A footwear (10) and sole construction (14) having dynamically responsive spring devices (46–52 and 54) of relatively small and compact size mounted internally in either or both of the heel and forefoot portions of the sole (14). Each spring device (46–52 and 54) includes a plurality of annular frusto-conical skirts which are positioned in end-to-end relationship about an axis that extends at right angles to the surface contact plane of the sole (14). The skirts are formed of a material having an elasticity which is sufficient to enable contraction toward a loaded position responsive to a compression load while storing elastic energy. The elastic energy is released to expand the spring (46–52 and 54) toward its unloaded phase when the load is reduced.
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FOOTWEAR WITH DYNAMICALLY RESPONSIVE
SOLE CONSTRUCTION

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of provisional patent application serial no.
60/041,517 filed March 24, 1997.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to footwear, and more particularly relates to the construction of soles for use in footwear.

2. Description of the Related Art

Prior art footwear intended for exercise and other sports activities such as running, cross training and aerobics have sought to design sole constructions which provide good foot support and stability, which are lighter in weight and which resist midsole breakdown. Among this prior
art is U.S. patent 5,435,079 to Gallegos for a Spring Athletic Shoe having a sole in which a coil spring is fitted at the heel portion above a hinge-like ground-impacting surface. The purpose is to provide shock absorbance and energy return. However, such a design has inferior stability because of the inherent weakness of a coil spring to sideward deflecting forces.

Another goal of athletic footwear designers is to reduce shoe weight without compromising support and stability. Athletes such as runners find lighter weight shoes more desirable because they increase performance.

Still another goal in the prior art is to provide athletic footwear with materials which resist breakdown. Conventional midsole materials eventually break down from the repeated impact forces encountered over a period of use. This results in an increase in pronation motion during the gait cycle which in turn increases the chance of injury to the user. Conventional foam midsole materials such as EVA foam are in common use for athletic shoes, but this type of material eventually breaks down. It would be desirable to provide a foamless midsole construction which will obviate the problem of breakdown and protect the athlete from injury.

The need has been recognized for footwear sole construction which obviates the foregoing and other limitations and disadvantages of prior art footwear. Despite the various footwear designs in the prior art, there has not yet been provided a suitable and attractive solution to these problems.
OBJECTS AND SUMMARY OF THE INVENTION

It is a general object of the invention to provide footwear with a dynamically responsive sole construction.

Another object is to provide footwear of the type described having a foamless sole through a cushioning spring device which resists breakdown for longer life.

Another object is to provide footwear of the type described which is relatively lighter in weight to enable improved athletic performance.

Another object is to provide footwear of the type described in which the sole construction incorporates a dynamically responsive spring device which is stable throughout the gait cycle.

Another object is to provide footwear of the type described incorporating a sole construction having a cushioning spring device which is sufficiently elastic to store energy under load and then release the stored energy back into the shoe when the load is released.

The invention in summary provides footwear and a sole construction in which an elastic spring device is provided in either or both of the heel and forefoot portions of the footwear. The spring device comprises a plurality of portions disposed in end-to-end relationship along an upright axis with respect to the sole. Each portion is comprised of annular frustro-conical skirts having large and small diameter inner and outer rims. The rims of corresponding diameters for the skirts are mounted in juxtaposed relationship so that they function in the manner of a Belleville
washer. The material which forms the spring device has an elasticity which is sufficient to enable contraction toward a loaded position responsive to a compression load while storing elastic energy. The elastic energy is released back into the shoe as the spring expands toward its unloaded position when the load is reduced.

The foregoing and additional objects and features of the invention will appear from the following specification in which the several embodiments have been set forth in detail in conjunction with the accompanying drawings.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a right side elevational view, partially broken away, of an athletic shoe for a user's right foot, incorporating one embodiment of the invention.

FIG. 2 is a bottom plan view of the shoe of FIG. 1.

FIG. 3 is a cross-sectional view taken along the line 3-3 of FIG. 2.

FIG. 4 is a cross-sectional view taken along the line 4-4 of FIG. 2.

