

IMPROVED BLAST RESISTANT FOOTWEAR**Field of the Invention**

5 The present invention relates to the construction of footwear and, in particular, to a boot which is constructed to protect the foot from serious damage resulting from the impact of projectiles and explosions from anti-personnel mines.

Background Art

10 Anti-personnel mines which are designed to explode as a person steps on the mine represent a common and serious problem for any troops deployed either on a conventional battle field or involved in guerilla warfare.

The amount of explosive present in a mine will dictate whether the mine on exploding maims or kills the person triggering the mine. For those devices designed simply to maim, protective footwear can play a role in
15 lessening the likelihood of serious injury. Such footwear can also have a role in lessening the damage caused by the impact of projectiles such as bullets and shrapnel.

The present inventor has developed boots, and in particular boot soles, that can protect the foot of a person triggering an anti-personnel mine
20 containing reasonable quantities of explosive while still providing the wearer with sufficient toe-to-heel flexion in the boot to allow activities such as running, jumping and climbing (see Singapore Patent Application nos 9500037-8 and 9501007-0). It would be desirable to have a further improved boot that could protect the foot and lower leg of a wearer from
25 explosions produced by mines having larger quantities of explosive and from mines using high temperature explosives which can rip through boots of earlier designs.

Summary of the Invention

30 According to a first aspect, the present invention consists in footwear comprising a cocoon of blast-resistant material shaped to substantially surround a boot, the cocoon having a sole and an upper, the cocoon being connected to the boot or the leg of the wearer of the boot.

The sole of the cocoon may be comprised of rubber or polyurethane and have embedded therein at least one further layer of woven aramid fibre. The cocoon is preferably attached to the boot by straps extending from the cocoon around the upper portion of the boot.

5 According to a further aspect, the present invention consists in a boot for a foot of a wearer, the boot having a sole and an upper, the sole having at least one woven aramid layer embedded through the sole, the boot being characterised in that a cocoon of blast-resistant material is incorporated into the boot such that it would substantially surround the entire foot of a wearer
10 of the boot.

 In a preferred embodiment of both aspects the cocoon comprises at least one sheet of blast-resistant material. The blast-resistant material can be comprised of an aramid weave comprising at least one-ply of at least 1000 dtex aramid (eg Twaron® 2010). It can be composed of woven 1200 dtex
15 aramid such as Twaron® 2040 having a 460 g/m² tight plain weave. The cocoon can comprise or include a layer of woven ceramic fibre or ceramic/glass-ceramic woven composite fibre.

 The cocoon in the second aspect is preferably shaped in the form of a "bootee" that can be embedded in the sole and upper of the boot.

20 The aramid weaves comprising the protective layer in the cocoon can be incorporated into a sandwich of layers including layers of woven ceramic fibres or a separate ceramic/glass-ceramic composite woven fibre to further increase the strength of the cocoon when exposed to high temperatures. A layer of woven ceramic fibres can comprise the outermost layer of the
25 cocoon.

 The sole of the boot is preferably comprised of at least an outer portion and an intermediate portion. The outer sole can be comprised of rubber or polyurethane moulded to suit the requirements of the boot. The portion of the cocoon extending through the sole preferably is positioned
30 between the outer portion and the at least one woven aramid layer embedded in the sole.

 The intermediate portion preferably has a plurality of layers of woven aramid embedded within it. In one embodiment, the woven aramid layers can

have carbon graphite fibres either interwoven with or between the aramid layers to further strengthen the sole. In a preferred embodiment, there are 24 layers of aramid, carbon and ceramic woven fibres (eg Toray,[®]/8HR,[®] M60/M80 6K/12K TOW plain weave, the density of which ranges from
5 300g/m² to 600g/m²).

