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(54) Title: SOLE

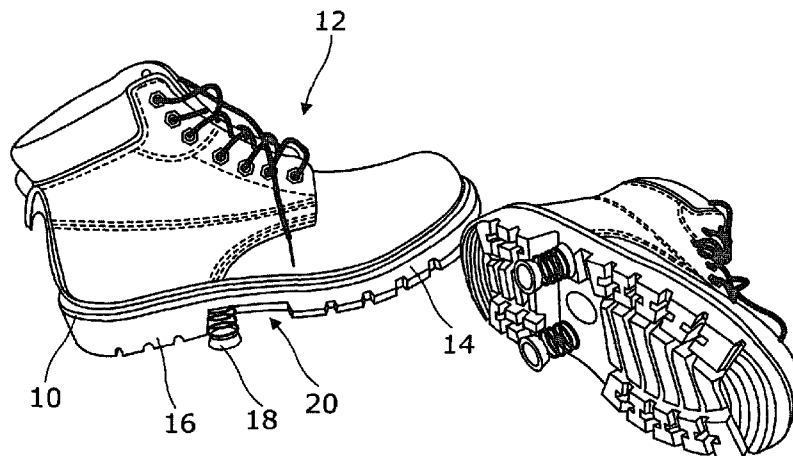


Figure 1

(57) Abstract: The disclosure relates to a sole (10) for an item of footwear (12), comprising: a toe portion (14); a heel portion (16); and a kinetic energy absorbing member (18) situated between heel and toe portions and having an extended position in which the kinetic energy absorbing member protrudes further from the sole than the heel portion and a retracted position in which the kinetic energy absorbing member protrudes no further from the sole than the heel portion.



## Sole

The invention relates to a sole for an item of footwear such as a boot or a shoe.

5 The mechanical principles underlying economical walking require mechanical energy to be lost at the beginning of each stance (or step). In humans, the foot geometry and vaulting motions during walking suggest that the anterior tibialis and associated connective tissues (AT+) act primarily to resist plantar flexion and to dissipate energy. However, muscles and their surrounding structures involved in resisting plantar flexion of the foot  
10 (principally the anterior tibialis) can be damaged during a range of common activities. Normal use in walking can then be inhibited due to pain.

A problem with prior art footwear is that the load placed on the user's anatomy is not, in some cases, suitably alleviated. It would therefore be advantageous to reduce the loading  
15 on such tissues during walking without altering the basic mechanics of the walking gait.

According to a first aspect of the invention there is provided a sole for an item of footwear, comprising:

20 a toe portion;  
a heel portion; and  
a kinetic energy absorbing member situated between heel and toe portions and having an extended position in which the kinetic energy absorbing member protrudes further from the sole than the heel portion and a retracted position in which the kinetic energy absorbing member protrudes no further from the sole than the heel portion.

25 The provision of the kinetic energy absorbing member and its location on the sole enables energy to be absorbed during a walking step and so potential stress on the user's anatomy is alleviated. In some examples, the user's walking gait may be unaffected by the action of the kinetic energy absorbing member. The terms 'step' and 'stride' may be used herein  
30 to refer to a user's stance.

The sole may comprise a plurality of kinetic energy absorbing members. The heel and toe portions may be more rigid than the kinetic energy absorbing member. The kinetic energy absorbing member may be provided at least partially in a recess in the sole. The kinetic  
35 energy absorbing member may be elastic or resilient. The kinetic energy absorbing member may comprise a spring.

The kinetic energy absorbing member may be a shock absorber. The kinetic energy absorbing member may be configured to dissipate absorbed energy as heat. The kinetic energy absorbing member may comprise a dashpot.

- 5 The toe portion may be configured to be level with the heel portion during a midstance of the user.

The sole may comprise a catch for selectably (or selectively) locking the kinetic energy absorbing member in the retracted position. The catch may have: an open position in  
10 which the kinetic energy absorbing mechanism is free to move between the retracted position and the extended position; and a closed position in which the kinetic energy absorbing member is locked in the retracted position. The catch may be configured such that the user is able to select whether the catch is in the open position or the closed position.

