Apparatus for measuring a foot includes a body (12) on which a person may rest a foot, and means (16) carried by the body (12) to define a reference location for the foot. Means (18, 40) is provided to apply pressure to two or more selected portions of the foot whereby to tension the foot to an extent sufficient to modify the tissue distribution in the foot in a manner which at least partially simulates the response of the foot when enclosed in a shoe or other item of footwear. Also included is means to make plural measurements of the foot while it is so tensioned.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>Austria</td>
<td>FR</td>
<td>France</td>
<td>MR</td>
<td>Mauritania</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AU</td>
<td>Australia</td>
<td>GA</td>
<td>Gabon</td>
<td>MW</td>
<td>Malawi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BB</td>
<td>Barbados</td>
<td>GB</td>
<td>United Kingdom</td>
<td>NL</td>
<td>Netherlands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE</td>
<td>Belgium</td>
<td>GN</td>
<td>Guinea</td>
<td>NO</td>
<td>Norway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BF</td>
<td>Burkina Faso</td>
<td>GR</td>
<td>Greece</td>
<td>NZ</td>
<td>New Zealand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BG</td>
<td>Bulgaria</td>
<td>HU</td>
<td>Hungary</td>
<td>PL</td>
<td>Poland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BJ</td>
<td>Benin</td>
<td>IE</td>
<td>Ireland</td>
<td>PT</td>
<td>Portugal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BR</td>
<td>Brazil</td>
<td>IT</td>
<td>Italy</td>
<td>RO</td>
<td>Romania</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA</td>
<td>Canada</td>
<td>JP</td>
<td>Japan</td>
<td>RU</td>
<td>Russian Federation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF</td>
<td>Central African Republic</td>
<td>KP</td>
<td>Democratic People's Republic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CG</td>
<td>Congo</td>
<td>KR</td>
<td>Republic of Korea</td>
<td>SD</td>
<td>Sudan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CH</td>
<td>Switzerland</td>
<td>KZ</td>
<td>Kazakhstan</td>
<td>SE</td>
<td>Sweden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CI</td>
<td>Côte d'Ivoire</td>
<td>LI</td>
<td>Liechtenstein</td>
<td>SK</td>
<td>Slovak Republic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM</td>
<td>Cameroon</td>
<td>LK</td>
<td>Sri Lanka</td>
<td>SN</td>
<td>Senegal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>Czechoslovakia</td>
<td>LU</td>
<td>Luxembourg</td>
<td>SU</td>
<td>Soviet Union</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZ</td>
<td>Czech Republic</td>
<td>MC</td>
<td>Monaco</td>
<td>TD</td>
<td>Chad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DE</td>
<td>Germany</td>
<td>MG</td>
<td>Madagascar</td>
<td>TG</td>
<td>Togo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DK</td>
<td>Denmark</td>
<td>ML</td>
<td>Mali</td>
<td>UA</td>
<td>Ukraine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES</td>
<td>Spain</td>
<td>MN</td>
<td>Mongolia</td>
<td>US</td>
<td>United States of America</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FI</td>
<td>Finland</td>
<td></td>
<td></td>
<td>VN</td>
<td>Viet Nam</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
FITTING AND MANUFACTURE OF FOOTWEAR

This invention relates generally to the fitting and manufacture of footwear. In various aspects, the invention is concerned with an improved method and apparatus for the measurement of feet, with improved footwear and its method of manufacture, and with improved last design. The invention in its different aspects may be applied in the fitting of shoes and other footwear, in both commercial and custom manufacture of footwear and of footwear lasts, and/or more generally to therapeutic podiatry and medical foot treatment. In this specification and its claims, the term "shoe" is used generically to embrace any form of footwear.

The usual purpose of measuring a foot is to facilitate selection of the most appropriate sizing of footwear. Traditionally this has involved recording static, two-dimensional measurements of an unrestricted, or free form foot. Linear measurements include lengths from heel to most distal digit, heel to the first Metatarsal-phalangeal joint (M.T.P.) [inside ball of foot], and width across the ball of the foot. Circumferential measures include around the ball of the foot and around the apex of the instep. An example is US patent 4395826 which discloses measurement of the circumference of an infant's foot at the front end of the metatarsal bone, utilising a device for tensioning a tape about this region of the foot at a succession of different reading points. The infant's foot is viewed as more of an amorphous soft tissue mass with few hard boney landmarks to fit. The patent describes a method of fitting by volume that measures a series of circumferences and determines by empirical experience what is the most likely successful fitting.

These measurements may be performed in varying degrees of weight bearing (full, partial or non-weight bearing). The degree of loading will change the shape and linear measurements of the foot - usually the greater the load, the greater the linear increase.

Soviet patent 688174 discloses a foot measurement device having an embracing heel stop and translatable spring-loaded rods for respectively measuring the dimensions of the front and rear of the foot. The rods are fitted with sensors which signal a predetermined contact force being applied. The front rod is mounted for movement fore and aft, as well as side to side over the arch.
In general, foot measurement, whether effected in connection with custom footwear manufacture or for therapeutic purposes, or by way of the standard retailer's sole plate, can at best be a guide: the methods effectively only establish a relative size categorisation, e.g. narrow medium or broad, for a probable length (8, 8\frac{1}{2}, 9 etc.). This broad description then directs the fitter or wearer to the likely category range from which a number of shoes can be tried, evaluated and compared before making a final selection or decision. Even custom-made or therapeutic shoes often require modification of the last on initial assessment or subsequent to initial trials.

Modern technologies are being introduced, e.g. based on computerised scanning, to enable recording of more detailed information on the measurement of the foot in its relaxed state, although this information is digitised and usually very extensive and difficult to interpret. These technologies have reduced labour costs in the manufacture of custom footwear, but overall costs are similar to hand-crafted manufacture and the applicant considers that the reliability of the measurement techniques and subsequent fitting and performance has not been significantly advanced. If ten custom footwear professionals were to independently make shoes for a given person's foot, there would be significant variations in the final shapes and designs. Clearly though, one shoe will fit better than the rest, and one will be the worst for a given circumstance. These variations reflect the multifactorial decision process that occurs when changing or translating the free form foot into a purposefully different last shape, and this may be quite independent of the technical methods used such as plaster moulds, computer x-ray scans with CADCAM equipment, or direct measurements.

The problem lies not in gathering volumes of measurements, digital or otherwise, or in the accuracy and speed of producing a conventional last, but rather in reliably translating key measurements and characteristics of the foot into optimum last (and shoe) design and shape.

It is well understood that poorly fitting shoes are a significant source of pain and discomfort to people as they grow older, and it is not uncommon for people to later require podiatric surgery or extended courses of treatment to correct significant foot deformities. Problems arise not only from shoes which distort the shape of the
foot by pressure but also from shoes which are too loose or which confine one
dimension but inadequately support another dimension. Despite this, it is now
common practice in the footwear industry for manufacturers not to provide full
ranges of shoe widths for each length size. Each manufacturer endeavours to
produce an ideal or average shape shoe for each length size: these shapes vary from
manufacturer to manufacturer and even from model to model and thus purchasers
are left to choose the best fitting shoe from the retailer's full range. This is often
done without any skilled guidance and may be overly influenced by fashion
considerations.

Certain ski-boots and so-called "pumps" represent efforts to improve the fit
of shoes to real feet. In the ski-boot example, a rigid external (crustacean)
framework is used and the stability of the foot within the boot is not primarily
achieved within the foot section, but rather by having a rigid lower leg section which
controls the foot through the longer lower leg lever arm. If high density foam is
used in ski-boots and exactly conforms to the static foot shape, the wearer will
become very uncomfortable. It is not possible to eliminate all movement of the foot
relative to the custom moulded boot during activities, and mismatched convex
contours of the toes and foot with adjacent convexities of the boot/boot fill (as the
reciprocal concavities have shifted) is not tolerable. A functional pressure transition
is required to allow for normal residual foot movement (instability). It must also be
noted that there is no ankle movement per se and other activities like walking are
difficult to achieve. This is a single purpose shoe.

