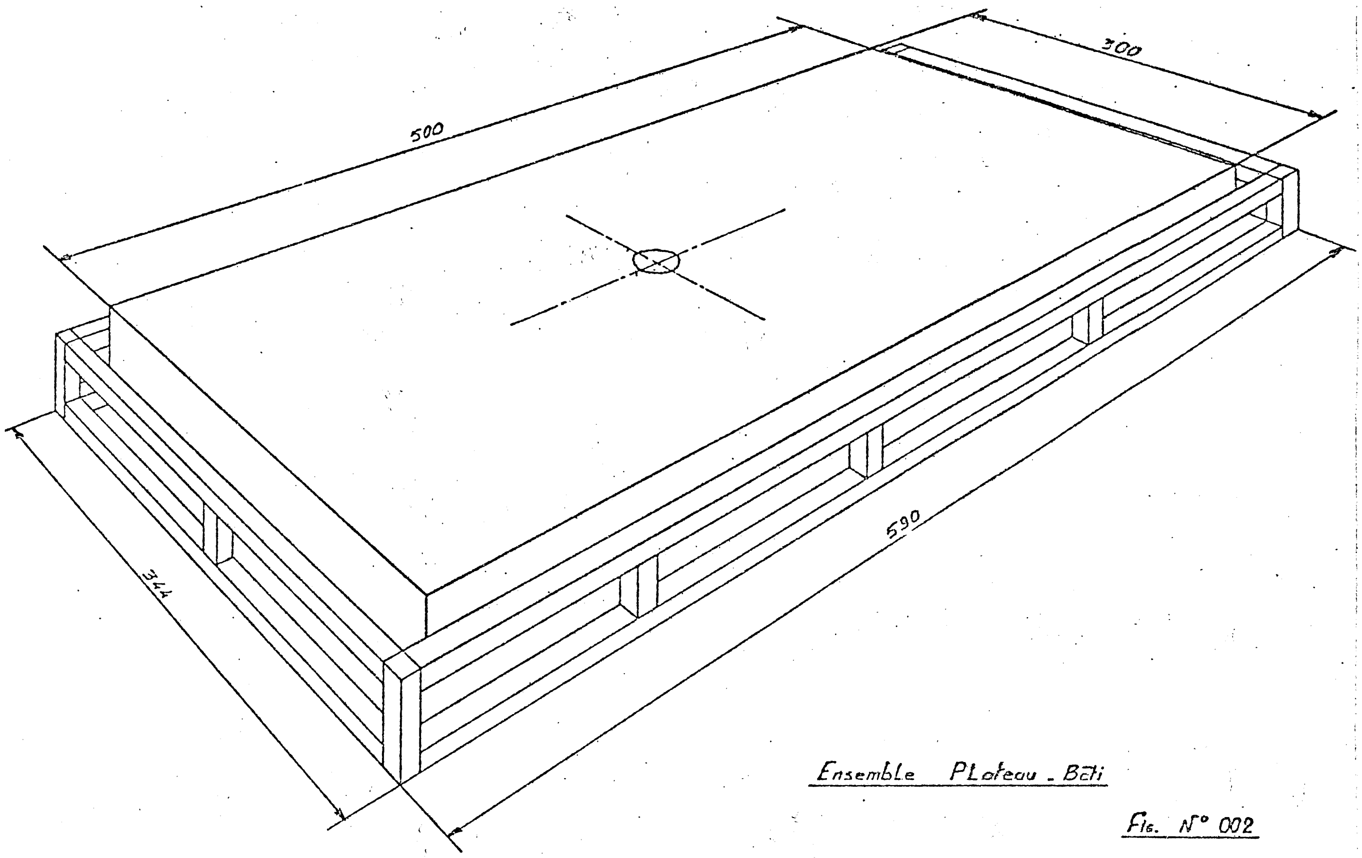


FIGURE 1

When analyzing walking, the total forces between the foot and the surface give a resultant R composed of (i) R_x (horizontal force in the direction of the walk), (ii) R_y (horizontal and perpendicular to R_x), (iii) R_z (vertical component), (iv) a resultant moment which can be broken down into 3 moments M_x, M_y, and M_z, about the axes OX, OY and OZ respectively.