15

The kinetic energy absorbing member may protrude between 10 mm and 40 mm further from the sole than the heel portion in the extended position. Preferably, the kinetic energy absorbing member protrudes 20 mm further from the sole than the heel portion in the extended position. The kinetic energy absorbing member may be configured to absorb  
20 between 5 J and 50 J per step. The kinetic energy absorbing member may be configured to transition between the extended position and the retracted position within 0.08 s and 0.12 s. Preferably, the kinetic energy absorbing member is configured to transition between the extended position and the retracted position in 0.1 s.

- 25 According to a further aspect of the invention there is provided an item of footwear comprising a sole according to the first aspect of the invention and described above. The item of footwear may be a shoe or boot, for example. A training shoe is an example of a shoe.

- 30 One or more embodiments of the invention will now be described, by way of example only, and with reference to the accompanying figures in which:

Figure 1 illustrates items of footwear that each comprise a sole with a kinetic energy absorbing member situated between heel and toe portions;

- Figures 2a to 2c illustrate catch mechanisms for retaining a kinetic energy  
35 absorbing member in a retracted position; and

Figure 3 illustrates configurations of a sole at a range of stages in a user's step, or stance.

Unlike muscle, passive engineered devices are capable of repeatedly absorbing considerable energy at high rates in simple structures of lightweight, low-volume materials. The arrangement of the sole in figure 1 enables energy from a user's step to be absorbed and, optionally, returned in a subsequent phase of the step.

Figure 1 illustrates items of footwear 12 that each comprise a sole 10 with two kinetic energy absorbing members 18 that are situated between a toe portion 14 and a heel portion 16 of the respective sole 10. Providing a plurality of kinetic energy absorbing (KEA) members 18 across the breadth of the sole 10 improves the balance of the sole compared to the case where a single KEA member 18 is provided by the sole 10.

The KEA members 18 each have an extended position in which the respective KEA member 18 protrudes further from the sole 10 than the heel portion 16. Each KEA member 18 also has a retracted (or compressed) position in which the KEA member 18 protrudes no further from the sole 10 than the heel portion 16. The KEA member 18 is configured to be deflected, or actuated, from the extended position into the contracted position when a user steps on the KEA member 18 in an early part of his stance (or step).

The members 18 are provided at least partially in a recess 20 in the sole 10. In the retracted position, the members 18 may be completely within the recess 20. Each KEA member 18 is typically level, or co-planar, with the heel portion 16 in the retracted position. After an absorbing deflection, contact between the heel portion 16 of the sole and the ground provides an 'end stop' to the deflection of the KEA member 18.

The KEA members 18 are situated near a mid-portion of the sole 10 between the toe portion 14 and the heel portion 16. The members 18 may be considered to be provided at a waist of the shoe 12, which is an area where stirrups may normally be attached to the shoe 12. The positioning of the members 18 is such that in the retracted position the members 18 are in compression axially, or in line, with a user's leg.

The provision of the kinetic energy absorbing members 18 and their location on the sole 10 enables energy to be absorbed during a walking step so that potential stress on the user's anatomy is alleviated. The primary aim of the KEA member 18 is to absorb energy – by load reduction – that would otherwise be absorbed by the anterior tibialis and associated connective tissues (AT+). The deflection of the KEA member 18 during a step is discussed in further detail with regard to figure 3, below.

In contrast to some known spring-boots, the kinetic energy absorbing KEA members 18:

- 1) are situated near-underneath (or forward of) the ankle, and
- 2) have a limited compressibility, with a defined 'end-stop' position due to heel and sole contact when the foot is flat on the floor during the vaulting phase of stance.

The location of the members is arranged to reduce the energy input to the anterior tibialis and associated connective tissues (AT+) through reduction in muscle tension (due to moving the centre of pressure forwards, thus shortening the moment arm of the ground reaction force about the ankle) rather than through reduction in AT+ stress (which would be the case with an absorber positioned at the heel 16).