The Reebok "Pump" [trade marks] also recognises the need for restoring
appropriate volumetric matching with the foot. The basic system is a rubber bladder
which is pumped up and applies a uniform pressure according to the design of the
shoe tensioning and the position of the bladder. Again, this system is difficult to
tolerate as there is no directional stabilisation control or pressure distribution. Later
disclosed developments of this system involve the use of a maze of interconnected
channels and sub-bladders, but this is overly technical, unreliable and impractical.

It is an object of the present invention in its first and second aspects to at
least in part alleviate one or more of the problems outlined above, and in particular
to enable the taking of meaningful foot measurements that directly relate to
corresponding measurements of an associated last. The invention entails, in its first aspect, the realisation that this object can be met by adopting a new approach to the measurement of feet. Instead of measuring the foot in a static or relaxed state, the invention proposes an approach which pre-tensions parts of the foot with a view to at least partially simulating the dynamic behaviour of the foot under the influence of the shoe when worn. Thus, in particular aspects, the invention proposes to simulate key compressive and other physical elements of footwear when taking measurements of a foot. In respective other aspects of the invention, it is proposed that the measurement process is best effected with the heel area not merely resting against a backstop but substantially immobilised to provide a reference point, and there is provided an arrangement for measuring the arch of the foot.

This primary proposal is made because it has been appreciated that the traditional static measurement approach, by providing information on the non-restricted foot, does not reflect the reality of what follows when the shoe is worn. The foot is a selectively pliable and compressible complex of tissues including bones, muscles and many other soft tissues. It can be made to assume a wide variety of different shapes, some of which may be therapeutic and others destructive, both in the short term and the long term. Changing shape may be caused by voluntary internal forces, i.e. muscle action, or by external forces such as those arising from footwear or the forces applied in specific activities by the ground through footwear. A simple example of the latter is the tendency of a foot to move forward in the shoe if breaking hard when walking down a steep hill.

All shoes will apply direct pressure to the compressible pliable foot, thereby altering the shape and linear dimensions of the foot. The different designs of footwear will apply differing stresses to differing parts of the foot, which will therefore be changed or distorted in different manners by different designed or styled shoes. A shoe dimensioned exactly to the free form or relaxed state of the foot will actually be very loose when worn. A compressible foot will readily move within such a shoe during use, and the loss of control or stabilisation of the foot within the shoe causes excessive movement and slippage of the foot, which in turn results in discomfort, pathology such as calluses and blisters and loss of performance. The invention entails the realisation that these problems can be at least partially
alleviated by an improved technique of measurement at the outset, preferably one which allows determination of information relevant to producing a high performance shoe on the basis that:

5

(i) the shoe will not intimately fit all over;
(ii) the foot dimensions vary over a day;
(iii) the foot dimensions vary within a shoe as a result of functional performance.

10 In short, the invention seeks not merely to account for the shape of the foot, its external form or contour, but to account for the configuration of components in the underlying skeletal structure.

The invention accordingly provides, in a first aspect, apparatus for measuring a foot comprising:

15 a body on which a person may rest a foot;
means carried by the body to define a reference location for the foot;
means to apply pressure to two or more selected portions of the foot whereby to tension the foot to an extent sufficient to modify the tissue distribution in the foot in a manner which at least partially simulates the response of the foot when enclosed in a shoe or other item of footwear; and
means to make plural measurements of the foot while it is so tensioned.

In this first aspect, the invention further provides a method of measuring a foot comprising:

resting the foot on a body at a defined reference location;

applying pressure to two or more selected portions of the foot whereby to tension the foot to an extent sufficient to modify the tissue distribution in the foot in a manner which at least partially simulates the response of the foot when enclosed in a shoe or other item of footwear; and

making plural measurements of the foot while it is so tensioned.

30 The means for determining a reference location of the foot preferably comprises generally U-shaped means, preferably a plurality of selectable interchangeable U-shaped elements, for gripping and immobilising the heel region
of the foot.

The foot response simulated may be a response selected in relation to a particular type of shoe, e.g. while walking and standing in the case of general shoes, or while undertaking a specific activity in the case of special purpose footwear, e.g. playing basketball in basketball boots.

The means to apply pressure to the foot is preferably disposed to apply said pressure to selected pressure tolerant areas of the foot, for example to the sides of the foot or to the lateral regions of the arch behind the metatarsal phalangeal (MTP) joints and the ball of the foot. For this purpose, the means may typically include pressure applying elements or the like, e.g. flat or curved plates, which are moveable laterally, and means to monitor and control the applied pressure in accordance with experience or provided data. This process may of course be automatic. The pressure applying elements are preferably adapted to receive a range of selectable interchangeable three-dimensional forms adapted to fit different foot shapes and to allow enhanced distribution and control of the pressure application.

The body of the apparatus may be a sole plate marked with an appropriate grid to allow two-dimensional measurements and coordinates to be determined and recorded.

The apparatus may further include means to measure parameters of the arch of the foot, for example, the angulation or inclination, height, position and profile type. There may also be means to measure one or more of the height and longitudinal placement of one or more of the malleoli, the angle of the outside surface of the big toe relative to the inside medial border of the foot, and the angulation of the metatarsal shafts.

This means may include selectable interchangeable components, and/or may be adjustable, to suit different sized feet.

In its second aspect the invention provides apparatus for measuring a foot comprising:

a body on which a person may rest a foot;

means carried by the body to define a reference location for the foot;

means to make plural measurements of the foot at said reference location; and
means to measure at least two parameters of the arch of the foot, preferably including the inclination and height thereof.

A third aspect of the invention is concerned with footwear manufacture.

In the past, difficulties have often been experienced in comfortably fitting "unusual" feet in conventional custom made or mass produced shoes, for example feet having boney prominences, other pressure intolerant or pressure sensitive regions, or relative instep and arch dimensions outside a standard range. Problems with boney prominences and pressure intolerant or sensitive regions have been addressed, e.g. by:

(i) Providing a complementary concavity in the shoe. This may be done in a "pre-manufacture" stage by building up the last where appropriate. Post-manufacture, the upper may be locally extended with a "bunion stretcher" or like instrument;

(ii) Cutting out an aperture or opening in the upper, as with a "sandal"-type design; or

(iii) Using soft, pliant materials which will readily deform in use or by working with tools.

Variation of lasts has also been employed to provide for relative instep and arch differences. For example, lasts with more volume and height over the area of the tongue (that is, a higher instep) are used to make shoes for people with high insteps, or to be marketed for people with high insteps. Conversely to match feet with lower insteps, appropriate lasts are modified to have material removed from this corresponding area. However, as already noted, many modern manufacturers have reduced the size of their inventory by "universalising" their fittings, that is eliminating the fractional widths and often lengths, thereby maintaining a suitable range of essentially cosmetically different footwear.

This trend for manufacturers not to provide full ranges of shoe widths for each length size has occurred notwithstanding, as already noted, that it is well understood that poorly fitting shoes are a significant source of pain and discomfort to people as they grow older. Indeed, it is not uncommon for people to later require
podiatric surgery or extended courses of treatment to correct significant foot deformities. Problems arise not only from shoes which distort the shape of the foot by pressure but also from shoes which are too loose or which confine one dimension but inadequately support another dimension.

5 In particular, as a result of rationalisation in favour of "universal" fittings, styles or designs specifically for the size and shape of the instep have been deleted, and it is difficult to find any examples of any styles specifically promoted for accurately matching the different instep profiles found in the normal population.