The intermediate portion of the sole can also include a deflection plate running along the sole from the toe to the heel. The deflector plate preferably has a first side directed towards the outer portion, this side having an angled surface designed to deflect the effect of an explosive blast away
10 from the foot. The deflector plate can be comprised of a composite aramid fibres and carbon fibres embedded in an adhesive/polymer. The ratio of aramid to carbon fibres in the composite is preferably 50:50 with the strands of the fibres being approximately 85% unidirectional along the toe-to-heel axis of the boot.

15 The sole can include an upper portion which comes into contact with the foot of the wearer. The upper portion can be fabricated from chopped aramid and nylon fibre board. In another embodiment, the upper portion can comprise at least four layers of woven aramid adhered with adhesive/polymer such as nylon.

20 The boot upper is preferably fabricated from leather and can have an outer leather layer and an inner vamp layer of leather or cotton between which the portion of the cocoon extending through the upper is positioned.

Stitching can be used to retain the layers constituting the cocoon in place in the footwear. The stitching is preferably comprised of woven aramid
25 yarn. To ensure adequate strength is provided by the stitching, further layers of woven aramid fibres (such as Twaron[®]2040) can be inserted in the intermediate portion of the sole. Preferably, a layer of aramid fibres is present above and below the at least one woven aramid layer in the intermediate portion, with the additional layers extending at least partially into
30 the upper of the boot.

The boot is preferably shaped so as to enclose at least the ankle of a wearer thus affording a level of protection for the ankle and the lower portion of the leg.

Brief Description of the Drawings

Hereinafter given by way of example only, preferred embodiments of the invention are described with reference to the accompanying drawings, in which:

5 Figure 1 is a vertical cross-sectional view of the boot according to the present invention;

 Figure 1A is a vertical cross-sectional view of the cocoon present in the boot depicted in Figure 1;

 Figure 2 is an enlarged and simplified cross-sectional view of the mid-
10 boot region along line II-II of the boot depicted in Figure 1; and

 Figure 3 is a vertical cross-sectional view of an alternative embodiment of a cocoon that surrounds a boot.

Description of the Preferred Embodiment

 A boot having the features of a preferred embodiment of the present
15 invention is generally depicted as 10 in Figures 1 and 2. The boot 10 has a standard shaped upper 11 adapted to enclose at least the foot and ankle of a wearer, a composite sole 12 and a cocoon of blast-resistant material 13 in the shape of a bootee (see Fig. 1A).

 As is depicted in Figures 1 and 2, the blast-resistant layers 18 and 19
20 can extend throughout the entire upper 11 by including layers 18 and 19 between the outer leather layer 25 and the inner vamp leather layer 26 in the upper quarter of the upper 11. These layers can be connected to the layers in the bootee portion 13 by appropriate stitching 30.

 The composite sole comprises an outer polyurethane sole 14 having a
25 tread 17, an intermediate sole portion 15 and an upper sole portion 16.

 The cocoon 13 consists of at least one layer of ceramic or ceramic/glass-ceramic woven composite fibre making up the outer cocoon 19
and at least one layer of aramid weave 18. The aramid weave 18, in this
embodiment, comprises at least one-ply of at least 1000 dtex aramid having
30 a satin or plain weave (eg Twaron® 2010). The layers 18 and 19 surround the foot of a wearer of the boot 10 and once placed in the boot 10 are embedded in the upper boot portion 11 and between the outer sole 14 and the intermediate sole 15.

To improve the blast resistance of the sole 12, the intermediate sole 15 has a plurality of layers of woven aramid fibre 21 and carbon fibre 22 embedded in the polyurethane. A deflector plate 23 also extends from the toe to the heel of the sole 12 and further serves to strengthen the sole 12.

5 The deflector plate 23 has an angled lower surface 24, the angle of the surface 24 being adapted to deflect the effect of an explosive blast away from the foot of a wearer of the boot 10. The deflector plate 23 is comprised of a composite 50:50 woven aramid fibre and carbon fibre embedded in adhesive/polymer.

10 The boot upper 11 is fabricated from an outer leather layer 25 and an inner vamp leather layer 26. The cocoon 13 is supported between the layers 25 and 26.

