NEWSLETTER NUMBER 2

JULY 1976

FORCE PLATFORM GROUP

INTERNATIONAL SOCIETY OF BIOMECHANICS

Group Chairperson

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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

Enclosures:- 1977 Subscription forms, Questionnaire.

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 1975 Fifth International Congress of Biomechanics at the University of Jyväskylä, Finland, the Group re-formed itself, and elected Peter Cavanagh as chairperson with Howard Payne as secretary. It was decided that six-monthly newsletters should be produced and sent to all members, who were 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 his '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".

Editorial

The Newsletter No. 1 contained the inevitable errors of a new publication and although this present Newsletter should be an improvement readers are requested to be patient until 'debugging' is complete.

This issue contains an article by Klaus Nicol who describes the equipment and applications at the Institute of Sport in Frankfurt. They have used no less than three force platforms in a single investigation, which surely is some kind of record. Dr. Nicol, himself, has developed a flexible mat capable of force measurement by compression of the dielectric in a capacitor and has already used this together with the three force platforms. Indeed the whole subject area of force platform research seems to be expanding exponentially - from a handful of force platforms ten years ago, there are now several hundred being used throughout the world. To avoid duplication of effort, and this is possible in a tool which is used in so many different disciplines, it is essential that some kind of central 'library' and information centre is established. The formation of the Force Platform Group and the initiation of the Newsletter has been a start and it is now proposed that a register of all users should be compiled. As reported in this issue, the U.S.A. Committee of Prosthetics Research and Development has already published a "Preliminary Register of Gait Laboratories". We can assist them and ourselves by collecting information concerning the use of force platforms in biomechanics research throughout the world. Members are invited to assist by completing and returning the enclosed questionnaire. It is hoped that results will be published in Newsletter Number 3.

Corrections to Newsletter No. 1

Please amend your copy of Newsletter No. 1 as follows:-

Page 21

Paul, J.P., and Poulson, J. The analysis of forces transmitted by joints in the human body. Proc. of Fifth Intl. Conference on Experimental Stress Analysis. Udine, Italy, C.I.S.M. Udine, 1974

Paul, J.P., and McGrouther, D.A. Forces transmitted at the hip and knee joint of normal and disabled persons during a range of activities. Acta ortho Belg 41 Supplement I. 78.88 1975

(See also Additions to Bibliography in this issue)

Biomechanics V

In all the references to Biomechanics V (Ariel, Ballreich, Baumann, Bosco et al, Desipres, Groh et al, Mann et al, Matake, Miller et al, Nigg et al, Payne et al, Ramey, Soderberg et al, Suzuki, Tveit and Wilson et al) please substitute as follows:-

"............... IN: Biomechanics V (ed. Komi, P.V.), University Park Press, Baltimore, in press, 1976."

The compilers of the bibliography and the editor of the Newsletter apologise for any inconvenience caused to the people concerned.

Use of Kistler Force Platforms at the Institute for Sport in Frankfurt

by Klaus Nicol

1. Introduction

In recent years Kistler force platforms have been used at the Institute of Sports Sciences of the Frankfurt University for various very different measuring purposes. The problems that had to be solved in each use were a) to affect as little as possible the natural movements of the subjects, b) to measure ground forces with an accuracy adapted to the problem, usually the maximum accuracy which could be achieved, and c) to work economically.

The following 6 main complexes of problems result from these requirements:-

1) Measuring without hindrance to the subjects
2) Hitting the platform when measuring
3) Supporting the platform according to the instructions of the manufacturer
4) Considering the variation of sensitivity over the surface of the platform
5) Considering further error sources
6) Economic recording and evaluation

While the problems 1), 2) and partly also problem 6) had to be solved for each new task, the solutions of problems 3) to 5) are substantially independent of the special situation. This paper is therefore divided into the general treatment of points 3) to 5) and into the treatment of points 1), 2) and 6) for the different investigations which we carried out.

2.1 Mounting the Platform

In order to achieve maximum accuracy of measurement, especially to avoid unwanted oscillations and to protect the plate from damage much care must be taken to support it: Its four feet must be supported by a base which is plane with a tolerance of 1/10 mm and which is allowed to give way only 1/10 mm at a load of 1000 kp. These requirements are a consequence of the construction principle almost generally followed with force platforms in which (in the present case 4) force transducers are mounted on a base plate and support a cover plate. This is also the reason for the size of the surface which is too small for many purposes. The problem of supporting the force platform was solved by mounting it on a steel plate with a thickness of 50 mm, the contacting surface of which was machined. The steel plate itself rested in a layer of sand. This bedding attenuated the system so much that when high impact biomechanical measurements were performed, as they occur in high jumps, no oscillations worth mentioning were observed. During other test measurements, e.g. light blows with a hammer the oscillations were considerable with the resonant frequency of the total system, at 200 Hz. The mounting plates and the corresponding cavities in the bottoms had a dimension of 60 x 60 cm so that the platform could be turned and used either in the longitudinal or the transverse direction.

The whole construction had a height of about 11 cm to which the surroundings had to be adapted. This problem had to be solved according to the particular situation.

2.2 Variation of Sensitivity

The greatest measuring error in our tests was caused by the variation of sensitivity over the surface. Within the inner measuring surface it is only $\pm$ 2%, but increases in the border areas to $\pm$ 5%. In almost all the measurements we were forced to use these border areas since, otherwise, the problem of hitting the plate would have been made even more difficult.