The limited compressibility of the members 18 allows normal 'vaulting' walking mechanics to be maintained, at least up to moderate walking speeds. In contrast, known leaf-spring shoes or 'jumping stilt' designs may require the user to adopt a bouncing 'running-like' gait, even at low speeds, and so can make the user feel unstable and tired.

The heel and toe portions 14, 16 are typically provided by a rubber or plastics material that is more rigid than the kinetic energy absorbing members 18. The kinetic energy absorbing members 18 can be provided by an elastic and/or resilient material such as the spring shown in figure 1, or alternatively by an energy dissipating absorber such as a shock absorber. Both resilient and dissipative KEA members 18 can reduce loading on the user's tibialis anterior (shin) muscles.

One advantage of the use of springs is that they are a cheap option for implementing the KEA members 18. Another advantage of the use of springs, or any other resilient KEA member 18, is that energy can be returned to the user's step as well as simply absorbed. The absorbed energy may be returned later in the user's step in order to power a toe-push stage of late stance, for example. The extent of deflection, energy absorption and compressed length of the springs can be selected according to a user's weight and intended walking speed.

As an alternative to using a resilient kinetic energy absorbing member 18, the KEA member 18 may be provided by a shock absorber. Shock absorbers typically resist an applied force in proportion to a velocity of a deflection caused by the applied force, rather than the extent of the deflection. The shock absorber may be configured to dissipate absorbed energy as heat. A general purpose dashpot or Ace Controls Shock Absorber

MA 150EUM-B are examples of suitable shock absorbing mechanisms for use as the KEA member 18. Where a shock absorbers' bodies are longer than the height of the sole 10, the shock absorbers can be mounted on the sides of the sole 10 and extend upwards (away from the sole on its inner side) in parallel with the legs of the user.

5

Figures 2a to 2c illustrate catch mechanisms for retaining a kinetic energy absorbing member 18 in a retracted position. Any suitable structure for selectably locking the kinetic energy absorbing member 18 in the retracted position can be used as a catch.

10 The catch mechanism in figure 2a comprises a first catch member 22 provided on a side of a shoe 30 (although the first catch member 22 could also be provided on a side of sole 10 of the shoe 30) and a second catch member 24 extending from a peripheral end of a kinetic energy absorbing member 18. A band 26 retains the first catch member 22 in place with the second catch member 24. This catch may be suitable for securing the KEA  
15 member 18 in a retracted position when the user is running or walking on soft ground, for example.

Figure 2b shows a shoe 40 with a deflectable cover or flap 28 pivotally connected to the toe portion 14. A free end of the flap 28 is in contact with a kinetic energy absorbing  
20 member 18 such that the flap 28 is flush with a peripheral surface of the heel 10 of the shoe 40 when the KEA member 18 is in a retracted position. The flap 28 extends tangentially to the toe portion 14 of the shoe 40 when the KEA member 18 is in the extended position, as illustrated in figure 2b.

25 Figure 2c illustrates a catch mechanism retaining the flap 28 of figure 2b in the retracted position. The catch mechanism comprises a first catch member 22 provided on a side of a shoe 50 (although the first catch member 22 could also be provided on a side of the sole 10 of the shoe 50) and a second catch member 24 extending from a side of the flap 28. A band 26 retains the first catch member 22 in place with the second catch member 24. This  
30 catch may be suitable for securing the KEA member 18 in the retracted position and so reduce the likelihood of a user tripping when scuffing the shoe 40.

A number of other embodiments of the invention are also envisaged. The KEA member 18 may be fully retained inside a structure that prevents lateral movement of the member.  
35 A base may be provided on the peripheral end of the KEA member 18 to provide an improved grip on the ground. The base may prevent wear and allow use on moderately compliant surfaces, such as short grass. The kinetic energy absorbing member 18 may

be interchangeable or tuneable so that its properties can be easily adapted for a particular user's load and intended use (including walking speed).

Figure 3 illustrates configurations of a sole 10 similar to those described with reference to figures 1 and 2 at three stages in a user's step: early stance 62, vaulting period 64 and late stance 66.