Rationalisation of the range of shoe size problems has further compounded the adverse effect on feet of features of shape which do not reflect real foot shape. A well known example especially, in women's shoes, is the shape of the shoe toe. In the normal human without any superimposed deformity due to long term use of incorrect (tapered) footwear, the big toe angle (i.e. the angle of the medial edge of the big toe relative to the midline of the foot itself) is 5 to 6°. The shoe industry standard is 12 to 15°, usually increasing for women's high fashion footwear. A medial shoe toe angle of 15° will cause medial pressure on the normal (non-deformed) big toe, pushing it laterally. This can cause great discomfort, dysfunction and even pathology, particularly if the shoe has a rigid toe box or toe cap, as found in safety shoes.

20 The steel toe cap is a more tangible example of this mismatching. While there are some relatively neutral toe caps on the market, these tend to be "orthopaedic" in nature and appearance. There is very poor acceptance by the wearer because of the unconventional medical appearance.

It has been realised, in accordance with the third aspect of the invention, that these various problems are susceptible to at least alleviation by adoption of a common concept: the fitting of the shoe with one or more internal outstanding segments disposed to lie between the shoe and the foot in one or more relatively recessed portions adjacent one or more prominent portions of the foot, whereby to redistribute pressure away from said prominent portion(s) by stabilising the adjacent relatively recessed portion(s) and reduced span of the upper material to the prominent portion(s).

The invention therefore provides, in its third aspect, a shoe fitted with one or
more internal outstanding segments in accordance with the aforesaid concept. In this aspect, the invention also provides a method of forming a shoe, and a method of modifying a shoe, comprising fitting the shoe with one or more internal outstanding segments in accordance with the aforesaid concept.

The internal outstanding segments may comprise pads or like inserts affixed to or affixable to the internal surface of the shoe. The shoes may be manufactured for sale (either in mass production or custom manufacture) with the segments either built in or separate, e.g. as a kit of selectable components, or they may be modified to include the segments subsequent to manufacture. The material of the segments/pads is preferably substantially incompressible or only slightly compressible, in order to avoid the development of high local pressures during use of the shoe.

In its third aspect, the invention still further provides a kit of selectable pads or like inserts for a shoe, which pads or inserts are shaped to be disposed to lie between the shoe and the foot in one or more relatively recessed portions adjacent one or more prominent portions of the foot, whereby to redistribute pressure away from said prominent portion(s) by stabilising the adjacent relatively recessed portion(s) and reduced span of the upper material to the prominent portion(s).

In its fourth and fifth aspects, the invention relates to shoemakers' lasts.

Lasts, generally are expensive items. In the past, one last has often been made do on a mass-production basis for large numbers of shoes etc. which are not necessarily of the size shape or other characteristics appropriate for a potential individual wearer of the shoe, but are averaged out.

Desirably a last would be "custom-built" to each foot. However the cost of producing lasts as known and used hitherto usually prohibits this.

Traditional orthopaedic shoe manufacture has usually required a large range of fractional width, length and profile dimensions to accommodate a wide spectrum of diversity of individual foot shapes. Contemporary shoe design often involves predominantly the use of soft materials for the upper - materials that can be quite "forgiving" compared to stiff orthopaedic-grade leathers and construction often used in the past. The softness and pliability of the upper material enable the foot, including the toes, to "deform" or to accommodate themselves "comfortably" within
a configuration that fits by volume rather than to prescribed anthropometric measurements. This type of fitting tends to reduce the range and consequent retail inventory.

However, as already observed, there are those whose shoe requirement are such that they can only with difficulty be met by this and other prior methods. In effect, they require custom-made shoes. Such shoes can be and have been produced either using individually-designed lasts made of wood, plastics or from plaster moulds, or by modifying ad hoc a standard last using build-ups of cork or other material seen as suitable. This can be a time-consuming, expensive, judgemental and subjective operation and can vary considerably from one practitioner to the other, and not always to the benefit of the patient or customer.

Historically there has not been a consensus or understanding of the key structural characteristics of the foot related to footwear use, nor to the structural changes that occur to that foot when inside a shoe.

Commercial changes to footwear mostly occur in the obvious visual aspects - the shape of the line of instep and the materials and colours of uppers and heel height. As such most efforts to render lasts adjustable or modular have been directed to these areas - interchangeable toe portions, add-on instep or heel-sole members. Essentially the body of the last, that is the orientation of heel to mid-foot, width and other underlying structural components and configuration, has not been changeable.

The improved measurement system identifies more changes than have been able to addressed in commercial fitting, though accessible in the niche, hand-made or computer-aided fields. The fourth aspect of the invention provides a mechanical last that can be recycled or adjusted in the areas of key measurements identified by the measurement system.

Recent adoption of the so-called CADCAM process tends to alleviate some of the disadvantages of prior practices just described, but even so, the method can be relatively time-consuming and expensive.

An object of the invention in its fourth and fifth aspects is to provide an improved form of adjustable last. Another object is to provide, in a relatively quick and simple fashion, a last which is closely and reliably related to or cognated with
parameters (e.g. specific dimensions, function and anatomical characteristics) of a particular foot.

A fourth aspect of the present invention provides a last or last body having means which divides the last or last body, or a component thereof, into mutually spaced portions whose spacing may be varied by flexing to alter a dimension or shape feature of the last. The means is preferably a slit, slot or the like in the last or last body, or in the aforementioned component thereof.

Preferably, the required or desired flexing does not substantially exceed the elastic limit of the material i.e. to ensure that the last material returns at least substantially to its original form when flexing forces are removed.

The mutually spaced portions may be held apart by a range of suitably coded and possibly interchangeable spacers, wedges, threaded tension bolts, or like temporary inserts. In general, means may be included for adjusting the width of the slit, slot or the like.

Advantageously the gaps are not so wide as will seriously affect the shaping of material stretched over the last, but if need by a wedge or the like could be such that its outer end face affords effective continuity for the last surface.

In its fifth aspect, the invention provides a last formed in a plurality of separable components including a heel member, an elongate spine member adapted to project forwardly from the heel member, means for attaching the spine member to the heel member, a toe member adapted to be attached to the front end of the spine member, an instep member to overlie the spine member, and respective side members supportable by the spine member in a manner permitting their longitudinal, lateral and angular adjustment with respect to the spine member.

The spine member is preferably a flat plate, and the heel member is preferably a substantially hollow piece of U-configuration adapted to receive the rear end of the spine member, and to slidably receive and seat the side members and instep member. The attaching means is preferably adaptable to allow adjustment of the relative height or the angular orientation of the heel and spine members.

The invention will now be further described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a somewhat diagrammatic isometric view of the foot measurement
device according to an embodiment of the first and second aspects of the invention;

Figures 2 and 3 comprise a series of sketches indicating different foot parameters, or sets of foot parameters, which may be determined with the measurement device shown in Figure 1;

Figures 4 and 5 schematically depicts the manner in which the upper of a traditionally made shoe reacts with the foot therein;

Figure 6 is a diagram depicting an embodiment of the third aspect of the invention;

Figures 7A to 7E illustrate how the third aspect of the invention may be applied in a post-manufacture procedure;

Figures 8 and 9 illustrate the confinement of the big toe in a traditionally manufactured shoe;

Figures 10A and 10B illustrate further embodiments of the third aspect of the invention, in relation to the confinement of the big toe;

Figures 11 to 14 demonstrate by comparative sketches various features of the third aspect of the invention in its different embodiments.

Figure 15 diagrammatically depicts several alternative embodiments of the fourth aspect of the invention;

Figures 16A and 16B are plan and side exploded views of a last according to an embodiment of the fifth aspect of the invention;

Figures 17A and 17B are views similar to Figures 16A and 16B of the assembled last;

Figure 18 illustrates a range of different adjustments of the last shown in Figures 16 and 17; and

Figure 19 illustrates abnormal foot conditions (B,C) known as metatarsus adductus which are fully measurable in accordance with the first aspect of the invention and for which a satisfactory last may be readily formed in accordance with the fifth aspect of the invention. The natural unaffected foot is shown at A.