To hold the various layers together, stitching 27 through the side of the boot can be employed as depicted in the drawings. The stitching 27 can be comprised of woven aramid fibres (eg. 420 dtex aramid) and/or polyester. 15 To improve the strength of the stitching, two further layers 28 and 29 of aramid fibres are inserted in the intermediate portion 15 of the sole and extend into the upper 11 as depicted in Figure 2.

A boot having the features described above will be effective in 20 providing protection from explosions of anti-personnel mines containing at least 60 grams and possibly 80 grams of pressed compound B explosive.

An alternative embodiment of the invention is depicted in Figure 3. In this embodiment, the standard army boot 40, having a sole 46, is surrounded by an outer cocoon 41 into which the boot 40 has been placed. The cocoon 25 has the features of the cocoon 13 described above except rather than fitting within the boot, the cocoon 41 surrounds the boot and provides a quick and relatively inexpensive means of improving the blast-resistance of standard army boots. In the embodiment of the cocoon depicted in Figure 3, the cocoon 41 has a sole 42 and an upper 43, the upper having an inner surface 30 47 and an outer surface 48. Embedded within the sole 42 and upper 43 is at least one layer of ceramic or glass-ceramic fibre 45 and a layer of woven aramid weave 44. If desired, the sole 42 can have a plurality of layers of woven aramid fibre, preferably 4 layers, together with polymers, such as

nylon and/or carbon fibre embedded therein. A deflector plate, as described above, could also be incorporated into the sole 42.

5 The cocoon 41 could be strapped to the boot 40 by straps 49 as depicted in Figure 3. Alternative means of attachment could be employed as desired.

10 It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

**CLAIMS**

1. An article of footwear comprising a cocoon of blast-resistant material shaped to substantially or entirely surround a boot, the cocoon having a sole and an upper, the cocoon being connected to the boot or the leg of the wearer of the boot.
2. The article of footwear of claim 1 wherein the blast-resistant material comprises an aramid weave comprising at least one-ply of at least 1000 dtex aramid and/or a layer of ceramic fibre or ceramic/glass-ceramic woven composite fibre.
3. The article of footwear of claims 1 or 2 wherein the aramid fibres are incorporated into a sandwich of layers of woven ceramic fibres or ceramic/glass-ceramic woven composite fibres.
4. The article of footwear of any one of the preceding claims wherein the sole is comprised of rubber or polyurethane and has embedded therein at least one further layer of woven aramid fibre.
5. The article of footwear of claim 4 wherein carbon graphite fibres are sandwiched between the woven aramid fibre layers.
6. The article of footwear of any one of the preceding claims wherein the cocoon is attached to the boot by straps extending between the cocoon and the boot.
7. A boot for a foot of a wearer, the boot having a sole and an upper, the sole having at least one woven aramid layer embedded through the sole, the boot being characterised in that a cocoon of blast-resistant material is incorporated into the boot such that it would substantially or entirely surround the foot of a wearer of the boot.
8. The boot of claim 7 wherein the cocoon comprises at least one sheet of blast-resistant material which is embedded in the sole and at least a portion of the upper of the boot.
9. The boot of claims 7 or 8 wherein the blast-resistant material is composed of an aramid weave comprising at least one-ply of at least 1000 dtex aramid.