The early stance 62 is characterised by a user placing his foot on the ground heel-first. During the early stance 62, energy is absorbed by deflection of the kinetic energy absorbing member 18 due to the interaction between the sole 10 and the ground 70. This deflection can occur over approximately 0.1 seconds, independent of the size of the member 18. That is, the KEA member 18 is configured to transition between the extended position and the retracted position in 0.1 s. In practice, the KEA member is configured to transition between the extended position and the retracted position within 0.08 s and 0.12 s. The impulse period for a resilient KEA member 18 implemented using a spring may be largely insensitive to the spring construction. However, a KEA member implemented as a dashpot, or other shock absorber, may have an adjustable impulse period and so the interval over which deflection occurs may be varied depending on attributes of the user, such as his height, weight and desired level of energy absorption.

The deflection of the kinetic energy absorbing member can allow for a normal heel-to-sole early stance plantar flexion motion. For an adult (with a leg length of 1 m) with an absorber placed under the ankle, this would require a maximum deflection of approximately 20 mm. Therefore the kinetic energy absorbing member preferably protrudes 20 mm further from the sole than the heel portion in the extended position. In practice, the kinetic energy absorbing member protrudes between 10 mm and 40 mm further from the sole than the heel portion in the extended position. The energy and deflection calculations can be used to inform the spring specification.

For a moderately tall user with a leg length of 1 m walking normally at a moderate speed of 1.6 m/s, the energy absorbed by the KEA member 18 may be up to 0.25 Joules per step per kilogram of the user's mass. This level of energy absorption is towards the upper end of the acceptable range and a half of this value may be a sensible value. In practice, the kinetic energy absorbing member may be configured to absorb between 5 J and 50 J per step.

An important advantage of the sole 10 is that loading of the anterior tibialis and associated connective tissues (AT+) is reduced during plantar flexion in the early stance 62. The reduced loading can be demonstrated through inverse dynamics, ultrasound and electromyography intensity studies, for example. Reduction in loading alleviates AT+  
5 soreness in healthy subjects after walking, and in particular rapid downhill and/or loaded walking. The soles 10 may also provide a reduction in perceived AT+ soreness and improved comfort during downhill walking.

Following the early stance is a vaulting period 64 of the stance, or midstance, in which the  
10 kinetic energy absorbing member 18 is deflected into the retracted position. The toe portion 14 may be flat, or level, with the heel portion 16 during the vaulting period 64. In order for the toe portion 14 to be level with the heel portion 16, the toe portion 14 may be co-planar with the heel portion 16. Both the toe portion 14 and the heel portion 16 are in contact with the ground. In the vaulting period 64, the kinetic energy absorbing member  
15 18 neither absorbs nor returns energy from the interaction between the sole 10 and the ground.

Following the midstance is the late stance 66. In the late stance 66 the user pulls on his calf muscles. The calf muscles pull up on the heel, levering down on the balls of the toes,  
20 thereby lifting the ankle (and the user's body).. Deflection of the kinetic energy absorbing member from the retracted position into the extended position may occur over a 0.1 s interval when the user pushes off from the ground.

Where the KEA member 18 is provided as a resilient KEA member 18, energy may be  
25 returned to the user's step during this phase of the stance by the KEA member 18 recoiling. The recoil energy may further reduce stress on the user and ease his step.

The basic vaulting mechanics of walking are maintained by the sole 10 in that:

- midstance forces match those of stiff-limbed vaulting models.
- 30 - kinetic and potential energy fluctuations reflect passive vaulting motions.
- ground reaction forces show the expected 'crash, vault, shove' profile during the stance.