The variation of relative sensitivity A(s) over the surface S of the platform (s = surface element) is a systematic error, i.e. an error that can be corrected in principle. However, the correction can only be done when the distribution of pressure p(s) effected by the acting total force F is known. In this case F can be calculated by

$$F = \int_S p(s) \quad A(s) \quad ds$$

This is, for example, the case when the distribution of force over the area support (e.g. foot) can be estimated and when the position of the area of support on the plate is recorded (e.g. by a video tape-recorder). When said data are known with an accuracy of $< 10\%$ this sort of error can be reduced to less than 1%.

We hope to be able to solve this problem fully by determining the pressure distribution by means of an instrumented mat on the platform.

2.3 Further Error Sources

In contrast, the elimination of the second-greatest error, the cross coupling of the force components, is possible without further information either by the x-y-compensator on sale or by calculation.

Attention must also be paid to the temperature drift (output changes by 10^{-4} per degree) which becomes apparent in strong sunshine when recording small signals and when measuring periods are long. This can, however, be controlled by repeated resetting of the measuring capacitor. In the case of poor shielding drift may occur due to partially rectified interfering voltages.

As a whole, the platforms proved to be strong and not very susceptible to troubles in spite of the extreme strain at times. The weakest members of the measuring chain are - as often found in electronic measurement - the cables and plugs.

3.1 Broad Jump Indoors (1)

For testing the support forces occurring at the take-off for the broad jump a plate was installed in the floor of a gymnasium provided with a tartan surface. In order to increase the probability of hitting the plate it was built-in in such a manner that its long border extended parallel to the direction of running. The surface was coated with plastic material.

The registration was effected in ultraviolet sensitive (UV-) paper which was evaluated manually. The impulses were determined by a planimeter.

3.2 Walking (2)

The test presented the least number of problems for measurement. First of all we could use the so-called "hall for diagnosis" of the Institute which is set up exclusively for biomechanical measurements. It is a 15 x 8 m gym, in the middle of which a cavity with a depth of 20 cm is provided for the platform. Cable channels connect the plate to the computer storing and evaluating the measured values and displaying the results. Secondly, the probability of hitting the platform was about 50% which - as only one plate was used - equalled the probability of obtaining a valid recording. Thirdly, the tests could be repeated very often - at least with non-physically handicapped persons. It was also possible to cover the platform and thus prevent a subject from adjusting his steps to hit it, causing falsification of the resulting movement. With this arrangement 750 measurements have been performed and evaluated within a few days.

3.3 Shot Putting (3)

For our investigations of shot putting, the complicated electronic equipment had to be protected from weather influences. It was also desirable, not the least for reasons of motivation, to provide conditions