The resultant R at the point of application O1 on the platform, is determined by the coordinates XO1 and YO1.

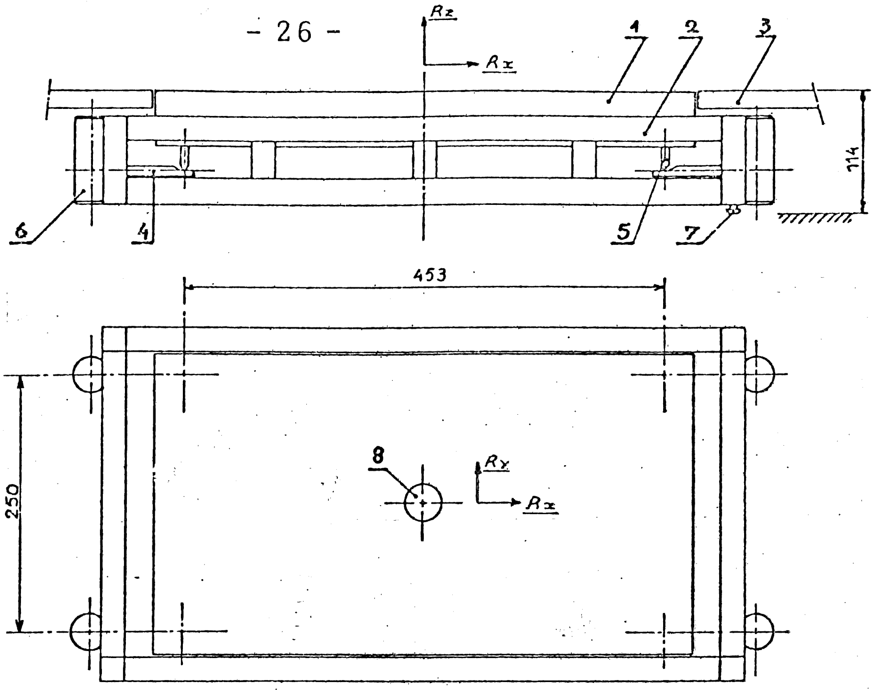
II. Description of the various mechanisms



Ensemble PLateau - Bâti

Fig. N° 002

Figure 2 shows the platform in perspective, and the main dimensions for the smaller of the 2 platforms. The principal structures of the system are drawn in Figure 3 (with dimensions).