10. The boot of any one of claims 7 to 9 wherein the aramid fibres comprising the blast-resistant material are incorporated into a sandwich of layers of woven ceramic fibres or ceramic/glass-ceramic woven composite fibres to further increase the strength of the cocoon.
- 5 11. The boot of any one of claims 7 to 10 wherein the sole is comprised of an outer portion and an intermediate portion.
12. The boot of claim 11 wherein the outer sole is comprised of rubber or polyurethane.
13. The boot of claims 11 or 12 wherein the cocoon extends through the
10 sole between the outer portion and the at least one woven aramid layer embedded in the sole.
14. The boot of any one of claims 11 to 13 wherein the intermediate and/or upper portion has a plurality of layers of woven aramid embedded therein.
- 15 15. The boot of claim 14 wherein carbon graphite fibres are sandwiched between the woven aramid fibre layers.
16. The boot of any one of claims 7 to 15 wherein the sole includes a deflector plate.
17. The boot of claim 16 wherein the deflector plate is in the intermediate
20 portion of the sole.
18. The boot of claims 16 or 17 wherein the deflector plate has a first side directed towards the outer portion, the first side having an angled surface to deflect the effect of an explosive blast away from the foot of a wearer.
- 25 19. The boot of any one of claims 16 to 18 wherein the deflector plate is comprised of a composite of woven aramid and carbon fibres embedded in an adhesive/polymer.
20. The boot of claim 19 wherein the ratio of woven aramid to carbon fibres is 50:50.
- 30 21. The boot according to any one of claims 7 to 20 wherein the boot upper is fabricated from an outer leather layer and an inner vamp layer of leather or cotton between which the portion of the cocoon extending through the upper is positioned.