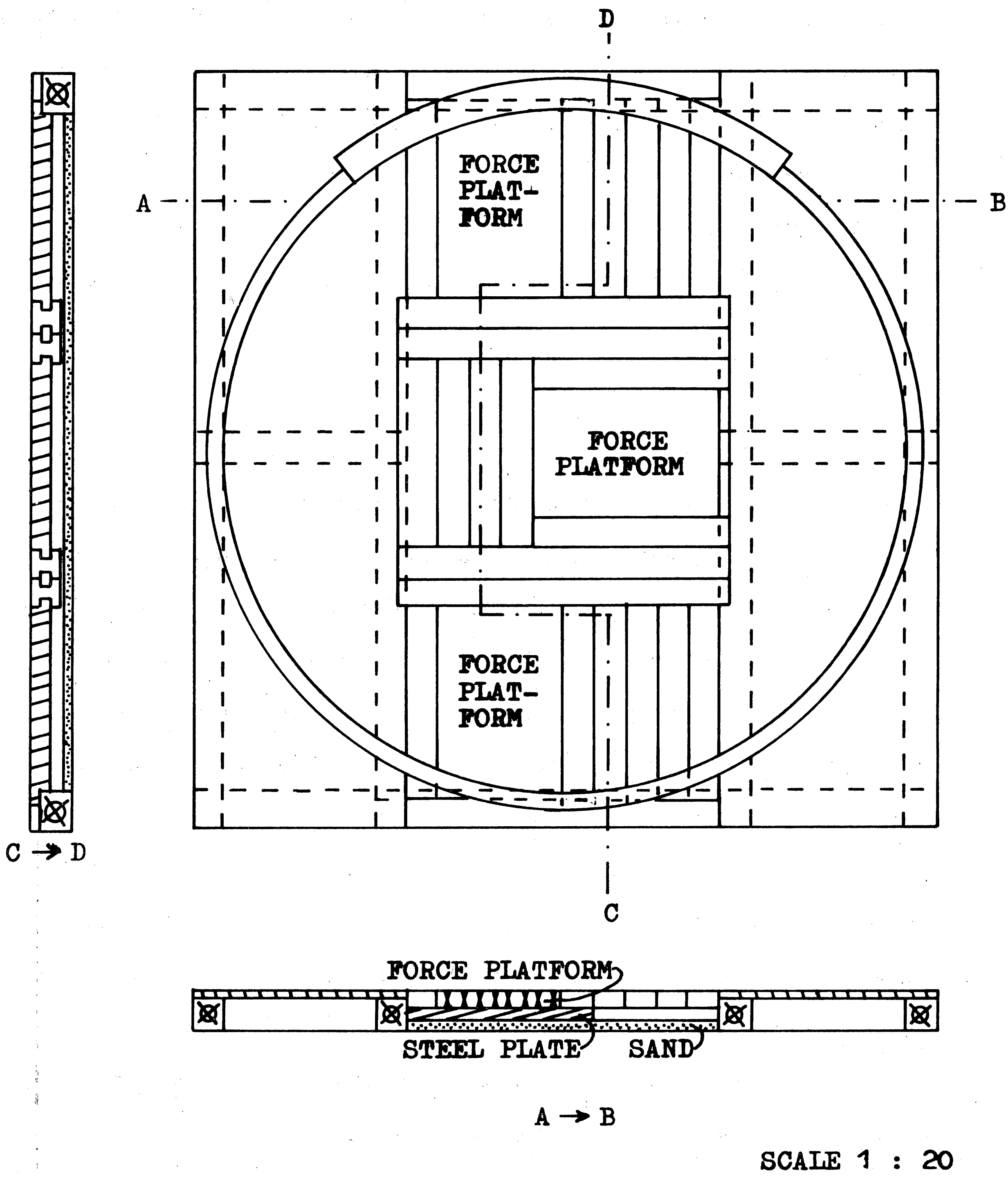

Fig. 1 Platform of the circle for shot putting.

Three force platforms are mounted on steel plates supported on a layer of sand.

similar, to a competition, i.e. to avoid indoor shots or a collecting net, as have been used e.g. by Wartenweiler. (4). This problem was solved by installing the circle for shot putting and the measuring equipment in a hangar. The put was performed through a door into the paved yard where rubber mats absorbed the impact of the shot. The platform of the circle for shot putting was a beam construction with a height of 13 cm. The three measuring plates which were mounted on the steel plates could be moved freely in the sand layer (see Fig. 1). It was somewhat difficult to adapt the level of the plates to the surroundings after a displacement.

The data were recorded and evaluated by the computer, which was connected to the equipment by a cable of 100 m. The force/time functions were displayed on a computer screen, placed near the circle.

3.4 Broad Jump Outdoors

While the cinder-track of a sport ground was being replaced by a tartan surface there was the opportunity to build-in a cavity for a platform in front of the broad jump pit. It was fitted with a tub made of stainless steel, the horizontally bent upper edge of which was connected with the tartan coating (see Fig. 2). When no measurements are carried out the cavity is covered with an iron lid coated with tartan. Although the top of the platform was provided with a tartan coating having a thickness of 20 mm, several athletes complained of the hardness of the surface.

The data were recorded either on expensive UV paper or on magnetic tape; which had a recording speed of $3\frac{3}{4}$"/sec. For evaluation the signals were transmitted at $\frac{15}{16}$"/sec to a plotter which recorded them on inexpensive paper. Both techniques were also used for the following investigations.

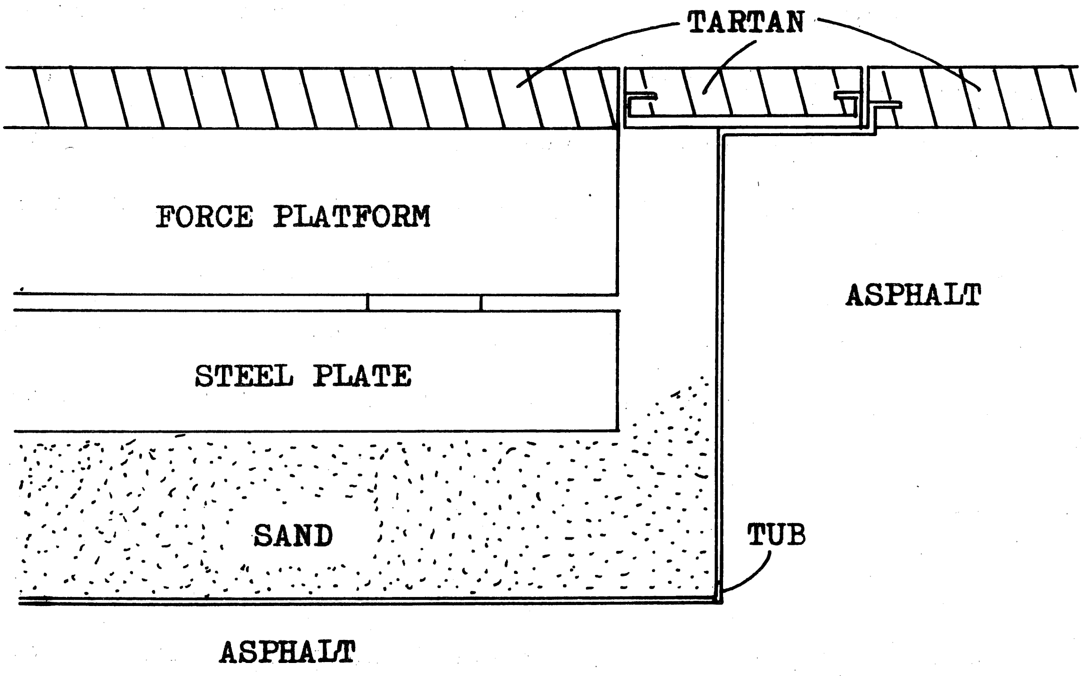

Fig. 2a

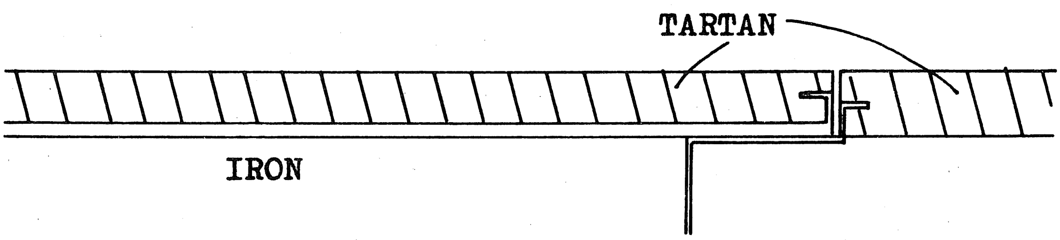

Fig. 2b

SCALE 1 : 3

Fig. 2 Cavity for the force platform in a tartan track.