FIG. 5 is a lateral cross-sectional view to an enlarged scale of a spring device which is one of the components for the shoe of FIG. 1.

FIG. 6 is a side elevation view of an athletic shoe in accordance with another embodiment.
FIG. 7 is an exploded view, to a reduced scale, showing components of the athletic side of FIG. 6.

FIG. 8 is a perspective view, partially cut away and exploded, of the heel portion of an athletic shoe in accordance with a further embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the drawings, FIGS. 1 and 2 illustrate generally at 10 an article of footwear providing an athletic shoe for a person's right foot. The shoe 10 is shown as adapted for use in cross-training. A shoe of mirror image design, not shown, would be provided for the user's left foot. While a cross-training shoe is illustrated, the invention encompasses a wide range of athletic shoes and active footwear, including shoes designed for running, track and field, aerobics, court shoes such as basketball and tennis, field sports such as soccer, American football, rugby and lacrosse, walking and hiking.

Shoe 10 is comprised of a lasted upper 12 which is mounted onto a sole 14. Fitted below and about the side of the upper is a U-shaped single layer mesh frame 16 having a plurality, shown as four, of fingers 18 which wrap around the sides of the upper. A U-shaped shank support 20, which can be of carbon fiber material, is fitted below and wraps around the sides of the mesh frame in the area of the shoe's shank.

The sole comprises a heel portion 22 and forefoot portion 24. The sole includes of a top sheet 26 (FIGS. 3 and 4) of suitable thermoplastic material such as clear or tinted polyester which is preformed into an elongate flat bottom that extends from the heel portion to the forefoot.
portion. Side portions of the top sheet at the heel are curved up at 28 so as to nest about the bottom and sides of shank support 20. The sides of sheet 26 at the forefoot portion are also curved up 30 into a cup shape.

The sole further includes a bottom sheet 32 of a suitable thermoplastic material such as clear or tinted polyester which is preformed with an elongate center portion 34. The edges 36 at the heel and sides of sheet 32 are curved up in conformance with the sides of the top sheet. The center portion of the bottom sheet is formed with a plurality, shown as six, of circular openings 38-42. Opening 38 at the heel is made larger in diameter relative to the instep opening 40 and forefoot openings 42. Preferably, the four openings 42 in the forefoot portion are oriented in a diamond pattern as viewed from below in FIG. 2

A forefoot outsole 44, which preferably is formed of a transparent elastomeric material, is provided with a flat bottom and upturned flat edge so as to conform with and fit about the lower and front sides of the shoe's toe. The outsole includes four annular elastomeric inserts 46-52 which are removably fitted within respective forefoot openings 42. Another annular elastomeric insert 54 is removably mounted in instep opening 40. The inserts can be removable by suitable means such as providing an interference fit into the openings, or by screw threads. The insert can be formed of a suitable carbon-mixed elastomeric for wear durability. Each of the forefoot and instep inserts are formed with upstanding intrusive rims 53, 53' (FIG. 4).

A rear foot outsole comprises a large diameter, removable annular insert 58 made of a suitable elastomeric material mixed with carbon for wear durability. Heel insert 58 is formed with an upstanding intrusive rim 61.
(FIG. 5). The insert 58 receives major impact forces during and immediately following the heel strike phase of the gait cycle. Inserts 46-54 are each formed with small diameter circular openings 57, 57' (FIG. 4), while heel insert 58 is formed with a large diameter circular opening 59 (FIG. 5). These openings 57 and 58 can be covered with sheets (not shown) of outsole material to keep rocks and other debris out of the spring devices.

As best shown in FIG. 3, at the heel portion the opposite sidewalls 60 of the bottom sheet, as well as the back wall 62 of the bottom sheet (FIG. 1) extend upwardly where they lie in overlapping relationship with the margins of the lower edges and back edge of top sheet 26. These overlapping portions of the top and bottom sheets are secured together by suitable means such as adhesive. Within the sole, an internal chamber 64 is formed between the horizontal portions of the top and bottom sheets as well as the upright sidewall portions of the bottom sheet.