**Claims**

1. A sole for an item of footwear, comprising:  
a toe portion;  
5 a heel portion; and  
a kinetic energy absorbing member situated between heel and toe portions and having an extended position in which the kinetic energy absorbing member protrudes further from the sole than the heel portion and a retracted position in which the kinetic energy absorbing member protrudes no further from the sole than the heel portion.  
10
2. The sole of claim 1 wherein sole comprises a plurality of kinetic energy absorbing members.
3. The sole of claims 1 or claim 2 wherein the heel and toe portions are more rigid  
15 than the kinetic energy absorbing member.
4. The sole of any of claims 1, 2 or 3 wherein the kinetic energy absorbing member is provided at least partially in a recess in the sole.
- 20 5. The sole of any of claims 1, 2, 3 or 4 wherein the kinetic energy absorbing member is elastic or resilient.
6. The sole of claim 5 wherein the kinetic energy absorbing member comprises a spring.  
25
7. The sole of any of claims 1, 2, 3 or 4 wherein the kinetic energy absorbing member is a shock absorber
8. The sole of claim 7 wherein the kinetic energy absorbing member comprises a  
30 dashpot.
9. The sole of any preceding claim wherein the toe portion is configured to be level with the heel portion during a midstance of the user.
- 35 10. The sole of any preceding claim comprising a catch for selectably locking the kinetic energy absorbing member in the retracted position.

11. The sole of any preceding claim wherein the kinetic energy absorbing member protrudes between 10 mm and 40 mm further from the sole than the heel portion in the extended position.
- 5 12. The sole of any preceding claim wherein the kinetic energy absorbing member is configured to absorb between 5 J and 50 J per step.
13. The sole of any preceding claim wherein the kinetic energy absorbing member is configured to transition between the extended position and the retracted position within  
10 0.08 s and 0.12 s.
14. An item of footwear comprising the sole of any preceding claim.
15. A sole substantially as described herein with reference to the accompanying  
15 drawings.
16. An item of footwear substantially as described herein with reference to the accompanying drawings.