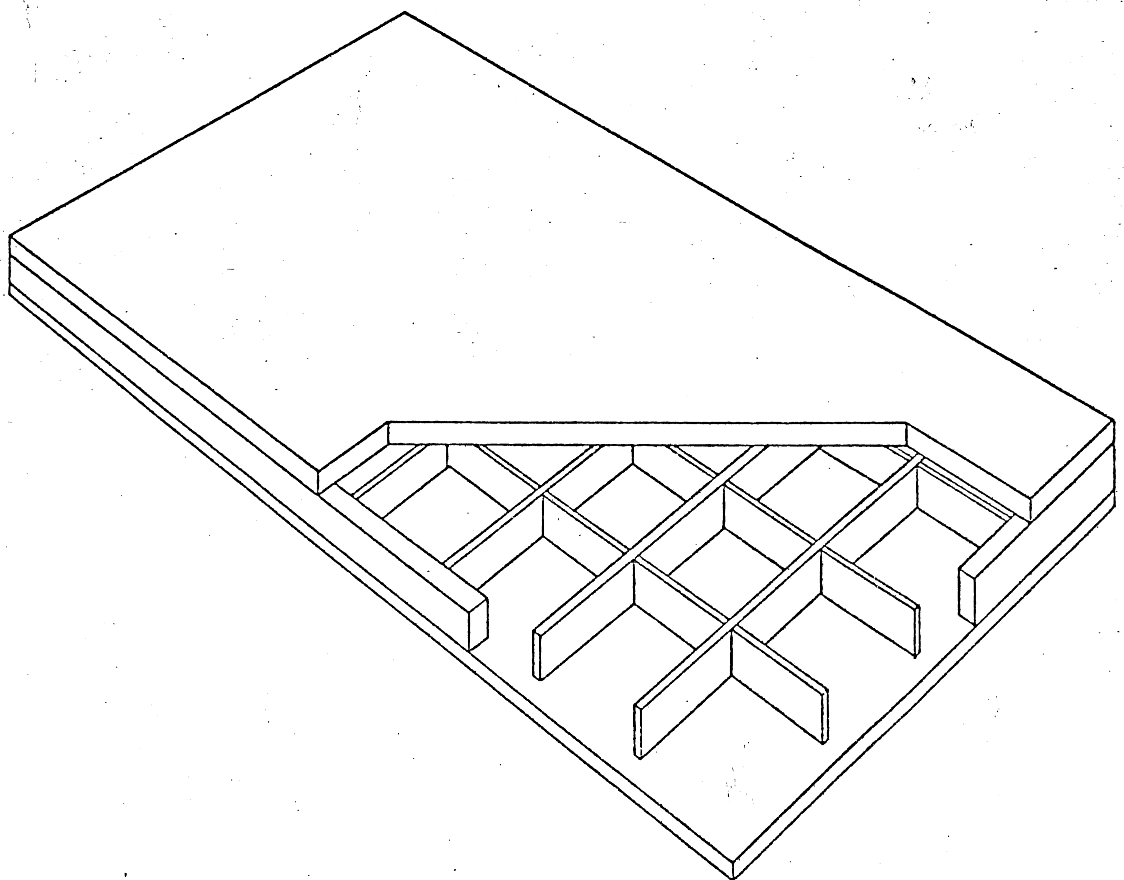


8	1	Fixation élastique		
7	4	Pieds réglables		
6	4	Supports Cpt. Rz		
5	4	Capteurs Rx Ry		
4	4	Capteurs Rz		
3	1	Piste de marche		
2	1	Bâti	A-42	(tube carré)
1	1	Plateau	Bois	
REP	NB	DESIGNATION	MATIERE	OBS

C-E-R-A-V-A-L

Echelle : | Le 07-06-77 | F.P. — R.V.

Fig: N° 003



STRUCTURE INTERNE du PLATEAU

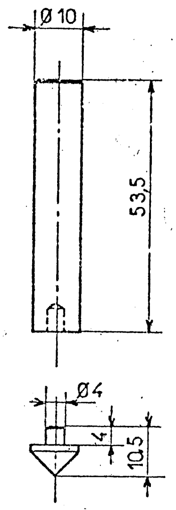
Fig: 004

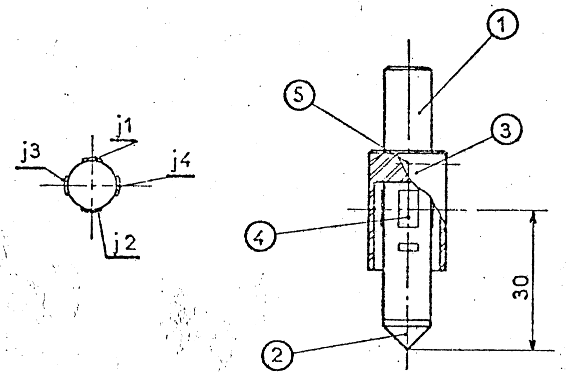
The plate is composed of 2 horizontal layers 10mm thick at 50mm apart as shown in Figure 4. These layers are reinforced by 5mm supports at 90°. All these elements are scaled and joined to form a light and very rigid system.

Transducers

The housings for the transducers are steel cylinders, for the transducers recording in the direction of R_z, and aluminium for those which refer to the directions R_x and R_y.

The drawings labelled 5 and 6 represent the housings for the transducers which measure the components R_x and R_y (Figure 5) and R_z (Figure 6). The dimensions of the various electric gauges joined to the housings are also indicated on Figures 5 & 6.