The foot measurement device 10 illustrated in Figure 1 is preferably portable and knockdown. It comprises a generally flat sole plate 12 provided with a two-dimensional grid 14 for obtaining, inter alia, co-ordinates for selective features of a foot 5 rested on the plate. Towards the rear of the sole plate are upwardly projected
studs 30 for detachably mounting a selected one of several different sized U-shaped heel cups 16 which embrace and grasp both sides of the heel area 6 of the foot below the malleoli 7 to substantially immobilise the foot on the plate 12. Cup 16 is therefore effective to define a reference location for the foot. Each heel cup 16 has a pair of lateral tabs 17 with holes to receive studs 30, the fastening being completed by respective nuts 31.

Detachably carried on either side of sole plate 12 are respective pressure plates 18 which are adjustable lengthwise and laterally of the foot, and at least to an extent angularly. This adjustment is achieved by supporting the plates 18 on carriers 33 with laterally extending elongate slots 34 which engage respective pairs of upstanding threaded studs on the sole plate. These studs are themselves slidably longitudinally of the sole plate 12 in side slots 39. Again, respective nuts 36 are engaged with the studs, in this case to fix the studs at respective locations lengthwise of the crossed slots 34,39. It will be appreciated that the slots allow carriers 33 to be moved both longitudinally and laterally of the foot and also to be rotated to a degree (the studs are loose fits in slots 34,39).

Adjustable calibrateable force means 40 is provided on carriers 33 to load the plates 18 against the sides of the foot and so apply a pre-tensioning pressure, the angular adjustability of the plates allowing even distribution of the pressure. Each force/loading means may be a compression spring loading of the pressure plate 18 with respect to the carrier. Each means 40 preferably includes means to monitor and control the applied pressure in accordance with experience or provided data.

Pressure plates 18 may be brought up against the sides of the foot beside the arch and instep and rearwardly of the MTP joints. These parts of the foot are chosen for the pressure application because they are relatively pressure tolerant, in contrast, e.g. to bony prominences such as the lateral extremities adjacent the first and fifth MTP joints. The pressure plates 18 are adapted to receive contoured three-dimensional elements or forms 20 which may be selected in relation to the foot shape so as to further balance and distribute the applied pressure. In the subsequent manufacture of a shoe or last, the shoe or last may be provided with a matching internal form (for the shoe) or complementary shape (for the last) to match the selected forms attached to the pressure plates. The lateral pressure plates 18 may
perform a secondary role in determining the angulation of the metatarsal shafts by reference to the underlying grid or by direct angular measure.

Application of pressure by plates 18 is such as to tension the foot to an extent sufficient to modify the tissue distribution in the foot in a manner which at least partially simulates the response of the foot when enclosed in a shoe or other item of footwear.

The preferred measuring apparatus further includes an overhead post arrangement 22 from which depends an adjustable inclined contact plate 24 for measuring the height and angulation or inclination of the arch 8. Also provided is a separate post arrangement 23 for supporting one or more adjustable pointers 26 to measure the height and lengthwise positions of one or both of the malleoli 7. Post arrangement 22 includes a lengthwise rail 52 fixed to respective upstanding corner posts 54 on one side of the sole plate 12. Each post fits firmly in a respective socket 56 fixed to sole plate 12, and has lateral pins 55 which engage angled side slots 57 in the sockets so that the assembly of posts 54 and rail 52 can be folded down flat across the sole plate during storage of the measurement device. An overhead arm 58 is detachably attached to rail 52 for lengthwise adjustment and carries contact plate 24 in an angularly adjustable coupling.

Post arrangement 23 for measuring one malleoli includes an upstanding rear corner post 45 which fits firmly in a socket 46 fixed to sole plate 12. Post 45 has lateral pins which engage angled side slots in socket 46 so that the post can be folded down flat during storage of the device. Contact pointer 26 is adjustably carried on an arm 47 which is in turn adjustable and detachably carried by post 45.

Each detachable and adjustable coupling in the post arrangements 22,23 is by a simple U-clamp 49 with thumb screw 50 for setting the position of one component along the other.

In an alternative embodiment there may be similar fold-down rail and post assemblies, akin to the assembly of posts 54 and rail 52, at both sides of the sole plate. Malleoli measurement devices would be slidably carried by each of the rails, in addition to the arch contact plate. Other optional measurement features, in the illustrated embodiment or in other embodiments, would include 3-dimensionally slidable stops for measurement of lower leg profile, foot length, location of
prominences, individual toe location, and toe profiles, features and landmarks.

Specific pathologies on the plantar surface of the foot can be accurately marked with a suitable transfer dye which would reproduce on the underlay grid, enabling accurate location relative to the rest of the foot.

Provision (not illustrated) can be made to incorporate specific heel heights within the measurement system. As the amount of plantar flexion increases, the orientation of the bones within the foot changes in a non-linear fashion. That is, at different heel heights and resultant plantar flexions, there may be different positions and shapes of the foot. By using specific heel lifts placed under the heel on the sole plate, or by other mechanical means, the foot may be assessed more precisely in its functional position.

In a preferred practice of the first aspect of invention, provision is made to measure and record appropriate relationships for the following functional anatomical parameters, or sets of parameters:

1. Heel (calcaneal) width
2. Length of heel to first MTP joint
3. Length of heel to fifth MTP joint
4. Overall length of heel to most distal digit
5. Height and longitudinal placement of lateral malleolus
6. Height and longitudinal placement of medial malleolus
7. Height/placement of instep (plantar aspect of longitudinal arch)
8. Angulation of instep (plantar aspect of longitudinal arch)
9. Width (ML) across ball of foot (free or tensioned)
10. Orientation (inset-outset) of hindfoot (heel) to forefoot (ball of foot)
11. Plotted configuration of the toes
12. Angle of the first (great) toe to the medial border of the foot
13. Plotted (numerical) configuration of the (transverse) cross-section of the foot
14. The specific location, extent and projection of key prominent boney landmarks such as bunions
15. Angular relationship of the medial and lateral metatarsal rays

The successive steps involved in the determination of these parameters are
set out in diagrammatic/notation form in the sketches of Figures 2 and 3, in which the numbers assigned to the sketches correspond to the numbers in the above list of parameters.

These measurements may be extended to include measurements further up the lower leg to gain appropriate measurements and/or relationships for boot design and fitting.

It will be understood that the present practice of the preferred embodiment of the first and second aspects of the invention achieves at least three significant measurement enhancements relative to traditional static measurements. Firstly, key parts of the foot are selectively pre-tensioned by application of pressure with a view to matching, reliably predicting and improving the compressive characteristics of selected shoes. Relatively accurate objective correlation is achieved between a given shoe and a given foot, enhancing appropriate selection, customisation and design of lasts and footwear. Thirdly, more meaningful information is provided on the shape and angular orientation of the different functional components of the foot.

The pre-tensioning pressure applied to the foot, e.g. via pressure plates 18 in the illustrated embodiment, will be selected, inter alia, according to the nature of the footwear for which the measurement is being made. For example, for a shoe to be worn in an essentially sedentary occupation, a slipper-type low pressure fit is required. At the other extreme, a high pressure and high level of foot pre-tensioning is desirable for a mountaineering or basketball boot. Ordinary walking or working shoes would fall between. The force or pressure applying means 40 would typically be calibrated according to application. In some cases, or for some applications, no pressure might be applied, i.e. the measurements might be taken without any pre-tensioning pressure.

A further optional utility of the inventive apparatus is as an assessment tool whereby specific medical type descriptions of foot characteristics such as metatarsus adductus or pes planus can be described with precise measured values. That is, instead of an opinion of, for example, moderate degree of metatarsus adductus, it could be described numerically as, say, 6 mm deviation from the midline. Such an application is discussed again below in connection with Figure 19. Thus, the apparatus could perform a function similar, for example, to the use of spirometry
(e.g. a "vitalograph") to describe parameters of respiratory function. Especially for such purposes, the system may be contained in a small portable form.