Fig. 2a The force platform, which is coated with tartan is mounted on a steel plate. The tub is supported by the asphalt layer under the tartan track.

Fig. 2b Cavity covered with an iron lid.

3.5 Javelin Throwing (5)

During an investigation of javelin throwing the supporting forces of both legs were measured in addition to a number of kinematic parameters. For this purpose two platforms were buried together with their mounting plates in the runway. Plates and runway were covered by a tartan surface glued to the plates and nailed to the cinder-track. Although it was expected that many athletes would not succeed in hitting both platforms, it was surprising that in only 30% of all trials did they not contact either platform.

3.6 Somersault (6)

On the same installation the supporting forces of take-off and landing were measured successively with the backward and forward somersault. It was again surprising that the gymnast had no difficulties whatsoever in hitting the plate.

3.7 Medium Distance Race (7)

The task was to measure the influence of fatigue on the supporting forces. For this purpose it was necessary to ensure by means of appropriate equipment that the runner hit the platform once in each 400 m lap. This was achieved by burying three platforms, one behind the other in the cinder-track. As a sufficient number of amplifiers was not available, equivalent outputs of the platforms had to be coupled to one amplifier. There was the difficulty that the sign of a signal of one platform, a prototype, was not in conformity with the new plates. This was remedied by utilizing another charge amplifier as inverter. Furthermore, the calibration showed that the sensitivity of a transducer for vertical forces of the old plate differed by 10% from that of the other three transducers. This was also remedied by an amplifier with variable gain. The calibration of the finished equipment proved that the sensivity over the surface varied by a maximum of ± 5%

as could have been expected on the basis of the performance of the individual plates. This was valid also for the case that the force acted simultaneously on two plates.

Spread in front of the dynamometers was a 20 x 1 m mat operating as an electric capacitor and this allowed the determination of flight and support intervals by the variation of capacitance caused by force imprint (for details see (8)). This mat and the dynamometers were protected from the athlete's spikes by a rubber mat.

We found that the platforms were powerful tools for our investigations, and we feel that, to a large extent, further progress in biomechanics will depend upon how many researchers are able to use dynamometers. Therefore it is important that the Kistler platform, now on sale, is supplemented by another dynamometer that is financially accessible to more people working in the field of biomechanics.

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(3) Ballreich, R. and Nicol, K. (1975) Relations of Kinematic and Dynamic Parameters to Performance in Shot Put, V. Congress of Biomechanics, Jyväskylä

(4) Lehmann, G., Wetterstein, A. and Wartenweiler, J. (1970) Kugelstosser im Labor, in/ Jugend und Sport, vol. 27, pp. 73 to 77

(5) Kaufmann, C. Dissertation on Javelin Throwing, in preparation

(6) Zschunke, K., Dissertation on Mathematical Description of Somersault, in preparation

(7) Carl, K., Dissertation on Middle-Distance Running, in preparation

(8) Nicol, K. and Hennig, E. (1976) A Time Dependent Method for Measuring Force Distribution Using a Flexible Mat as a Capacitor, Biomechanics V, Baltimore, London, Tokyo (in press)

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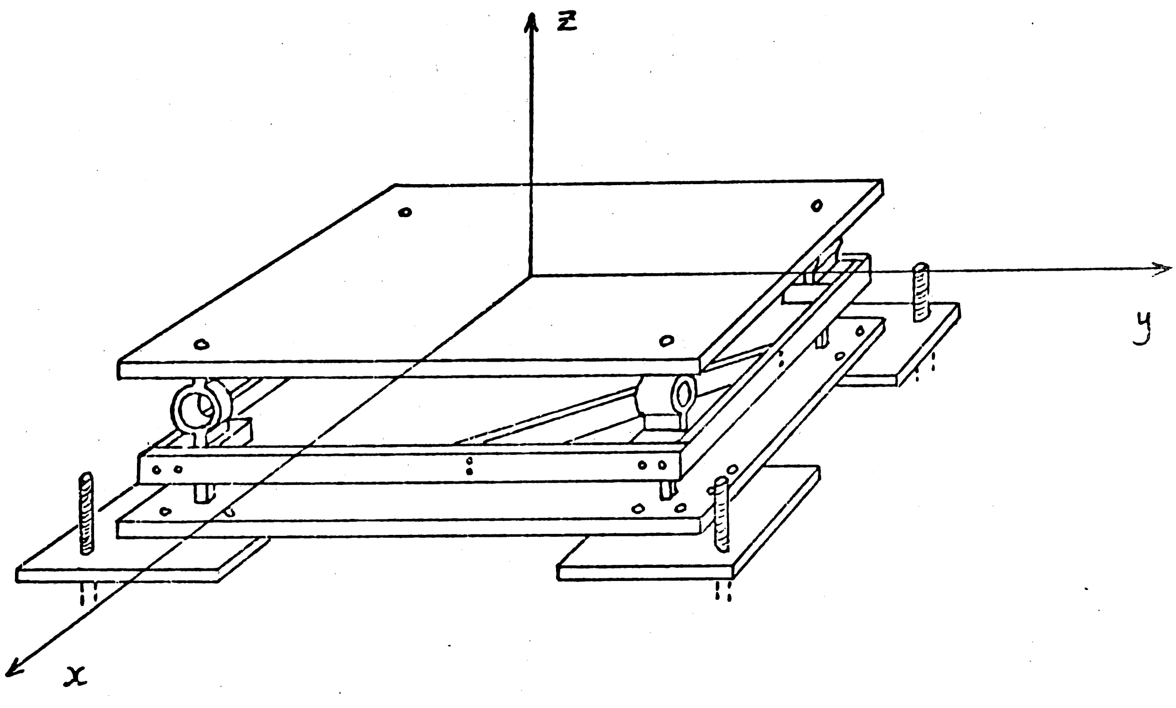
Outline of a Force Plate Design