5	8	Vis de fixation M3-10	XC 48 f	
4	16	Jauges 202 NC 13		120 OHMS
3	4	Capot	A - U 4G	
2	4	Tête	XC 65 f	(stubs)
1	4	Corps	A-U4 G	
REP	NB	DESIGNATION	MATIERE	OBS.
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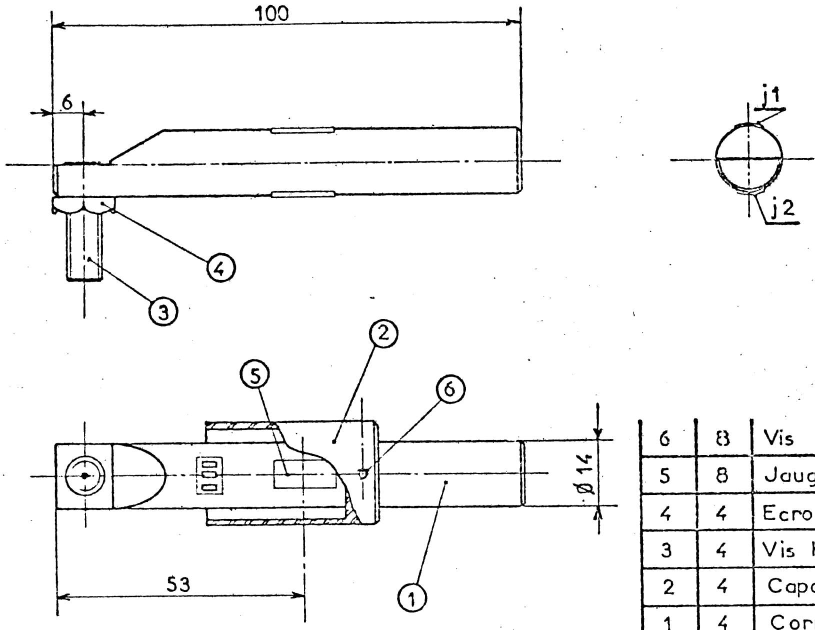
Echelle: 1		Le: 07-06-77		F. P. / R. V.
CAPTEURS Rx - Ry				N° 005



REP	NB	DESIGNATION	MATIERE	OBS
6	8	Vis Hc M3 - 10	XC 48 f	bout plat
5	8	Jauges 234 NC 13		350 OHMS
4	4	Ecrou "Pal"		
3	4	Vis Hc M8-15	XC 48 f	bout plat
2	4	Capot	A-U4G	
1	4	Corps	XC 65 f	"STUB"

C-E-R-A-V-A-L

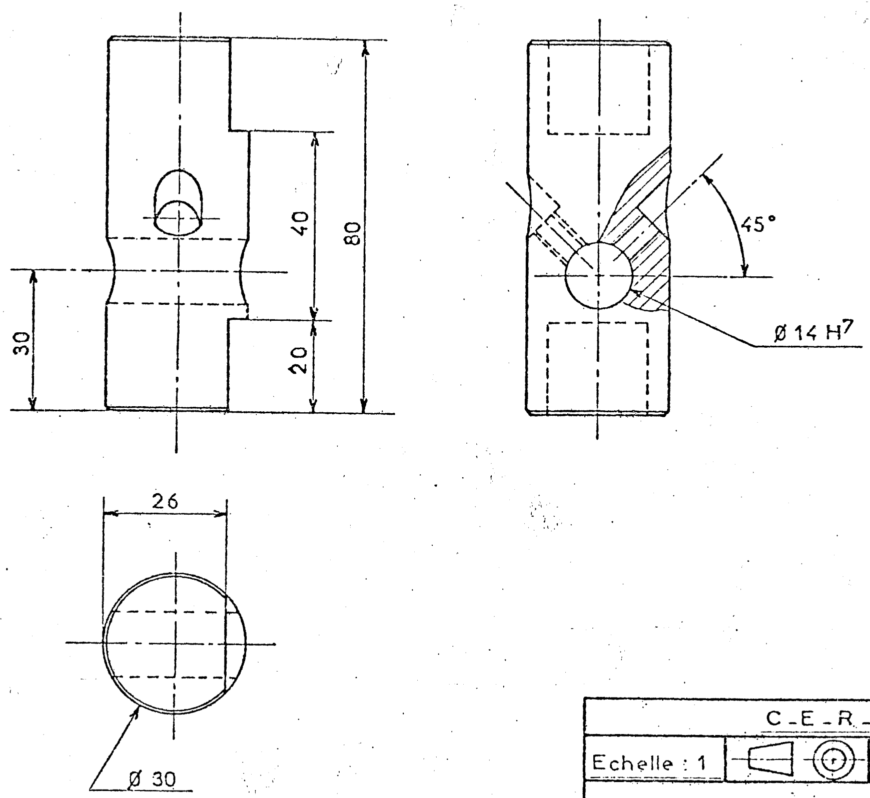
Echelle : 1 | Le: 07 - 06 - 77 | F. P. - R. V.