A cylindrical spring device 66 is fitted at the heel portion in chamber 64 and is axially aligned with opening 38. As best shown in FIG. 5, the spring device is comprised of a plurality, shown as four, of annular frusto-conical skirts 68-74. The skirts are disposed in end-to-end relationship along a longitudinal axis 76 which extends generally upright with respect to the plane of the lower surface of outsole insert 58.

Each skirt is generally in the shape of what is known as a Belleville washer, which is commonly used as a part of a bolt fastener system. As best shown in FIG. 5 for the typical skirt 66, the sides of the skirt around its circumference incline inwardly toward longitudinal axis 76 from a large
diameter circular outer rim 78 toward a small diameter circular inner rim 80 at an angle $\phi$ in the range of 3° to 20° and preferably 10°, with respect to a radial plane which is orthogonal with axis 76. The inner rim 82 of lowermost skirt 74 is seated about the intrusive rim 61 of outsole insert 58 while that skirt's outer rim 84 is disposed in juxtaposed relationship about its periphery with the outer rim of the next adjacent skirt 72 in the series. The remaining skirts are similarly positioned either with their respective outer rims disposed in juxtaposed relationship about their periphery or with their respective inner rims disposed in juxtaposed relationship about their peripheries, as best shown in FIG. 5. All of the skirts in the spring device could be integrally formed together by means such as injection molding, or the skirts could be individually formed and then secured together in end-to-end relationship by suitable means such as adhesive or sonic bonding.

In the invention, the end-to-end relationship of the annular frusto conical skirts provide a spring device having a high spring modulus while also strongly resisting sideways bending moments and forces, that is forces directed lateral to longitudinal axis 76. The spring modulus for the spring device also is a function of the particular material which forms the skirts.

In the invention, the skirts are formed of an elastomeric material having a modulus of elasticity which is sufficient to enable the skirts to contract or expand in an axial direction between the unloaded position shown in FIG. 5 and a loaded position, at which the overall axial length of device is shortened from that shown in FIG. 4, responsive to compression loads from a user's foot which act down from upper sheet 26 and against the top end of the spring device. For this purpose, the skirt material can advantageously be a composite of tough and durable fibers such as graphite, glass or nylon and a compatible synthetic polymer resin. A
composite material of this type not only has a high spring modulus but is also light in weight, durable and recyclable.

The circular interconnections between the adjacent skirts at their inner and outer rims lie in horizontal planes and have large diameters relative to the diameter of a wire in a coil spring in a heel support device as in a Gallegos Patent 5,435,079. The relatively wider circles of support between the skirts results in greater lateral stability in the spring devices and therefore in the shoe throughout the gait cycle. This is in contrast to a shoe incorporating a coil spring support as in the Gallegos patent where the heel would tend to wobble from one side to the other due to lateral forces such as when the area of heel strike is on either side of a vertical midplane through the shoe. The spring devices of the embodiment of FIGS. 1-5 are superior in both cushioning and controlling motion of the shoe's heel and therefore the user's heel.

Spring devices of a construction similar to that shown and described for FIG. 5 can be placed at other areas of the shoe, such as at the instep area where a spring device (not shown) is mounted within the chamber which is formed between top sheet 26 and insert 54. A cluster of four spring devices (only devices 86 and 88 are shown in FIG. 4) are mounted at the forefoot portion in the chambers above inserts 46-50 for supporting the foot's metatarsal heads and for push off during the gait cycle. The spring devices in the instep and forefoot areas are of smaller size and diameter as compared to spring device 66 in the heel portion of the sole. The number of spring devices which are provided, the particular locations at which they are placed and their spring modulus' would vary in accordance with the requirements of a particular footwear application, such as for tailoring the shoe to an individual athlete. In
addition, the spring devices in either of the instep or forefoot portions could be used either alone or in combination with the heel portion spring device, also in accordance with the requirements of a particular application.