Biomechanics Laboratory - Physical Education
University of Iowa,
Iowa, U.S.A.

by Barry Wilson



Materials

Top plate 30"x30"x3/4" Aluminum (machined hollow in a honeycomb pattern)

Bottom plate 30"x30"x3/4" Aluminum

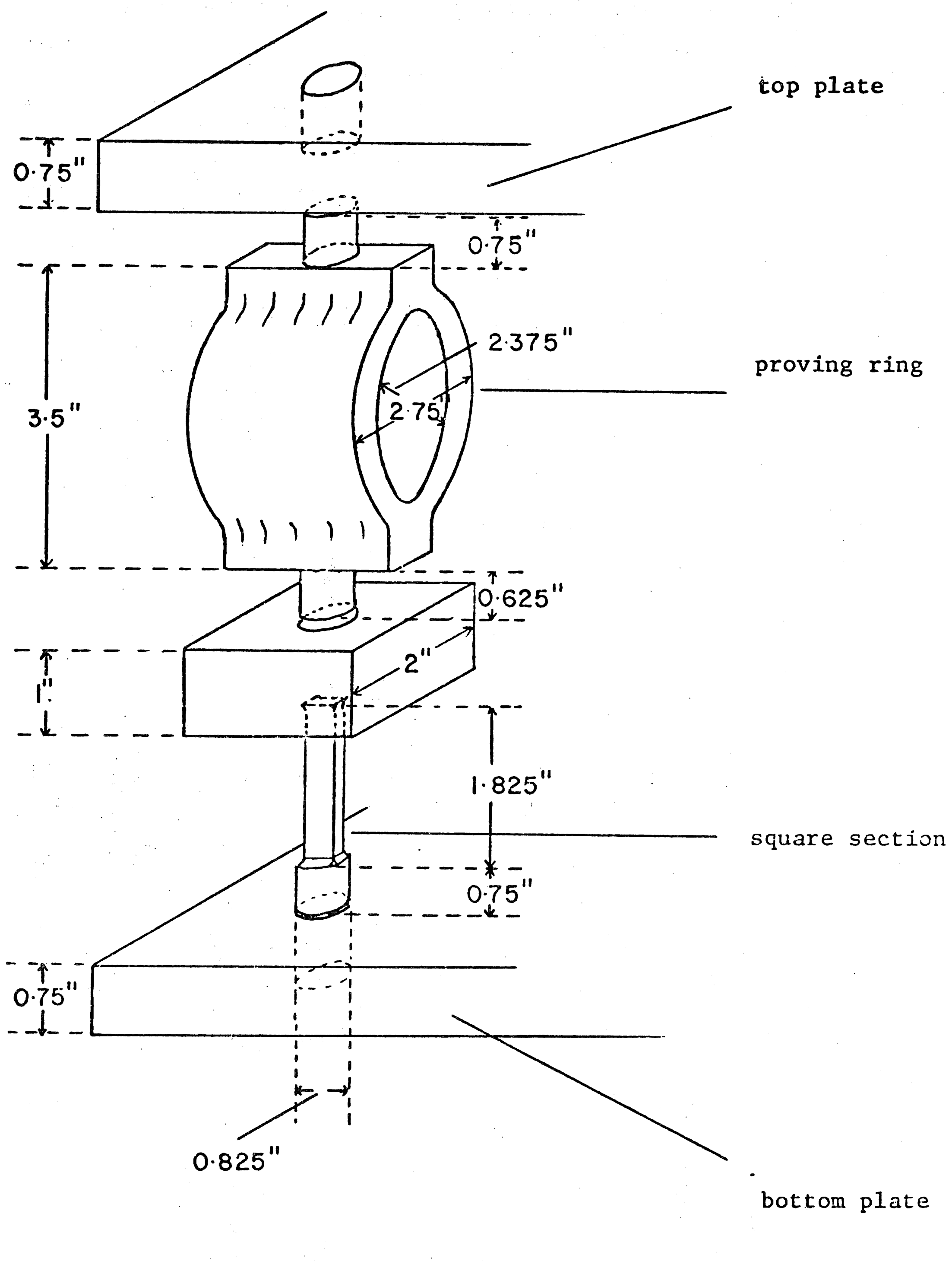
Center frame constructed of 1-1/2"x3/4" Aluminum

Proving rings 2-3/8" I.D. x 2-3/4" O.D. Aluminum

Supporting plates 12"x12"x3/4" Aluminum (bolted to concrete floor)