CAPTEUR Rz | N° 006

Frame

The frame consists of steel square tubes soldered together. The 4 transducers for the component R_z are encased in the supports shown in Figure 7. The transducers are bolted to the support. The system rests on 4 legs which can be adjusted to a suitable height. The forces on the plate are therefore by the R_x and R_y transducers transmitted to the fixed transducers on the frame which measures the force on the R_z direction (Figure 8).

The R_x and R_y transducers are interdependent. In this way, all the forces which are exerted on the platform are accounted for.



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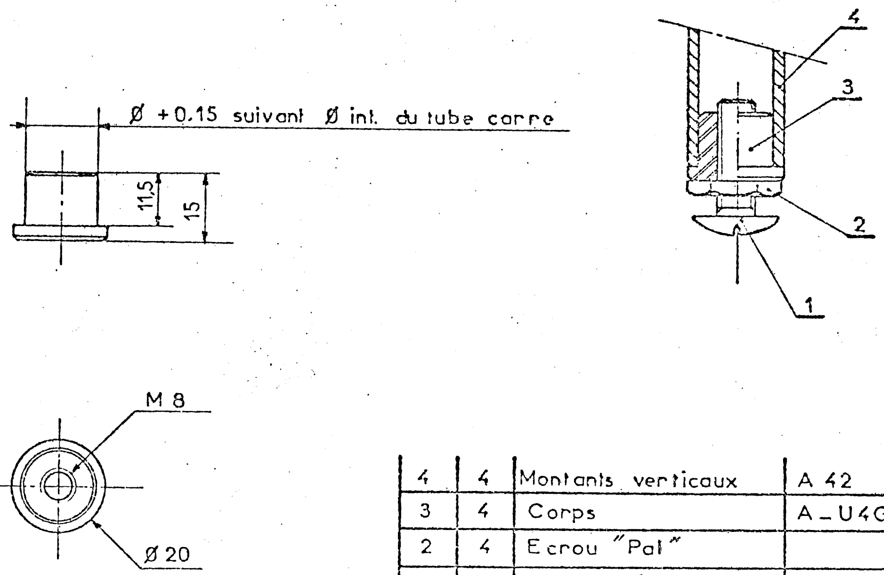
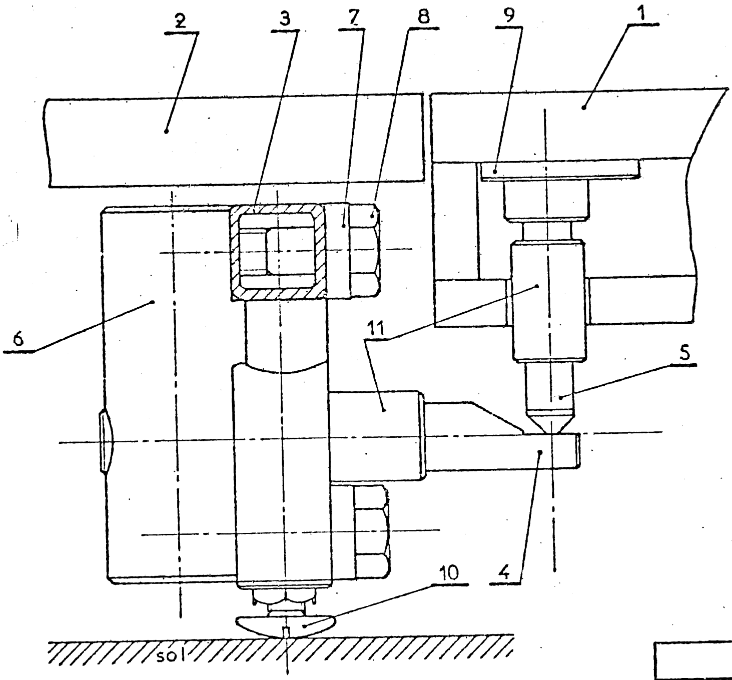
-SUPPORT POUR CAPTEUR Rz-			N° 007



REP	NB	DESIGNATION	MATIERE	OBS
4	4	Montants verticaux	A 42	Tube carre
3	4	Corps	A-U4G	
2	4	Ecrou "Pal"		
1	4	Vis de réglage		

C E R A V A L			
Echelle: 1		Le:07-06-77	F.P. - R.V.
			Mat: A-U4G
PIED REGLABLE			N° 008

A preloading system (Figure 9) ensures a good contact between the horizontal and vertical transducers with a force R_z exerted at the centre of the platform. In this way, the forces which are transmitted between the transducers are equivalent to the forces applied to the platform.