FIG. 4 illustrates details of the construction of the pair of spring devices 86 and 88 that are provided in the forefoot portion of the sole. Spring device 88, which is typical of the cluster of four at the forefoot, is comprised of a pair of upper and lower annular frusto-conical skirts 90, 92 which are mounted in end-to-end relationship about a longitudinal axis extending generally upright with respect to the surface contact plane of the lower surface of the forefoot portion. The small diameter inner rim of lower skirt 92 is seated about intrusive rim 53' of insert 52. The large diameter outer rim of the lower skirt is positioned in juxtaposed relationship about its periphery with the large diameter rim of upper skirt 90. The large diameter end of the upper skirt in turn is positioned in juxtaposed relationship below top sheet 26.

The spring devices in the forefoot portion, as well as the spring device in the instep, operate in a manner similar to that described for heel spring device 66. The compression loads from the instep and ball portions of the user's foot are applied down against the top ends of the spring devices. The skirts contract down toward their loaded positions while storing elastic energy. When the compression load is reduced, such as during and after the push off phase, the elasticity of the springs is sufficient to enable release of the elastic energy, thereby causing the skirts to expand and return to their unloaded positions. The released energy aids the user's push off action.
Any one or all of the spring devices in the heel, instep and forefoot portions can be replaced by removing the appropriate outsole inserts 46-58 and pulling the devices out. Spring devices of different physical properties can then be installed and secured in place by remounting the inserts. This enables one to individualize the shoe for different sports application or for different athletes. As used herein, "physical properties" means the degree of spring modulus, the degree of resistance to lateral forces, the load-bearing capacity, the size, shape and number of skirts, and composition of the material which forms the skirts.

FIGS. 6 and 7 illustrate generally at 94 an athletic shoe in accordance with another embodiment. Shoe 94 is comprised of a lasted upper 96 with a mesh frame 98 having a U-shape for fitting underneath and around the sides of the upper. A U-shaped carbon fiber shank 100 fits underneath and around the mesh frame. The sole 102 is comprised of a top sheet 104, preferably made of a transparent synthetic polymer, which has upturned edges at its sides and heel for fitting beneath and around shank 100. A bottom sheet 106, also preferably made of a transparent synthetic polymer, is formed with upturned edges at its sides and heel so as to fit beneath the top sheet with a chamber 108 between the two sheets. At the heel portion, a large diameter opening 110 penetrates through the bottom sheet. At the forefoot portion, four small diameter openings (only openings 112 and 114 are shown) penetrate through the bottom sheet.

A large diameter spring device 116, similar in construction and operation to spring device 66 in the first embodiment, is fitted within opening 110 and positioned in the chamber between the top and bottom sheets. Four smaller diameter spring devices 118, 120, similar in construction and
operation to the spring devices 86 and 88 in the first embodiment, are fitted through respective openings 112 and 114 and positioned in the chamber between the top and bottom sheets at the forefoot portion. A forefoot outsole 122, preferably formed of a transparent elastomeric material, is formed with an upturned curved front edge 124. When forefoot outsole 112 is fitted below the front of bottom sheet 106, upturned edge 124 provides protection for the shoe’s toe. A rear foot outsole 126, preferably formed of a carbon-mixed elastomer material for wear durability, is formed with upturned sides and rear edges which are mounted around the heel of the bottom sheet.

FIG. 8 illustrates the heel portion 128 in the sole 130 of a shoe in accordance with another embodiment. The sole is comprised of a compression molded midsole material, such as EVA, having a heel portion 132 and a forefoot portion, not shown. An upper (not shown), which can be of conventional construction, is mounted on top of the sole. A heel outsole 134, which preferably is of a suitable wear durable elastomer material, is mounted below the lower surface of the heel portion.

A vertically axised cylindrical internal chamber 136 is formed in the heel portion of the midsole. A vertical support column 138 is axially mounted upright within the chamber. This forms an annular spacing 140 between the support column and chamber’s outer wall.

An annular spring device 142 is mounted on heel portion 132 within spacing 140 and about the support column. The spring device is comprised of a plurality of skirts 144 which are constructed similar to the skirts of spring device 66 described for the embodiment of FIGS. 1-5.
The diameter of support column 138 is sufficient so that its outer surfaces are in juxtaposed supporting relationship with the inner rim of skirts. The skirt inner rims are free to axially move relative to the support column, and the outer rims of the skirts are also free to move axially relative to the wall of internal chamber 136.