Square sections 1-3/4"x3/8"x3/8" Aluminum

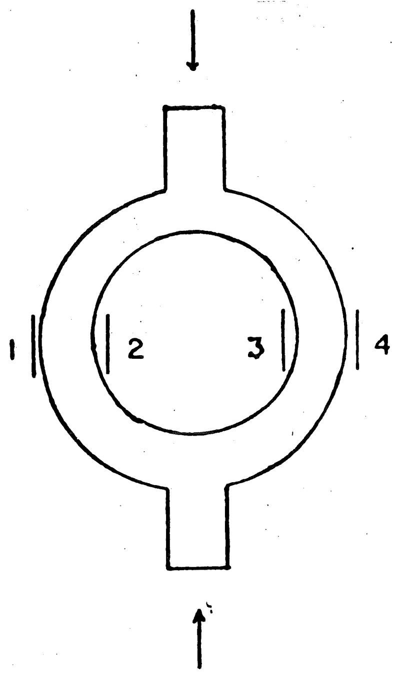
Construction: Tolerances were to $\pm$ 0.002". Sections were press fitted.



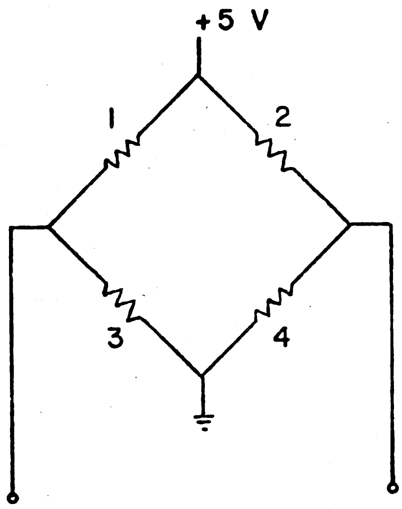
<u>Strain gages:</u>   FAE - 25 - 12 SR $8.40/pack (of 5)

BLH Electronics, Inc.
Waltham, Massachusetts 02154

<u>For verticals</u>



Full Wheatstone Bridge

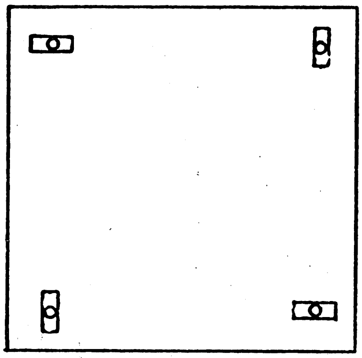


This configuration has been shown in laboratory testing to be insensitive to plate bending and insensitive to shear forces applied to the top plate.

While the individual vertical force rings were found to be moment sensitive in pairs the sum of the vertical forces was found to be independent (<0.5%) of applied horizontal loads (0 to 300 lb).

Proving rings are "opposed" for stability of the platform e.g.

Top view:



In the present application individual verticals and the sum of the verticals are recorded.

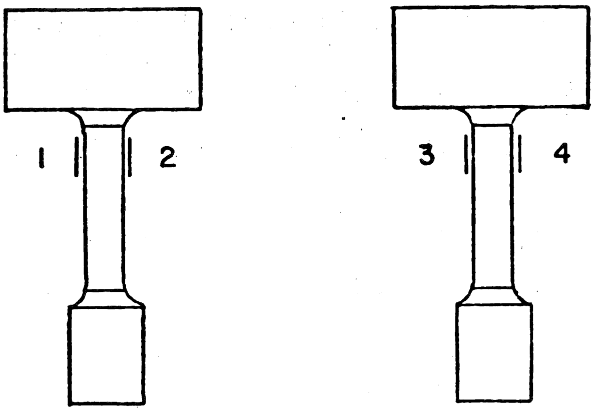
Specifications (verticals)

1. The maximum sensitivity of the verticals to static loading is 5 lbs-cm^{-1} deflection of recorder stylus.

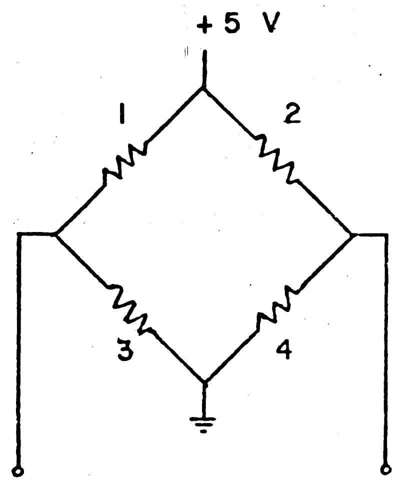
2. The frequency response of the verticals is approximately 120 Hz.

<u>For Horizontals</u>

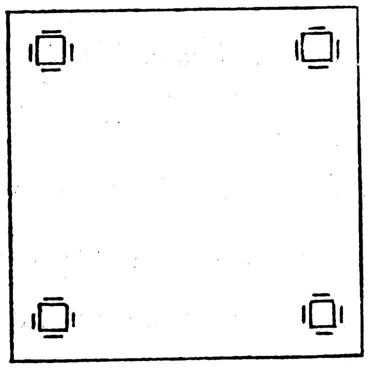
Bending members machined out of 2" x 2" aluminum



Full Wheatstone Bridge



Gage placement, top view:



In this configuration the horizontals are insensitive to plate deformations and vertical loads. In the present application F_x and F_y are used. This summation of the horizontals enables the horizontal sums to be independent of any couple applied about the Z axis.
In static calibration tests the horizontal force was found to be essentially independent (-0.9%) of the vertical load (0 to 500 lb).