Device 10 may further include a transparent overlay for locating bunions and other pathologies on the top or side surfaces of the foot. This may also be done by use of a locating rod, translatable on the same rail system, that provides co-ordinates of specific landmarks or deformities.

It will be understood that in more advanced forms of the measurement device 10, conversion and interpretation tables may be included, for example in associated computer databases. Direct electronic encoding and processing may also be utilised as too may X-Ray, laser and other techniques. Simulation of functional compressive forces may be applied manually, mechanically or electronically with suitable means for selecting and recording the definitive Site(s), amount, extent and duration of application.

In an alternative embodiment according to its first aspect, the invention may be applied in the form of or in conjunction with a hybrid mobile form to allow actual ambulation of the foot while simulating the compressive elements of the proposed shoe design and measurements. An adjustable, modified and/or abbreviated upper with scaled closure and suitable stabilising pads may be included for this purpose. In this manner, the wearer could functionally try and clinically evaluate the measurement recommendations before commitment to the selected shoe, or to the defined therapeutic management.

Attention is now turned to the third aspect of the invention, with particular reference to Figures 4 to 14.

According to a first embodiment of the third aspect of the invention, applicable for dealing with stabilisation about boney protuberances, one or more stabilising pads or like inserts may be fixed or fixable to the inside of the upper and adapted to bear wholly or substantially against "pressure tolerant" or less sensitive areas of the foot, so that when the shoe is being worn, the pad or pads tend to push the upper material outwardly around or in the neighbourhood of a pressure intolerant or sensitive region of the foot, thereby relieving the inward force that the material would otherwise exert on the region.

This embodiment of the invention is based on the principle that footwear
irritation is often caused or aggravated by rubbing and/or pressure of the upper on hard protruding or "landmark" regions of the foot. This is due to prolonged pressure connected with features of shape (e.g. protuberances), or arises from relative movement of the foot within the shoe. The unyielding nature of such protrusions necessarily forces the upper to assume a configuration of large curvature, which can only be supported by exerting a very large inward force at the very point where relief is required. The pads or like inserts provided in accordance with the first embodiment of the third aspect of the invention have the effect of reducing or controlling the upper material's curvature in sensitive regions e.g. by adding support where material would otherwise simply "bridge over" less sensitive (or more tolerant) areas. Controlling force is applied over a larger area, lowering localised pressure. It is therefore possible to further reduce the natural [weightbearing] spread of the ball of the foot by means of this shoe modification. This could allow the rationalisation of the range of width fittings while maintaining optimum foot-to-shoe matching.

By thus imposing or increasing pressure on tolerant areas of the foot, and relieving the sensitive areas of at least some of the undesirable pressure that would otherwise be exerted, such as by reducing "bridging" of the upper and causing it to assume a more regular configuration or curvature, the appearance of the shoe also will in general be much improved, there being usually less localised distortion of the outer surface of the upper material.

Figure 4 diagrammatically depicts the manner in which the upper 110 of a typical shoe, made according to traditional practice, applies pressure to boney prominences at the forward end of a foot 112 within the shoe. Pressure is depicted at four prominences in particular, i.e. the outer corner 115 of the big toe 114, the little toe 116, and the inner-and outermost metatarsal prominences 118,119. The internal bone structures involved are indicated at 120,121. In time, the upper 110 stretches as at 122,123 (Figure 5) to accommodate these prominences and compensate the applied pressure. Figure 6 indicates the solution provided by the third aspect of the invention, in accordance with the first embodiment: respective pads 125,126 are affixed to the interior of the upper to form internal outstanding segments occupying the cavities 130,131 (Figure 4) behind prominences 118,119.
These cavities 130,131 would otherwise exist because the shoe does not fit or complement the relatively pressure insensitive recessed sides of the foot trailing from prominences 118,119. Pads 125,126 provide proximal positive stabilisation, and control pressure and boney alignment. The shoe upper 110' to which pads 125,126 are applied may be a slightly larger size than a corresponding shoe 110 for the same foot according to traditional practice.

An adjustable applicator may be used to attach pads in a post-manufacture procedure. With reference to the example depicted in Figures 7A to 7E, an appropriate applicator or device 140 can be manipulated to assume general contour and spatial characteristics of the shoe as it is desired to be modified. Pads 125a,126a,127a are located on the applicator 140 according to prescription (Figure 7B), and adhesive applied on the exposed surfaces of the pads. Velcro fastening could also be employed. The applicator is then contracted by any suitable reduction mechanism (Figure 7C) to enable it to be inserted into the shoe.

Thereafter the applicator is expanded back to the required configuration (Figure 7D), advantageously with an additional expansion factor adapted to compress the pads against the inside surface of the upper and to encourage the adhesion to take effect. After an appropriate time, the applicator is removed and the shoe 110" (Figure 7E) is then ready for fitting.

If desired an adhesive stretch or like lining can be placed directly against the applicator before positioning the pads. This could provide an integrated smooth inner finish to the shoe.

Pads may be inserted into pre-designed pockets within the upper, i.e. between the inner [lining] and the outer layer of the upper. Appropriate means of referencing could be employed.

In a second embodiment of the third aspect of the invention, applicable for dealing with the stabilisation about the MTP joint, a stabilising pad can be placed proximal to the big toe to laterally shift the front of the foot, including the big toe. By this means the outside of the shoe toe section can have the more cosmetically standard taper whilst in the inside, the medial edge has an appropriate neutral shape and big toe angle to match the neutral foot. The shoe could be appropriately broader across the ball of the foot, but it is generally the toe shape which contributes
most to the overall cosmesis of the shoe in this context. This second embodiment lends itself to use with shoes with or without a conventional toe box.

Figure 8 compares in plan the normal big toe angle of about 5\(^\circ\) with the typical shoe profile have a big toe angle of around 15\(^\circ\), and Figure 9 illustrates the pressure and deformity which is inevitable when a normal big toe is confined in such a shoe. In accordance with the second embodiment of the third aspect of the invention, a stabilising pad 125' is affixed to the shoe interior (Figure 10A) and disposed to extend beside, and apply stabilising pressure to, the side of the big toe and the forward inside face of the foot. This pad 125' occupies a cavity 130' which would otherwise exist were the shoe upper 110'' to complement the correct big toe angle. Figure 10B depicts the case where there is both an outer 110'' and an inner 150, and a toe cap 152, the pad(s) 125'' being disposed between the inner and the outer.

Turning to a third embodiment of the third aspect of the invention, applicable for dealing with stabilisation about the arch of the foot, it has been usual in the shoe industry to use the sole of the shoe as the base or reference point for fitting. That is, the foot relates in a parallel fashion to the sole of the shoe. Full length insoles are used to raise the entire foot up towards the sagittal profile of the upper. Differential adjustment may occur over the tongue where the lace stays are present.

Distal to the lace stays, there is no adjustment usually in the region of the toes, where often there is a relatively rigid toe box or toe cap. An insole extending to the toes may excessively elevate the toes causing undue anterior pressure.

Lacing has been a means of allowing the shoe to open up wide enough to permit the (wider) anterior portion of the foot to pass through the (narrower) opening at the more posterior portion of the shoe.

Lacing has also permitted a fine tuning of the volume of the foot inside the shoe, that is, to accommodate for subtle volumetric differences in feet of different wearers found within the same fractional size, differences in thicknesses of socks, changes in the amount of swelling in the feet, seasonal and daily, and gradual stretching of the materials used to make the upper during use.

Classic orthopaedic fitting has strict criteria about the symmetry of closure of the lace stays from top to bottom and the degree of approximation. This relates not
only to cosmesis, but to the fit and control of the component parts of the shoe. If, for instance, the wearer’s instep is very low relative to the design of the shoe, greater closure of the lace stays may result in a loss of overall tension on the quarter panels of the shoe, compromising the fit. Conversely, a high instep of the wearer relative to the shoe can result in a loss of the contouring of the upper to those of the foot. Orthopaedic shoe ranges are extensive, and so the fitter under such circumstances would then select a suitable/appropriate/matching instep profile as well as the appropriate fractional width/length match.