The use and operation of the embodiment of FIG. 8 is similar to that described for the embodiment of Figs. 1-5. Compression loads from the user's foot acting against the top end of the spring device cause these skirts to contract from their respective unloaded positions shown in FIG. 8 toward loaded positions while they store elastic energy. As the compression loads are reduced following the heel strike phase, the elastic energy is released. The skirts expand then back toward their unloaded positions, and a part of this energy is recovered by being put back into the shoe during transition from the loading phase to the push off phase. The skirts remain stable during both contraction and expansion by resisting forces from the side.

It is clear from the foregoing that Applicants have provided an improved sole construction for footwear in which dynamically-responsive spring devices provide a support strength which is high relative to the device's size. This enables mounting of the spring devices into the interior of the sole. It also obviates the need for foam midsole material to provide cushioning; spring devices of the invention will last indefinitely in that they will not wear out in normal use. The small and compact size of the device due to the tandem stacking of relatively small annular frustococonical skirts also results in a lighter weight construction, and therefore, a lighter weight and more desirable shoe for athletes. The spring device is very stable and resists undesirable pronatory motion throughout the
gait cycle. Applicant's invention enables one to easily remove and replace the spring devices with a range of devices having the desired physical properties such as dynamic response characteristics so as to individualize or adapt the shoe for different athletes or for different sports activities or conditions.

Footwear embodying a sole construction in accordance with Applicant's invention can be cost-effective to a manufacturer. The stacked skirts can be injection molded as a single piece from a non-metallic material to save weight. Also, such material would not set off metal detectors of the type encountered in security areas such as at airports. The sides and/or bottom of the sole can be molded with windows of a transparent material to enable visualization of the spring devices. This would enable one to record operation of the devices on motion picture or video for a subsequent analysis of movement of the sole and its components throughout the gait cycle. Such an analysis would include measuring the stresses and loads that occur in the shoe throughout the heel strike phase, loading phase and push off phase.

While the foregoing embodiments are at present considered to be preferred it is understood that numerous variations and modifications may be made therein by those skilled in the art and it is intended to cover in the appended claims all such variations and modifications as fall within the true spirit and scope of the invention.
What is claimed is:

1. A sole construction for use in an article of footwear to be worn on the foot of a user, the sole construction comprising: a sole having a heel portion which comprises a sole top and a sole bottom, the sole bottom extending generally along a footwear-bearing surface contact plane, the heel portion comprising a spring device, the spring device having a top end positioned adjacent the sole top and a bottom end, the spring device comprising first and second annular frusto-conical skirts which are disposed in end-to-end relationship along a longitudinal axis which extends generally upright with respect to the surface contact plane, each of the first and second skirts having a large diameter outer rim and a small diameter inner rim, the first and second skirts being positioned either with respective large diameter outer rims disposed in juxtaposed relationship or respective small diameter inner rims disposed in juxtaposed relationship, and the first and second skirts being formed of a material having an elasticity which is sufficient to enable the skirts to contract along the longitudinal axis from respective unloaded positions toward respective loaded positions responsive to a compression load from a user's foot acting against the top end of the spring device while the skirts store elastic energy, the said elasticity further being sufficient to enable release of the elastic energy for causing the skirts to expand toward the unloaded positions responsive to a reduction in said compression load.

2. A sole construction as in claim 1 in which the spring device further comprises a third skirt which is disposed in end-to-end relationship with the second skirt along the longitudinal axis, the third skirt having a large diameter outer rim and a small diameter inner rim, the second and third
skirts being positioned either with respective large diameter outer rims
disposed in juxtaposed relationship or with respective small diameter
inner rims disposed in juxtaposed relationship.

3. A sole construction as in claim 1 in which the sole bottom is
carried by the bottom end of the spring device and the sole bottom has
an outer rim which is spaced below the sole top.

4. A sole construction as in claim 3 which further comprises a flexible
protective shroud mounted between the outer rim and the sole top.

5. A sole construction as in claim 1 in which the heel portion has an
internal chamber, and the spring device is carried within the chamber.