REP	NB	DESIGNATION	MATIERE
11	8	Capôt de protection	A-U4G
10	4	Pieds réglables	
9	4	Support Cpt. Rx Ry	A-U4G
8	8	Vis H, M10-40	E 26
7	8	Rondelles	Etiré
6	4	Support pour Cpt. Rz	A 56
5	4	Capteurs Rx et Ry	A-U4G
4	4	Capteurs Rz	XC 65 f
3	1	Bati (tube carré)	
2	1	Piste de marche	
1	1	Plateau	Bois

C-E-R-A-V-A-L

Echelle : 1 — Le : 07-06-77 — F. P. - R. V.

N° 009

The degree of preloading can be adjusted. This depends on the use of the platform. For example, the study of sporting activities necessitates a preloading factor greater than 10daN, which is the level used in gait analysis.

Natural frequency of the unloaded platform

The natural frequency is measured when the platform is unloaded. The lowest frequency obtained can be determined from the 3 transducers when the platform oscillates freely after a very short and sudden force. The lowest frequency for a 300 x 800mm platform is greater than 150Hz.

Construction of the plate

The platform consists of a plywood upper surface covered with either a thin layer of metal or plastic.

Weight

300 x 800mm Platform : approximately 8kg

800 x 1700mm Platform : approximately 15kg.

III. Electrical Schema

Connection of the transducers

Each corner of the platform is connected to 3 transducers, the gauges of which are attached on 2 surfaces. The axes of these 2 surfaces are parallel to the R_x and R_z directions.

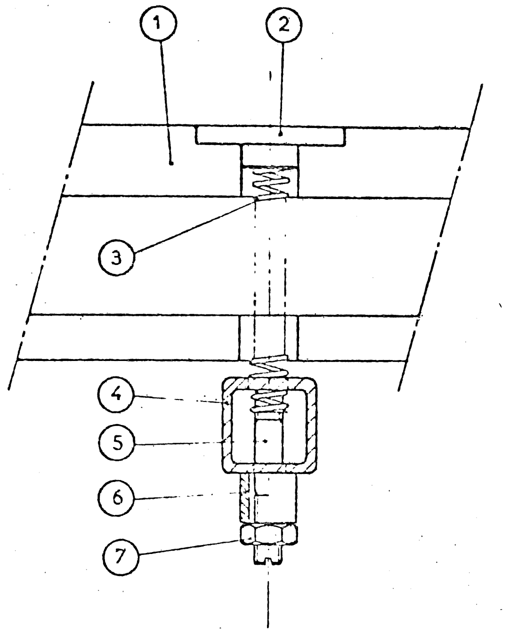
A Wheatstone half-bridge is formed by the junction of the 2 gauges coming from each transducer. The gauges are positioned on two symmetrically opposing surfaces which eliminates the effects of cross-talk. In this way, the extent of the R_z component of the resultant force is not affected by R_x and R_y components which applied at the same time.

Each transducer is connected to a continuous power supply and an amplifier. The regulation of the voltage supply of the gauges of each transducer can be used to adjust the sensitivity of each channel during calibration. Slight differences in the sensitivity may exist between the transducers of the same component. These differences are eliminated with the gain adjustments which are made prior to the operation of the system.

Amplification

An integrated circuit (741) powered by a continuous $\pm$15 volt supply allows amplification of the signal from each transducer. Figures 10 and 11 show the connections between the amplifiers and the transducers.

A single power supply of $\pm$15 volts powers the electronic circuitry. Total power consumption is 1.5 amps.