Specifications (horizontals)

1. The maximum sensitivity of the horizontals is 5 $lbs\text{-}cm^{-1}$ deflection of the recorder stylus.
2. The frequency response of the horizontals is 50 Hz.

Electronics:

1. AD 520 J I.C. amplifiers for each of the 8 bridges.
2. AD 201 Op. amps for "summers" for X,Y,Z forces.
3. Sanborn 150 recorder - thermograph writing unit 8 channel output. Recorder frequency response 50 Hz for 6 cm (full scale) deflections.
4. Red Lake Micro Millimite timing light generator as the time base for the recorder - variable between 10, 100, and 1000 Hz.

The force platform specifications outlined are a modification of a previous design which used a double hinged coupling system with strain gages mounted on proving rings for both horizontal and vertical force sensors.

The modified platform was designed by Barry D. Wilson under the supervision of Dr. James G. Hay, Department of Physical Education for Men. Dr. John R. Glover, Division of Energy Engineering, College of Engineering, provided technical assistance in the design of the electronics system.

Preliminary Register of Gait Laboratories

Dr. Peter J. Nelson of the Committee on Prosthetics Research and Development, National Research Council, 2101 Constitution Avenue, Washington DC 20418, U.S.A. has published a "Preliminary Register of Gait Laboratories" compiled by Dr. E.E. Harris.

The following extracts from the publication indicate the nature and scope of the Committee's work:-

"The responsibilities of the Committee have evolved over the years and now include every aspect of engineering directed toward the core of skeletal and neuromuscular deficits."

"Gait laboratories studying the fundamentals of gait have costly equipment and space requirements. Gait studies need special knowledge for their conduct and interpretation. Some laboratories are from time to time underemployed, and then not only are the costly equipment and space idle but the expert staff become absorbed into other activities. The Committee on Prosthetic Research and Development, both for its own program and as part of its mission of providing a service to others, has been seeking methods of coordinating and making better use of the laboratories in the U.S.A. With this end in view, they established a task force to standardize terminology and, as far as possible, data reporting so that there could be some comparison."

"As part of this general program, CPRD decided initially to collect and make available to those interested data about gait laboratories in the U.S.A. Close ties led to an expansion to include laboratories in Canada and the U.K. in this preliminary list. If there is a demand, the list might be expanded to anyone worldwide wishing to be included.
The purpose is: firstly, to facilitate exchange of information between laboratories; and secondly, to enable research workers without experience to know where to get help either by making use of available facilities or being advised on the establishment of their own".

In this preliminary register brief details of facilities and research in progress are given for the following institutions:

N. AMERICA WEST

Seattle - University of Washington

Seattle - VA Hospital

San Francisco - UC Berkeley

San Francisco - Shriners Hospital for Crippled Children

Palo Alto - Children's Hospital at Stanford

Los Angeles - Rancho Los Amigos Hospital

San Diego - Children's Health Center

N. AMERICA CENTRAL

Saskatoon - University of Saskatchewan

Winnipeg - Shriners Hospitals for Crippled Children

Rochester - Mayo Clinic

Milwaukee - VA Center

Iowa City - University of Iowa

Houston - Texas Institute for Rehabilitation and Research

N. AMERICA EAST

Cleveland - Case Western U. (VA)