6. A sole construction as in claim 5 in which the first mentioned
spring device has predetermined physical properties, the sole has an
aperture which opens into the chamber, the aperture being sized
sufficient to enable ingress and egress of the spring device into and from
the chamber, and further comprising an outsole portion which is
removably mounted within the aperture for enabling removal of the spring
device from the chamber and replacement with another spring device
having other physical properties which differ from said predetermined
physical properties.

7. A sole construction as in claim 1 in which the sole has an internal
cavity within the first and second annular frusto-conical skirts, together
with a support column mounted within the internal cavity, the support
column having an outer surface which is juxtaposed in supporting
relationship with the skirts.
8. A sole construction as in claim 1 in which the sole has an internal cavity within the first and second annular frusto-conical skirts, the sole bottom has an opening in register with the cavity, and a protective sheet is mounted on the sole bottom and spans across the opening.

9. A sole construction for use in an article of footwear to be worn on the foot of a user, the sole construction comprising: a sole having a forefoot portion which comprises a forefoot top and a forefoot bottom, the forefoot bottom extending generally along a footwear-bearing surface contact plane, the forefoot portion comprising a spring device, the spring device having a top end positioned adjacent the forefoot top and a bottom end, the spring device comprising first and second annular frusto-conical skirts which are disposed in end-to-end relationship along a longitudinal axis which extends generally upright with respect to the surface contact plane, each of the first and second skirts having a large diameter outer rim and a small diameter inner rim, the first and second skirts being positioned either with respective large diameter outer rims disposed in juxtaposed relationship or respective small diameter inner rims disposed in juxtaposed relationship, and the first and second skirts being formed of a material having an elasticity which is sufficient to enable the skirts to contract along the longitudinal axis from respective unloaded positions toward respective loaded positions responsive to a compression load from a user’s foot acting against the top end of the spring device while the skirts store elastic energy, the said elasticity further being sufficient to enable release of the elastic energy for causing the skirts to expand toward the unloaded positions responsive to a reduction in said compression load.
10. A sole construction as in claim 9 in which the forefoot bottom is mounted on the bottom end of the spring device and the forefoot bottom has an outer rim which is spaced below the forefoot top.

11. A sole construction as in claim 10 which further comprises a flexible protective shroud mounted between the outer rim and the forefoot top.

12. A sole construction as in claim 9 in which the forefoot portion has an internal chamber, and the spring device is carried within the chamber.

13. A sole construction as in claim 9 in which the sole has an internal cavity within the first and second annular frusto-conical skirts, the forefoot bottom has an opening in register with the cavity, and a protective sheet is mounted on the forefoot bottom and spans across the opening.

14. Footwear comprising the combination of a sole having a heel portion which comprises a heel top and a heel bottom, an upper mounted above the heel top, the heel portion comprising a spring device, the spring device comprising first and second annular frusto-conical skirts which are disposed in end-to-end relationship along a longitudinal axis which extends generally upright with respect to the surface contact plane, the first and second skirts having respective large diameter ends and small diameter ends, each of the first and second skirts having a large diameter outer rim and a small diameter inner rim, the first and second skirts being positioned either with respective large diameter outer rims disposed in juxtaposed relationship or respective small diameter inner rims disposed in juxtaposed relationship, and the first and second
13 skirts being formed of a material having an elasticity which is sufficient to
14 enable the skirts to contract along the longitudinal axis from respective
15 unloaded positions toward respective loaded positions responsive to a
16 compression load from a user's foot acting against the top end of the
17 spring device while the skirts store elastic energy, the said elasticity
18 further being sufficient to enable release of the elastic energy for causing
19 the skirts to expand toward the unloaded positions responsive to a
20 reduction in said compression load.

15. Footwear as in claim 14 in which the spring device further
16 comprises a third skirt which is disposed in end-to-end relationship with
17 the second skirt along the longitudinal axis, the third skirt having a large
18 diameter end and a small diameter end, the second and third skirts being
19 positioned either with respective large diameter ends in juxtaposed
20 relationship or with respective small diameter ends disposed in
21 juxtaposed relationship.