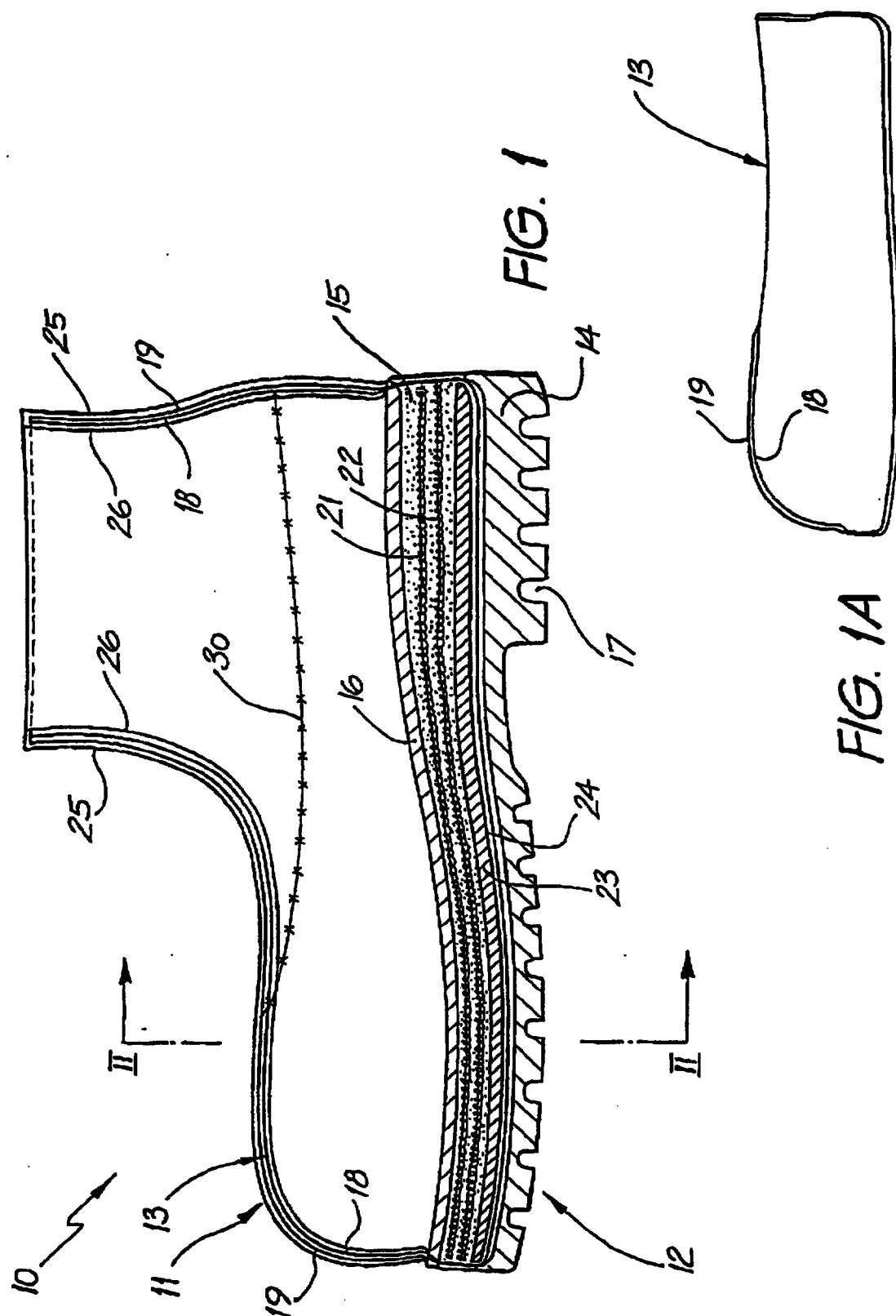


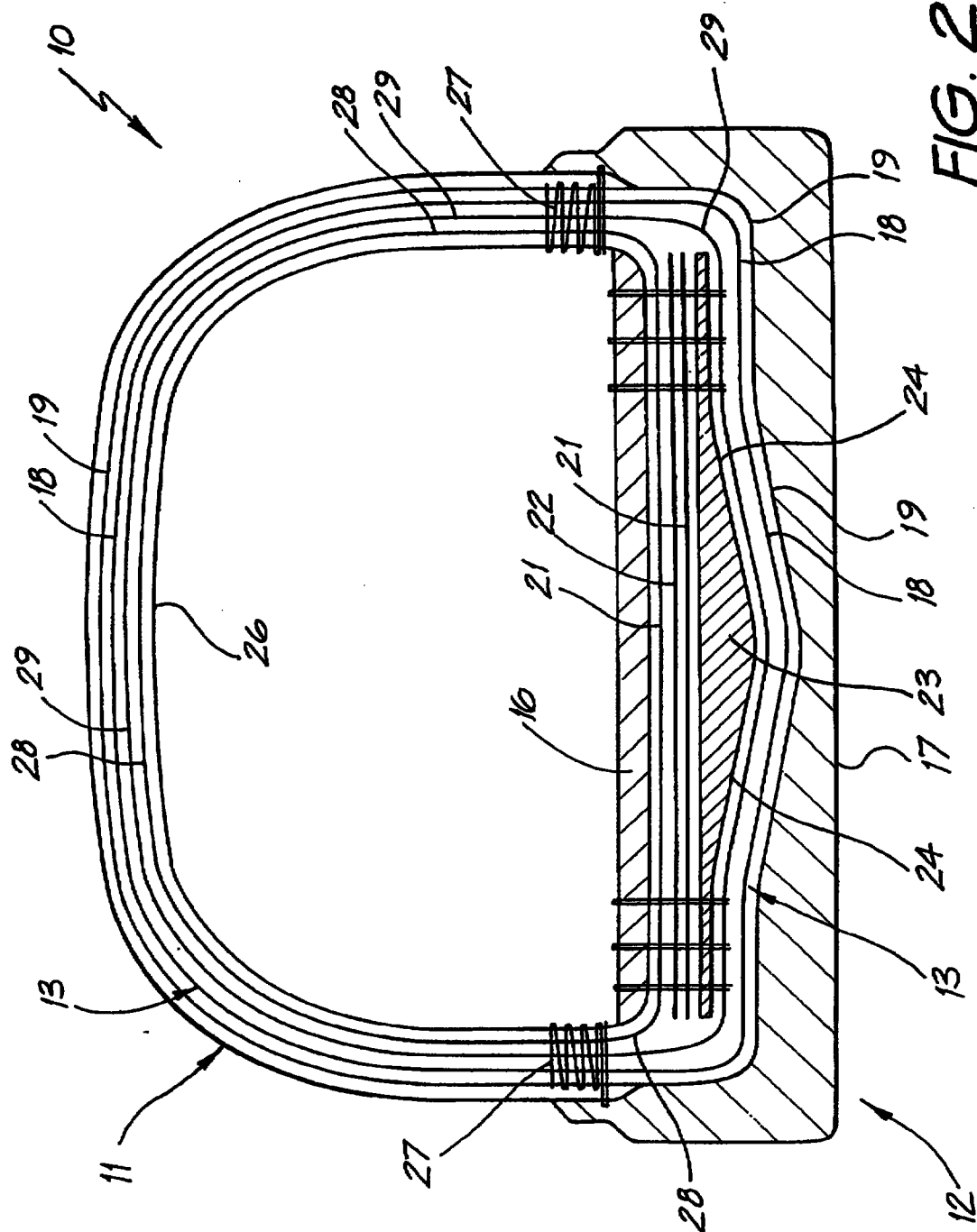
22. The boot according to any one of claims 7 to 21 wherein the layers are held together by stitching.