The modern practice in general footwear is to continue to use the bottom or sole of the shoe as the base reference point. If a foot has a low instep, the lace stays will be approximated closer. Excessive "bubbling" of the upper may occur, indicating a loss of overall positive contact, and a focus of pressure across the instep. A standard shoe fitted to a wearer with a higher instep may be found to have widely spaced anterior closure with excessive force applied through the closure straps rather than through more sweeping matched contours of the side quarters of the shoe.

Both situations result in uneven pressures, and therefore lack of fit or complement between the shoe and foot, compromising comfort and functional control.

"Pumps", the latest "state-of-the-art" and mentioned briefly earlier, use an inflatable bladder in the tongue which gives the wearer the ability to select and upgrade the "padding" against the closure straps. In this method, overall tensions of the upper around the foot can be more successfully maintained, improving comfort and control. This is an expensive technology and prone to problems with adjustments and durability. As the bladder is continuous, the inflation rate is equal throughout the system, limiting the amount of local or differential control. For this reason many wearers of this system only inflate the "pump" for short periods of marked demand as constant high inflation is difficult to tolerate for sustained periods of time.

In the third embodiment of the third aspect of the present invention, it is the anterior surface or upper of the shoe which is used as the reference point. Normal variations in instep height are accommodated by the use of wedges which are placed under the heel and longitudinal arch of the foot. A selection of tapered wedges of
suitable material such as E.V.A. or expanded polyurethane can be used. Unlike full length removable insoles, these tapered wedges do not extend into the metatarsal heads or toes, which may unduly raise these structures up against the vamp of the shoe.

The design and structure of the shoe must be such that there is a maintenance of sufficient purchase and control around the heel for wearers using the thickest tapered wedge. Stable and snug heel counters and high proximal trim lines could be options.

As the tapered wedges essentially fit under the heel, their use can be extended further than acting as just a spacer. The wedges can incorporate compliant, shock absorbent qualities. Much attention has concentrated on the traumas of foot impact on hard surfaces, particularly during heel strike. To achieve sufficient shock absorption, a requisite thickness of material is needed. One of the problems of the many specific commercial, shock absorbing inserts is they may unduly raise the foot out of a shoe not adequately designed for this addition.

Furthermore there is now an understanding of the need for a balance between energy dissipation and energy storage and recoil. Total energy absorption of foot impact reduces overall performance and may disrupt and damage the function of the foot, such as may occur when training barefoot in sand. Progress is slower than on harder, shock inducing surfaces such as concrete, and specific injuries may occur to the foot because of the greater internal foot movements. Therefore if a specific shock absorption and energy recoil is desired, this combination may more readily achieved by manipulating the material’s internal properties and its thickness.

It is more likely low insteps will be associated with inversion (flat foot) problems, particularly low muscle activity, which typically require greater shock absorption features. Pes cavus (high arch) is usually associated with overactive muscle activity, usually requiring less shock absorption. This relationship coincides with a converse thickness requirement for recoil versus dissipation, making implementation of the tapered wedge more viable.

The tapered wedge may be positioned under a conventional (removable) full length insole to improve cosmesis, conformity and location.

Another variation or complementary addition to this system of improved shoe
to foot conformity/tensions is to include into the design and management the use of pocket within the tongue of the shoe. The last design and upper configuration could be such that adjustment for the usual presentation of lower instep tongue could be accommodated. That is, the last and upper are optimally designed for normal to higher insteps, requiring maximum volumes. Specific provision may be made to maintain correct anthropometric relationships and control when reduced foot volumes are present, specifically a lower instep.

To maintain volume of the shoe, a series of preformed "instep" pads would preferably be available and could be inserted into the pocket(s). These would be of varying thickness, extents and durometers to match the clinical requirements. The pads could be manipulated in three dimensions. Composites to further refine continuity are possible, as the specific manufacture from blanks or modification from the existing range. These pads could also have topographical grids to enable accurate matched modification.

Using thermoplastic foam materials such as the modified prosthetic E.V.A.s, pads could be moulded into typical three dimensioned contours or directly formed on an appropriate model. This would give a ready contoured "set" to the tongue, enhancing donning, pressure distribution, accurate location/placement of the tongue and the appearance of the final free form shoe.

To aid in location of these volume control/anterior stabilising pads, a grid could be printed within the pocket of the tongue. By careful design, the appropriate differential thicknesses, shape and site of the anterior pads can be predicted/determined and precisely placed for customisation of the shoe.

Lacing or other differential closures would refine the adjustments for individual, changing parameters of foot volume and shape as previously described.

The third embodiment of the third aspect of the invention will now be further discussed with reference to Figures 11 to 14. Figure 11 shows three arch/instep configurations, and Figure 12 indicates the behaviour of a tightened conventional shoe, of standard size, in each case, while Figures 13 and 14 demonstrate the response of a shoe fitted out in accordance with the invention with pads such as lower heel wedge 125°, high heel wedge 126° and arch pads 127. These arch pads include a differential thickness pad 127a for high arch/instep, a uniform thickness
arch pad 127b for average arch/instep height, and a thicker contoured (convex) pad 127c to help restore general profile to match standard shoe design. A combination of two pads 127a' and 126a' is shown in the last diagram of Figure 14.

Figure 15 diagrammatically depicts various embodiments of last incorporating the concept of the fourth aspect of the invention. In each case, a long slit has been formed in the last to define two spaced portions of the last. The spacing may be varied by the use of an adjustable or interchangeable wedge or separator in the slit. This arrangement permits easy variation of the dimension of a given last of predetermined shape, at least within a narrow range limited by the deformability of the last material. Preferably, the required or desired flexing does not substantially exceed the elastic limit of the material i.e. to ensure that the last material returns at least substantially to its original form when flexing forces are removed. In Figure 15A, a longitudinal vertical slit 300 trailing back from the region of the big toe allows for adjustment to be made in the last shape to compensate for variations in the orientation of the big toe. In Figure 15B, respective longitudinal slits 302,303, close to the surface at the sides of the last permit adjustment of the angular orientation of the metatarsus. A centrally located longitudinal slit 304 in a vertical plane, as in Figure 15C, permits adjustment of the width of the metatarsus, while Figures 15D, 15E and 15F show how other slits parallel and close to selected surface regions of the last respectively allow for adjustment of the depth of the instep, the rear contour of the heel and the forward depth or height of the last and foot.

Turning now to Figures 16 to 18, a modular adjustable and disassembleable last 200 in accordance with the fifth aspect of the invention includes a spine 201 in the form of a generally elongate flat plate, a heel segment 202, a toe segment 204 and respective side segments 206,207. The heel segment 202 is a hollow open front and open top piece which is of thin-walled construction but relatively rigid. It carries a fixed upstanding threaded stud 208 which receives the spine 201, by engagement with an aperture 211 therein, and is threadably co-operable with an adjuster knob 210 to raise or lower the rear of the spine.

Toe segment 204 has a rectangular slot 205 which receives the forward end of the spine in a relatively loose fit so that the transverse position of the toe segment on the spine can be adjusted. A selected position is fixed by respective set screws
(not shown) threadable from opposite sides of the toe segment. Each of the side segments 206,207 has the approximate external profile of the side of a last, and in addition has a longitudinally extending uniform slot 212 by which the side segment fits over the sides of spine 201. The heel segment, spine and side segments are dimensioned so that the side segments are received firmly into the hollow interior 203 of the heel segment in the assembled condition of the last (Figure 17A), the side shape of the heel matching the external shape of the side segments. Once the latter are in position, they are oppositely clamped by suitable set screws, one of which is depicted at 213.