New York - VA Prosthetics Center

Philadelphia - Moss Rehabilitation Hospital

Atlanta - Emory University

UNITED KINGDOM

Glasgow - University of Strathclyde

Manchester - University of Manchester

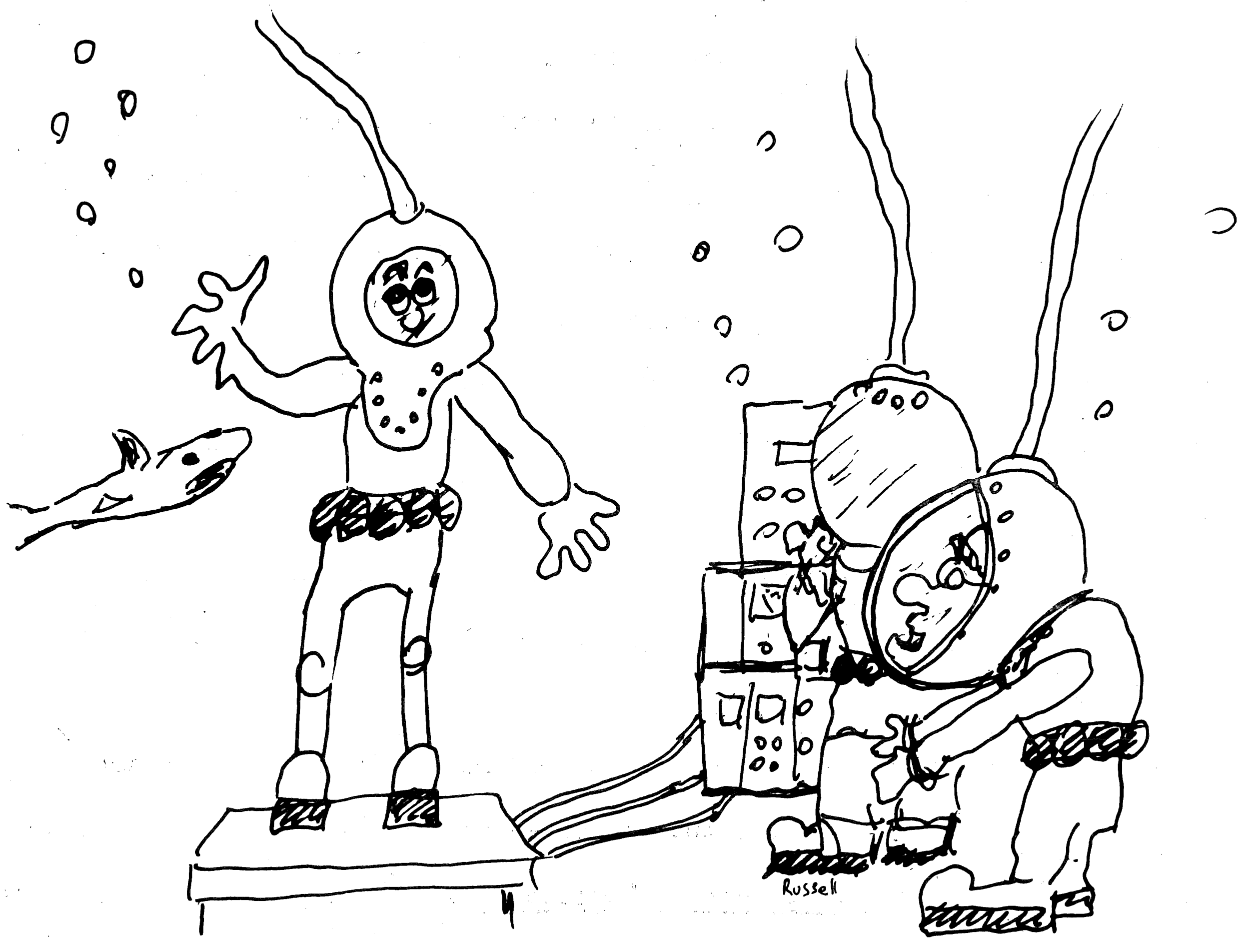
Birmingham - University of Birmingham

Oxford - University of Oxford

London - BRADU Roehampton

London - Polytechnic of Central London

London - Medical Research Council



Cartoon caption competition (no prizes!)

Readers are invited to submit appropriate captions for this cartoon.

THE UNITED KINGDOM NATIONAL DOCUMENTATION CENTRE FOR SPORT, PHYSICAL EDUCATION AND RECREATION

by Alan Bell

The National Documentation Centre for Sport, Physical Education and Recreation is sponsored jointly by the Sports Council and the University of Birmingham in England, and is housed in the Main Library building in the University.

The Centre was established at Queen's University, Belfast, in June 1969, and moved to its present home in August 1973. The Centre's collection of reference literature and services are available to anyone with a serious interest in sport physical education and recreation.

The purpose of the Centre is to supply the documentation requirements of individuals and organisations involved in interdisciplinary research, in advanced level teaching and in studies related to various aspects of sport, physical education and recreation.

In attempting to fulfil this purpose the Centre collects bibliographies - lists of references to the literature - and has a small backing-up collection of books and pamphlets. There is also a comprehensive collection of some 40 abstract and indexing journals and the Centre receives some 150 periodicals from British and foreign sources.

By scanning the periodicals received in the Centre and a number of bibliographical sources, two current-awareness bulletins are produced:-

<u>Monthly Selection of Recent Publications</u> - (includes books, pamphlets, etc.)

<u>Sports Documentation Monthly Bulletin</u> - (includes periodicals articles only)

These bulletins disseminate information on the serious literature published in the fields of sport, physical education and recreation and are available on subscription. Further details and sample copies can be obtained from the Director of the Centre.

Continued on next page.

Among its other services, the Centre offers an Enquiry Service and provides photocopies of existing lists of references or suggests appropriate bibliographic sources for the enquirer to search himself. Photocopies of articles can also be provided subject to the U.K. Copyright Act, 1956, and the Centre issues lists of its periodical and abstract journal holdings, (both free of charge).

Enquirers are welcome to visit the Centre, to see how it can help them and to use the literature collection. Further details from:-

Mr. G.A. Bell
Director
National Documentation Centre for Sport, Physical Education and Recreation
P.O. Box 363
Birmingham B15 2TT
England.

Tel: 021-472 7410

Additions to Bibliography

Barry Wilson is busy updating the Bibliography and this should be ready for Newsletter No. 3. In the meantime would you please add to your collection the following list of publications by John Paul and colleagues of the Bioengineering Unit at the University of Strathclyde, Glasgow, Scotland. Professor Paul reports that the Unit has now installed two Kistler force platforms.

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Letters Received

Many letters have been received and Jim Hay has asked for this one to be published.

February 26, 1976.

Dear Howard,

I have just received my copy of the I.S.B. Force Platform Group Newsletter and would like to congratulate you on another excellent production on behalf of the group.

There are two small, but important, corrections which I would like to draw to your attention and to the attention of members of the Group. First, while I am quite happy to accept credit for the good work of others -- "it sure beats working," as the saying goes -- the truth is that the force platform bibliography published in Newsletter No. 1 was the work of Barry Wilson. Whatever credit is involved is rightly his and his alone. Second, and on a similar theme, I have received a letter from Paavo Komi pointing out that he (and not Dick Nelson and Dewey Morehouse) is the editor of Biomechanics V, the proceedings of the Vth International Congress in Biomechanics held in Jyväskylä last summer. The citations for papers which are listed in the force platform bibliography and which will appear in Biomechanics V in due course, should therefore be changed accordingly.

Yours sincerely,

signed James G. Hay.