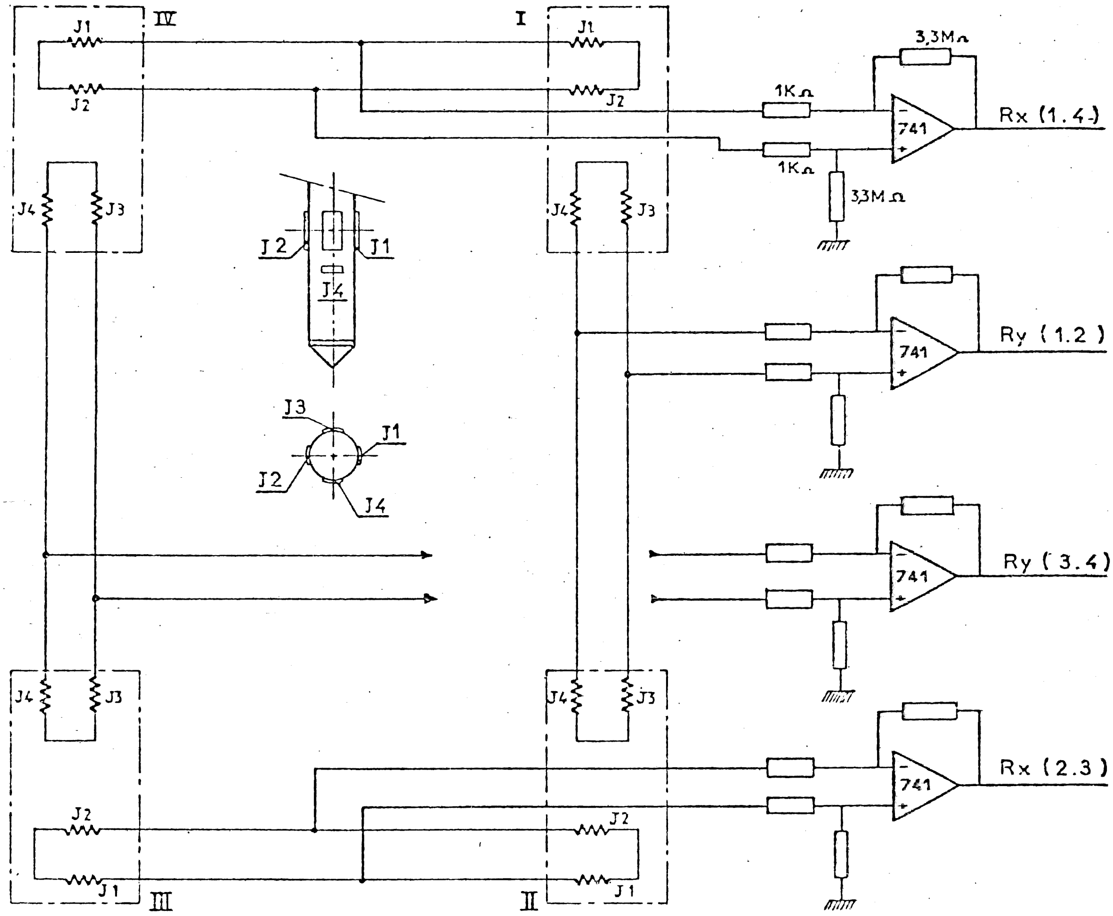


7	1	Ecrou M6		
6	1	Entretoise		
5	1	Axe fileté		
4	1	Tube carré		
3	1	Ressort de traction	45 S8	
2	1	Support	A-U4G	
1	1	Plateau		
REP	NB	DESIGNATION	MATIERE	OBS

C-E-R-A-V-A-L

Echelle : 1 | Le : 07 06 77 | F.P. R.V.

FIXATION ELASTIQUE | N° 010



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CABLAGE R_x - R_y | N° 011

Measuring system

The outputs of the 8 amplifiers and the corresponding forces

components are shown as follows:

		Components
Signal Amplifiers from the vertical transducers	1	$R_z 1$
	2	$R_z 2$
	3	$R_z 3$
	4	$R_z 4$
Signal Amplifiers from the horizontal transducers	5	$R_x 1,4$
	6	$R_x 2,3$
	7	$R_x 1,2$
	8	$R_x 3,4$

The resultant force in a given direction or the resulting moment with respect to an axis passing through a point on the platform can be obtained by summing the signals from several channels. This summation can be done by means of electronic circuitry, or a better alternative is to use a calculator or a mini-computer.