The final principal component of the last is an arch or instep segment 214 which is seated atop the side segments and again partly snugly housed within the heel segment. The last can be adjusted for longer toes or higher arches using spacers 216,217, and appropriate relief pads such as 218 may be applied to the exterior of the last to allow for particular conditions or pathologies.

It will be appreciated that the modular last arrangement depicted in exploded view in Figure 16 and shown assembled in Figure 17 may be readily adjusted in a wide variety of ways by simply relatively moving the various components within available limits. Some of the available adjustments are depicted and described in Figure 18. It will be seen that they variously involve adjustment of the height of the rear of the spine, differential lateral shifting of the side segments, transverse or angular shifting of the toe segment, and compensating movement of the instep segment. Further great flexibility is imparted by having a range of different sizes for each of the segments of the modular last, for example a range of three or four of each of the spine 201, heel segment 202, toe segment 204, side segments 206,207 and instep segment 214, as well as the instep and toe spacers 216,217.

The modular last concept of Figures 16 to 18 represents a departure from conventional attitudes in that the present invention entails an appreciation that exact smooth last shape is not critical: the practical reality is that the upper material will naturally bridge across imprecise zones and angular junction features.

It will be appreciated that the various aspects of the invention come together to provide an integrated wholly original approach to the fitting and manufacture of shoes. This approach identifies and rationalises key functional foot-to-shoe
components relating to both shape and stabilisation. The measuring system measures appropriate foot components in a reliable simulated fashion, using a concept of utilising stabilisation of the foot within the shoe. In particular, a measuring system embodying the first and/or second aspects of the invention permits a foot to be measured under the dynamic conditions to which it is normally subjected in the footwear for which measurements are being taken. The detailed measurement profile thereby obtained may be used in a practical and entirely mechanical manner to easily derive a corresponding last, utilising the modular system of the fifth aspect of the invention and/or the adjustments of the fourth aspect of the invention.

Viewed in another way, the last systems of the invention provide mechanical means of producing lasts which reflect the measurements. Finally, the third aspect of the invention provides a means of adjusting commercial finished shoes to match individual stabilisation and shape requirements.

An example of the integrated approach is provided by Figure 19, which illustrates abnormal foot conditions (B,C) known as metatarsus adductus which are fully measurable in accordance with the first aspect of the invention and for which a satisfactory last may be readily formed in accordance with the fifth aspect of the invention. The natural unaffected foot is shown at A. This foot condition entails a lateral curve in the lengthwise alignment of the foot. The measurement device 10 can be used to fully specify the relevant co-ordinates of the foot, while the centre right sketch of Figure 18 is a suitable corresponding adjustment of the modular last.
CLAIMS:

1. Apparatus for measuring a foot comprising:
   a body on which a person may rest a foot;
   means carried by the body to define a reference location for the foot;
   means to apply pressure to two or more selected portions of the foot whereby
to tension the foot to an extent sufficient to modify the tissue distribution in the foot
in a manner which at least partially simulates the response of the foot when enclosed
in a shoe or other item of footwear; and
   means to make plural measurements of the foot while it is so tensioned.

2. Apparatus according to claim 1, wherein the means for determining a
reference location of the foot comprises generally U-shaped means, preferably a
plurality of selectable U-shaped elements, for gripping and immobilising the heel
region of the foot.

3. Apparatus according to claim 1 or 2, wherein the means to apply pressure to
the foot is disposed to apply said pressure to selected pressure tolerant areas of the
foot, for example to the sides of the foot or to the lateral regions of the arch behind
the metatarsal phalangeal joints and the ball of the foot.

4. Apparatus according to claim 1, 2 or 3, wherein said means to apply pressure
to the foot includes pressure applying elements or the like, e.g. flat or curved plates,
which are moveable laterally, and means to monitor and control the applied pressure
in accordance with experience or provided data.

5. Apparatus according to claim 4, wherein the pressure applying elements are
adapted to receive a range of selectable interchangeable three-dimensional forms
adapted to fit different foot shapes and to allow enhanced distribution and control
of the pressure application.

6. Apparatus according to any preceding claim, wherein said body comprises a
sole plate marked with an appropriate grid to allow two-dimensional measurements and coordinates to be determined and recorded.

7. Apparatus according to any preceding claim further including means to measure parameters of the arch of the foot, for example, the angulation or inclination, height, position and profile type.

8. Apparatus according to any preceding claim further including means to measure one or more of the height and longitudinal placement of one or more of the malleoli, the angle of the outside surface of the big toe relative to the inside medial border of the foot, and the angulation of the metatarsal shafts.

9. A method of measuring a foot comprising:

resting the foot on a body at a defined reference location;

applying pressure to two or more selected portions of the foot whereby to tension the foot to an extent sufficient to modify the tissue distribution in the foot in a manner which at least partially simulates the response of the foot when enclosed in a shoe or other item of footwear; and

making plural measurements of the foot while it is so tensioned.

10. A method according to claim 9 including gripping and immobilising the heel region of the foot to define said reference location.

11. A method according to claim 9 or 10, wherein said pressure is applied to selected pressure tolerant areas of the foot, for example to the sides of the foot or to the lateral regions of the arch behind the metatarsal phalangeal joints and the ball of the foot.

12. Apparatus for measuring a foot comprising:

a body on which a person may rest a foot;

means carried by the body to define a reference location for the foot;

means to make plural measurements of the foot at said reference location;
and

means to measure at least two parameters of the arch of the foot, preferably including the inclination and height thereof.

13. A shoe fitted with one or more internal outstanding segments disposed to lie between the shoe and the foot in one or more relatively recessed portions adjacent one or more prominent portions of the foot, whereby to redistribute pressure away from said prominent portion(s) by stabilising the adjacent relatively recessed portion(s) and reduced span of the upper material to the prominent portion(s).

14. A shoe according to claim 13, wherein the internal outstanding segments comprise pads or like inserts affixed to or affixable to the internal surface of the shoe.

15. A kit of selectable pads or like inserts for a shoe, which pads or inserts are shaped to be disposed to lie between the shoe and the foot in one or more relatively recessed portions adjacent one or more prominent portions of the foot, whereby to redistribute pressure away from said prominent portion(s) by stabilising the adjacent relatively recessed portion(s) and reduced span of the upper material to the prominent portion(s).

16. A kit according to claim 15 including the shoe.

17. A shoe according to claim 14 or a kit according to claim 15 or 16, wherein said pad(s) or insert(s) comprise one or more stabilising pads or like inserts fixed or fixable to the inside of the upper and adapted to bear wholly or substantially against pressure tolerant or less sensitive areas of the foot, so that when the shoe is being worn, the pad(s) or insert(s) tend to push the upper material outwardly around or in the neighbourhood of a pressure intolerant or sensitive region of the foot, thereby relieving the inward force that the material would otherwise exert on the region.

18. A shoe according to claim 14 or a kit according to claim 17, wherein said pad
or insert is a stabilising pad can be placed proximal to the big toe to laterally shift the front of the foot, including the big toe.

19. A shoe according to claim 14 or a kit according to claim 15 or 16, wherein said pad(s) or insert(s) comprise one or more tapered wedges placed under the heel and/or longitudinal arch of the foot, which wedges do not extend into the metatarsal heads or toes.

20. A method of forming or modifying a shoe comprising fitting the shoe with one or more internal outstanding segments disposed to lie between the shoe and the foot in one or more relatively recessed portions adjacent one or more prominent portions of the foot, whereby to redistribute pressure away from said prominent portion(s) by stabilising the adjacent relatively recessed portion(s) and reduced span of the upper material to the prominent portion(s).

21. A last or last body having means which divides the last or last body, or a component thereof, into mutually spaced portions whose spacing may be varied by flexing to alter a dimension or shape feature of the last.

22. A last or last body according to claim 21, wherein said means is a slit, slot or the like in the last or last body, or in said component thereof.