23. The boot of claim 22 wherein the stitching is comprised of woven aramid yarn.

5 24. The boot according to claims 22 or 23 wherein two further layers of woven aramid fibre are present in the intermediate portion of the sole and extend at least partially into the upper of the boot.

25. The boot according to claim 23 wherein one layer of woven aramid fibre is positioned above the at least one woven aramid layer present in the
10 intermediate portion of the sole and one layer is positioned below.





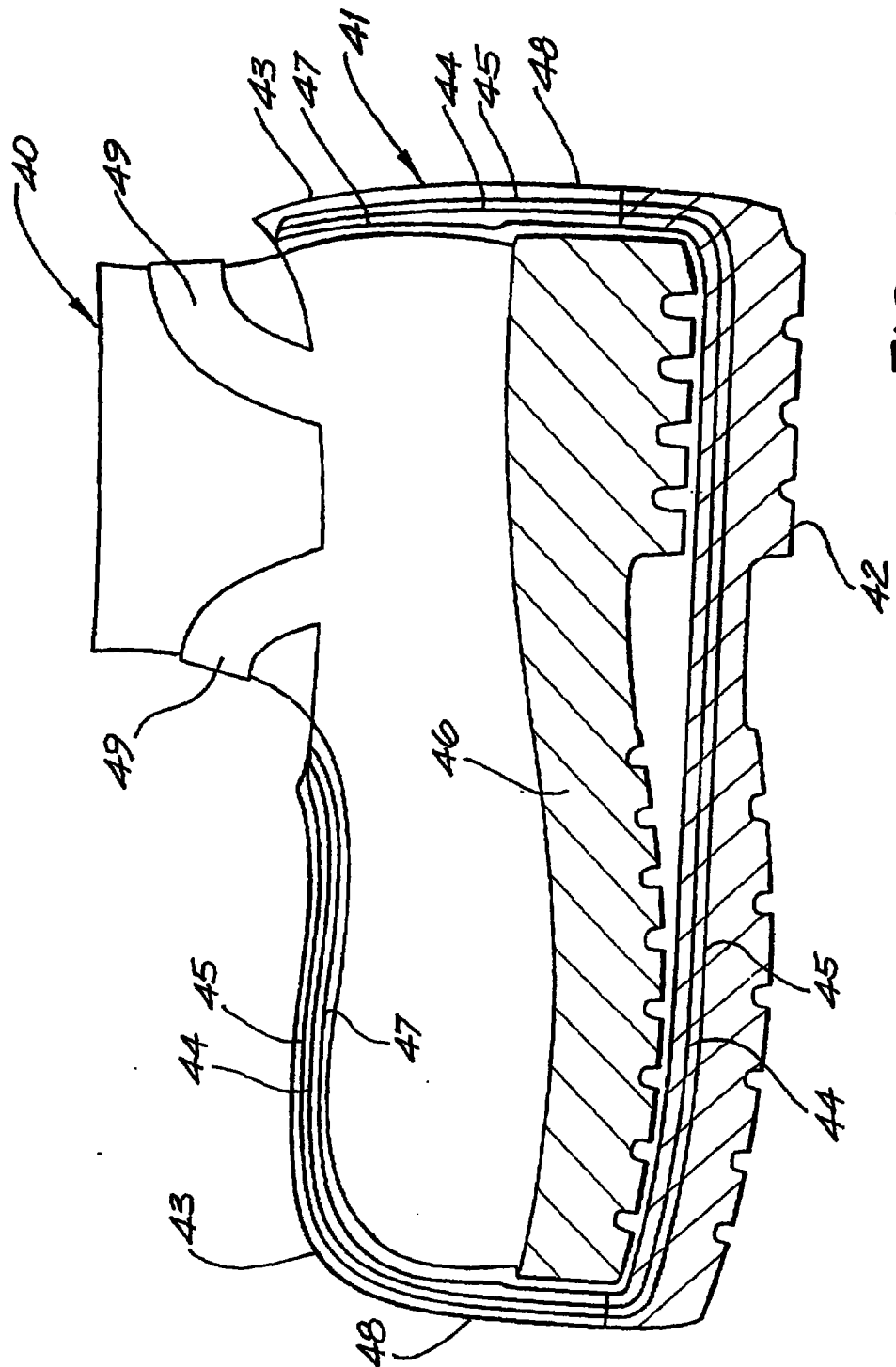


FIG. 3

PCT

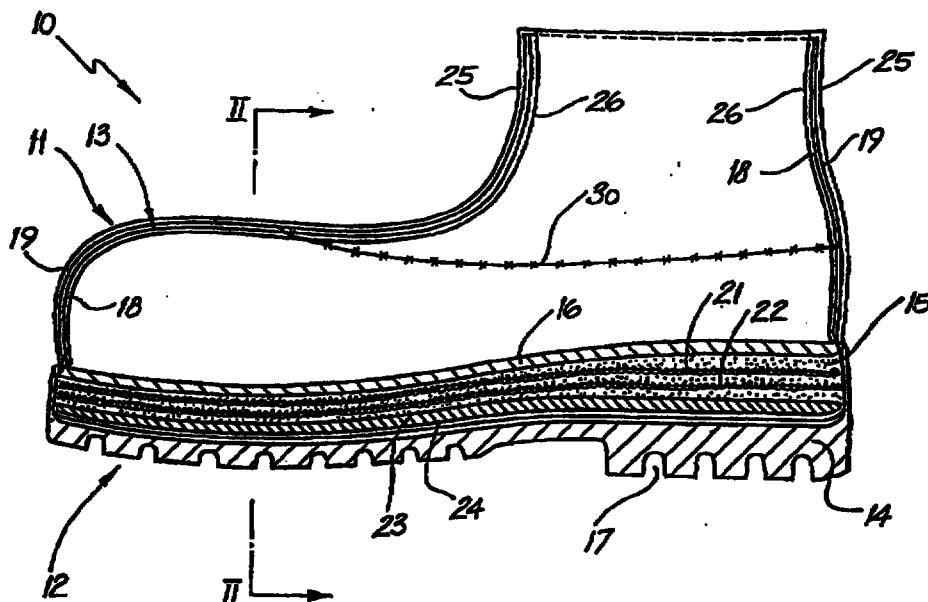
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(54) Title: **IMPROVED BLAST RESISTANT FOOTWEAR**



(57) Abstract

A boot (10) adapted to provide an improved level of protection against explosive blasts is described. In one embodiment, the boot has a sole (12), an upper (11) and a cocoon (13) portion which substantially encloses the foot. The cocoon can be comprised of an aramid weave (21), and/or, a further layer of carbon fibre (22) and/or woven ceramic fibres or ceramic/glass-ceramic woven composite fibres. The sole can incorporate layers of woven aramid and carbon fibres and a deflector plate (23) to provide enhanced protection. In an alternative embodiment, the cocoon can surround the boot and provide a quick and relatively inexpensive means of improving the blast protection to a wearer.