IV. General characteristics

The forces are positive when acting in the direction of the axes of the reference system.

The sign of the moments similarly corresponds to the convention of the reference system.

The maximum deviations are attained by the following values:

F_x, F_y - 50daN; F_z - 100daN/transducer (maximum of 400daN).

Overloading of up to 100% can be accommodated without deterioration of the transducers.

Amplification scale

F_x - 0.2volt/daN; F_y - 0.2volt/daN; F_z - 0.2volt/daN.

Variation of the signal according to the point of application of the force

The area bounded by the rectangle obtained by joining the points of intersection of the axes of the R_x and R_y transducers with the surface of the plate: $\pm 2\%$; beyond this area: $\pm 4\%$.

Accuracy of the measuring system

An 8 bit analogue - digital converter which processes voltages between ±10 volts. From the output signals of the amplifier, the following values were obtained: F_x, F_y - ±2%; F_z - ±3%.

Cross-talk

The influence of applied forces in one direction of the reference system on the other two directions is referred to as cross-talk.

$F_x - F_y$	±3%	$F_y - F_z$	±3%
$F_x - F_z$	±3%	$F_z - F_x$	±1.5%
$F_y - F_x$	±3%	$F_z - F_y$	±1.5%

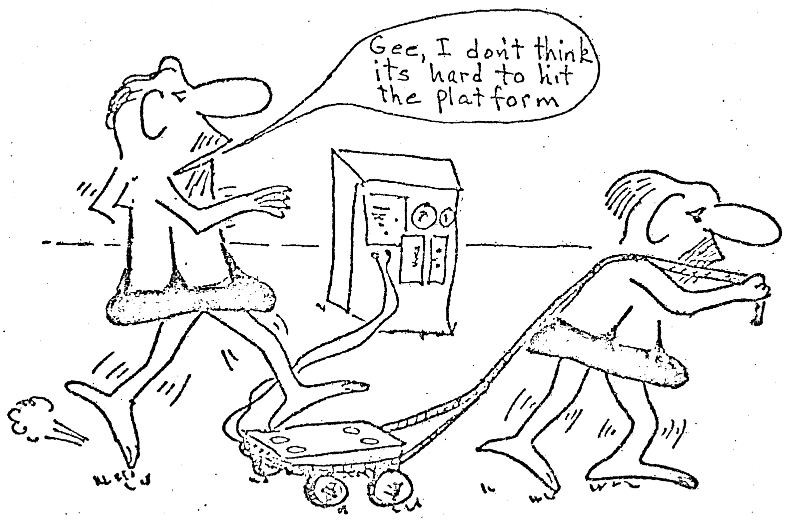
Temperature range under which the system functions normally: 0+50°C.

Linearity

The principal variations with respect to the axes are as follows:

R_x - ±1daN; R_y - ±1daN; R_z - ±2daN.

Submitted by: Barry T. Bates, Ph.D. and Donald McIntyre, Biomechanics/Sports Medicine Laboratory, Department of Physical Education, University of Oregon, Eugene, Oregon, 97403, USA



The Force Platform Group

International Society of Biomechanics

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Dear Colleague,

In the 4th Newsletter was included a register, or list of members and their research interests. In order to update this register would you allow me to publish brief details of your work. Please complete the questionnaire below and return to me as soon as possible:

1) Name --

2) Title (Mr., Mrs., Ms., Dr., Prof., etc.)---------------------

3) Address --

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4) Institution (if different to above) -------------------------

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5) Do you work with a force platform? Yes ______ No______

6) If answer is NO please give reasons for your interest:-

----

7) Please give brief details of your platform or platforms

Type ------------------------------

Transducers ------------------------------

Size of top surface ----------------------

Recorder ------------------------------

Other ------------------------------

8) What auxiliary equipment do you use? (e.g. E.M.G., cameras, etc.)

----

9) What are the main lines of your research? (e.g. sports techniques, gait analysis, etc.) ----------------------------------

10) Please list any relevant publications by you which have not been included in Newsletters 1 and 2. (Attach additional sheets if necessary)

Many thanks for your co-operation.

Barry D. Wilson,

Secretary, F.P.G.