23. A last or last body according to claim 22, further comprising means for adjusting the width of the slit, slot or the like.

24. A last formed in a plurality of separable components including a heel member, an elongate spine member adapted to project forwardly from the heel member, means for attaching the spine member to the heel member, a toe member adapted to be attached to the front end of the spine member, an instep member to overlie the spine member, and respective side members supportable by the spine member in a manner permitting their longitudinal, lateral and angular adjustment with respect to the spine member.
25. A last according to claim 24, wherein said spine member is a flat plate and the heel member is a substantially hollow piece of U-configuration adapted to receive the rear end of the spine member, and to slidably receive and seat said side members and instep member.

26. A last according to claim 24 or 25, wherein said attaching means is adaptable to allow adjustment of the relative height and angular orientation of the heel and spine members.
HIGH INSIDE

MEDIUM INSIDE

LOW INSIDE

FIG. 11

FIG. 12

Shoe loses tension and bulges and creases. Fit is loose and uneven.

Shoe fits smoothly with even pressure when matched with correct instep height.

Shoe loses even tensioning and conformity with high instep when adjusted by lacing only.
### INTERNATIONAL SEARCH REPORT

**International application No.**

PCT/AU 93/00296

#### A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. 5 A43D 1/00; 1/02; 3/00; A43B 7/22; 7/24

According to International Patent Classification (IPC) or to both national classification and IPC

#### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: A43B 7/14, 7/22, 7/24, 7/26, A43D 1/00, 1/02, 1/06, 1/08, 3/00, 3/02, 3/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

AU: IPC as above

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)

#### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to Claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>AU,A,5485/22 (CLARKE) 13 June 1922 (13.06.22) Pages 1 and 2 and figures</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>AU,B,24684/48 (C. &amp; J. CLARKE LIMITED) 10 February 1949 (10.02.49) Pages 2 and 3 and figures</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>AU,B,41567/68 (438341) (SAAD) 5 February 1970 (05.02.70) Pages 1 to 14 and figures</td>
<td>1,2,3,9,10,11,12</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C.

See patent family annex.

**Special categories of cited documents:**

- "A": document defining the general state of the art which is not considered to be of particular relevance.
- "E": earlier document but published on or after the international filing date.
- "I": document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified).
- "O": document referring to an oral disclosure, use, exhibition or other means.
- "P": document published prior to the international filing date but later than the priority date claimed.
- "T": later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention.
- "X": document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone.
- "Y": document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&": document member of the same patent family.

**Date of the actual completion of the international search**

23 September 1993 (23.09.93)

**Date of mailing of the international search report**

1 OCT 1993 (1.10.93)

**Name and mailing address of the ISA/AU**

AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION

PO BOX 200

WODEN ACT 2606

AUSTRALIA

Facsimile No. (06) 2853929

**Authorized officer**

RON WEBER

Telephone No. (06) 2832123

Form PCT/ISA/210 (continuation of first sheet (2)) (July 1992) copljm
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate of the relevant passages</th>
<th>Relevant to Claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>AU,B,39232/72 (INTERNATIONAL NOMINEES (BAHAMAS) LIMITED)) 23 August 1973 (23.08.73) Pages 2 to 9 and figures</td>
<td>1,9,10,11</td>
</tr>
<tr>
<td>X</td>
<td>GB,A,308018 (WILLIAM MASON LIMITED) 11 April 1929 (11.04.29) Pages 3 to 5 and figures</td>
<td>1,2,3,9,10,11,12</td>
</tr>
<tr>
<td>X</td>
<td>EP,A,284922 (AMFIT INC) 5 October 1988 (05.10.88) Columns 10 to 15 and figures 1 to 3</td>
<td>12</td>
</tr>
<tr>
<td>X</td>
<td>GB,A,162995 (COMPTON) 12 May 1921 (12.05.21) Pages 1 and 2 and figures</td>
<td>13,14,15,16,20</td>
</tr>
<tr>
<td>X</td>
<td>EP,A,316289 (GERI) 17 May 1989 (17.05.89) Columns 1 to 4 and figures</td>
<td>13,20</td>
</tr>
<tr>
<td>X</td>
<td>US,A,2033758 (CRONAN) 10 March 1936 (10.03.36) Pages 1 to 3 and figures</td>
<td>13,14,15,16,20</td>
</tr>
<tr>
<td>X</td>
<td>US,A,2170737 (SWANT) 22 August 1939 (22.08.39) Pages 1 and 2 and figures</td>
<td>13,14,15,16,20</td>
</tr>
<tr>
<td>A</td>
<td>US,A,3325919 (ROBINSON) 20 June 1967 (20.06.67) Pages 1 and 2 and figures</td>
<td>13,14,15,16,20</td>
</tr>
<tr>
<td>X</td>
<td>WO,A,86/01381 (MA) 13 March 1986 (13.03.86) Pages 1 to 6 and figures</td>
<td>13,14,15,16,18,20</td>
</tr>
<tr>
<td>X</td>
<td>WO,A,90/09115 (REEBOK INTERNATIONAL LTD) 23 August 1990 (23.08.90) See entire document</td>
<td>13,14,17,20</td>
</tr>
<tr>
<td>X</td>
<td>AU,B,53316/59 (237250) (LUDWIG) 7 April 1960 (07.04.60) Pages 1 to 3 and figures</td>
<td>21</td>
</tr>
<tr>
<td>X</td>
<td>EP,A,25346 (WHITE) 18 March 1981 (18.03.81) See entire document</td>
<td>21,22,23</td>
</tr>
<tr>
<td>X</td>
<td>US,A,2043649 (BLISS) 9 June 1936 (09.06.36) Pages 1 and 2 and figures</td>
<td>21</td>
</tr>
<tr>
<td>X</td>
<td>Derwent Abstract Accession No. E3820K/13, Class P22, SU,A,931147 (SHAKTA DOM SERVICE) 5 June 1982 (05.06.82) Abstract</td>
<td>21</td>
</tr>
<tr>
<td>X</td>
<td>Derwent Abstract Accession NO. 91-138771/19, Class P22, SU,A,1590065 (W-SIBE TECHN INST) 30 August 1990 (30.08.90) Abstract</td>
<td>21</td>
</tr>
</tbody>
</table>
# INTERNATIONAL SEARCH REPORT

### Box I  Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international search report has not established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. □ Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. □ Claim Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. □ Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box II  Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. Claims 1 to 8 are directed to an apparatus for measuring a foot having means to define a reference location and means to apply pressure to two or more selected portions of the foot and means to make plural measurements.
2. Note the method of claims 9 to 11 are not limited to the apparatus of claims 1 to 8 as the means to apply pressure may merely be the operator pushing with their hand.
3. Claim 12 is to an apparatus which measures at least two parameters of the arch of the foot.
4. Claims 13, 14, 17, 18 and 19 are directed to a shoe.
5. Claims 15 and 16 define a kit of selectable pads or like inserts for a shoe.
6. Claim 20 to a method of forming or modifying a shoe.
7. Claims 21 to 25 define a last or last body.

1. X As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims
2. □ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. □ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.: 
4. □ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 

**Remark on Protest**

□ The additional search fees were accompanied by the applicant’s protest.
□ No protest accompanied the payment of additional search fees.
This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EP 284922 AU 13346/88 JP 63257506 US 4876758</td>
<td></td>
</tr>
<tr>
<td>EP 316289 AU 24799/88 CA 1308554 IT 1229593 US 5005575</td>
<td></td>
</tr>
<tr>
<td>WO 86/01381 AU 48031/85 EP 191100 US 4598484</td>
<td></td>
</tr>
<tr>
<td>WO 90/09115 AU 50843/90 CA 2046640</td>
<td></td>
</tr>
<tr>
<td>EP 25346 US 4286348</td>
<td></td>
</tr>
</tbody>
</table>

END OF ANNEX

Form PCT/ISA/210(patent family annex)(July 1992) copljm