16. A sole construction as in claim 14 in which the heel bottom is
17 mounted on the bottom end of the spring device and the heel bottom has
18 an outer rim which is spaced below the heel top.

17. A sole construction as in claim 16 which further comprises a
18 flexible protective shroud mounted between the outer rim and heel top.

18. Footwear as in claim 14 in which the heel portion has an internal
19 chamber, and the spring device is carried within the chamber.

19. A sole construction as in claim 18 in which the first mentioned
20 spring device has predetermined physical properties, the sole has an
aperture which opens into the chamber, the aperture being sized sufficient to enable ingress and egress of the spring device into and from the chamber, and further comprising an outsole portion which is removably mounted within the aperture for enabling removal of the spring device from the chamber and replacement with another spring device having other physical properties which differ from said predetermined physical properties.

20. Footwear as in claim 14 in which the first and second annular frusto-conical skirts have inner rims which envelope an internal cavity, together with a support column mounted within the internal cavity, the support column having an outer surface which is juxtaposed in supporting relationship with the inner rims.

21. Footwear as in claim 14 in which the sole has an internal cavity within the first and second annular frusto-conical skirts, the sole bottom has an opening in register with the cavity, and a protective sheet is mounted on the sole bottom and spans across the opening.

22. Footwear comprising the combination of a sole having a forefoot portion which comprises a forefoot top and a forefoot bottom, an upper mounted above the heel top, the forefoot portion comprising a spring device, the spring device comprising first and second annular frusto-conical skirts which are disposed in end-to-end relationship along a longitudinal axis which extends generally upright with respect to the surface contact plane, each of the first and second skirts having a large diameter outer rim and a small diameter inner rim, the first and second skirts being positioned either with respective large diameter outer rims disposed in juxtaposed relationship or respective small diameter inner
rims disposed in juxtaposed relationship, and the first and second skirts
being formed of a material having an elasticity which is sufficient to
enable the skirts to contract along the longitudinal axis from respective
unloaded positions toward respective loaded positions responsive to a
compression load from a user's foot acting against the top end of the
spring device while the skirts store elastic energy, the said elasticity
further being sufficient to enable release of the elastic energy for causing
the skirts to expand toward the unloaded positions responsive to a
reduction in said compression load.

23. Footwear as in claim 22 in which the forefoot portion has an
internal chamber, and the spring device is carried within the chamber.

24. Footwear as in claim 22 in which the forefoot bottom is mounted
on the bottom end of the spring device and the forefoot bottom has an
outer rim which is spaced below the forefoot top.

25. Footwear as in claim 24 and further comprising a flexible shroud
mounted between the outer rim and the forefoot top.

26. Footwear as in claim 22 in which the sole has an internal cavity
within the first and second annular frusto-conical skirts, the forefoot
bottom has an opening in register with the cavity, and a protective sheet
is mounted on the forefoot bottom and spans across the opening.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
   IPC(6) : A43B 13/28, 13/18
   US CL : 36/27, 28, 38
   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)
U.S. : 36/27, 28, 38, 29, 37, 35B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>X</td>
<td>US 4,342,158 A (MCMAHON ET. AL.) 03 August 1982, see whole reference.</td>
<td>1-3, 5, 7, 14-16, 18, and 20</td>
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<td>4, 6, 8-13, 17, 19, and 21-26</td>
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<td>X</td>
<td>US 4,267,648 A (WEISZ) 19 May 1981, see whole reference.</td>
<td>1-3, 9, 10, 14-16, 22, and 24</td>
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<td>4-8, 11-13, 17-21, 23, 25, and 26</td>
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<td>US 5,651,196 A (HSIEH) 29 July 1997, see whole reference.</td>
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[X] Further documents are listed in the continuation of Box C.   [ ] See patent family annex.

Date of the actual completion of the international search   17 MAY 1998
Date of mailing of the international search report   9 JUN 1998

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Form PCT/ISA/210 (second sheet)(July 1992)*
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<td>US 819,449 A (OTTERSTEDT) 01 May 1906, see whole reference.</td>
<td>4, 11, 17, and 25</td>
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