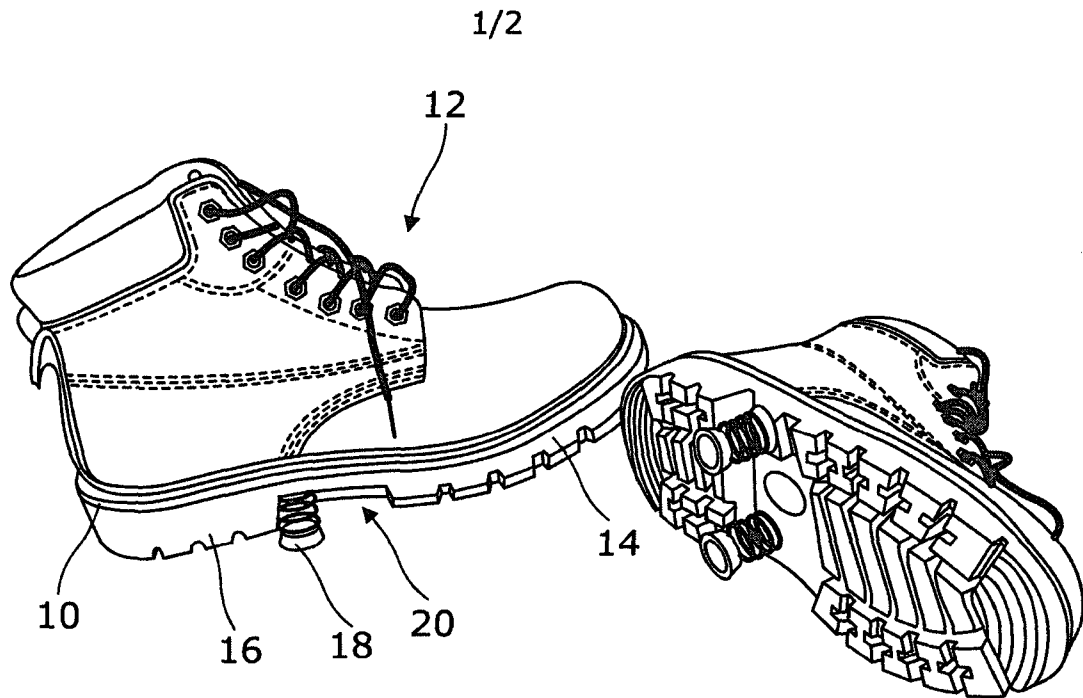


Figure 1

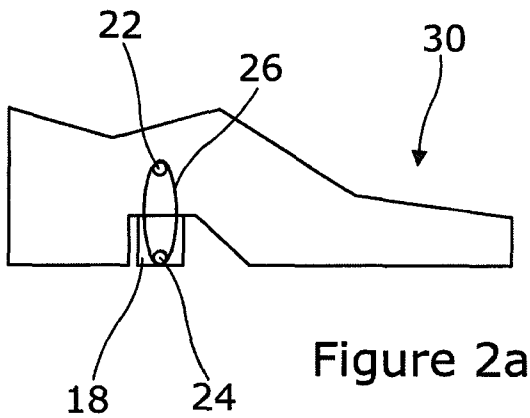


Figure 2a

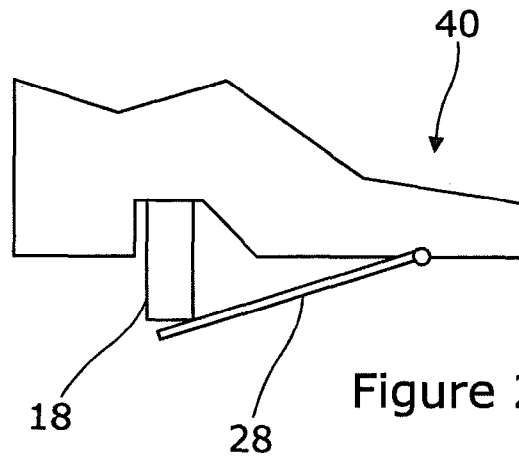


Figure 2b

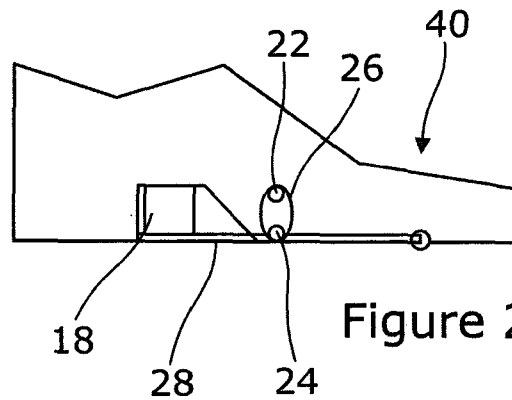


Figure 2c



INTERNATIONAL SEARCH REPORT

International application No  
PCT/GB2015/051468

A. CLASSIFICATION OF SUBJECT MATTER  
INV. A43B13/18 A43B5/06  
ADD. A43B7/14

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)  
A43B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 577 119 A1 (TECHNISYNTHESE) 14 August 1986 (1986-08-14) the whole document	1-9, 11-14
X	FR 873 618 A (LACOSTE) 15 July 1942 (1942-07-15) the whole document	1-7,9, 11-14
X	DE 10 2004 033611 A1 (SCHUHMAN) 16 February 2006 (2006-02-16) the whole document	1,3-14
X	US 898 951 A (ZOOBOAVCH) 15 September 1908 (1908-09-15) page 1, lines 9-93; figures 1-7	1-7,9-14
	-/--	

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 application or patent but published on or after the international filing date
- "L" 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  13 August 2015	Date of mailing of the international search report  24/08/2015
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Williams, Mark

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/GB2015/051468

## Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been 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.  Claims Nos.: 15, 16  
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:  
see FURTHER INFORMATION sheet PCT/ISA/210
  
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 No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

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

1.  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 fees, this Authority did not invite payment of additional fees.
  
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 and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/GB2015/051468

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 34 15 705 A1 (SCHUSTER) 31 October 1985 (1985-10-31) page 5, line 1 - page 7, line 8; figures 1-4	1-7,9, 11-14
X	----- US 250 108 A (STEWART) 29 November 1881 (1881-11-29) the whole document -----	1,3,5-7, 9,11-14

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2015/051468

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 2577119	A1	14-08-1986	NONE
FR 873618	A	15-07-1942	NONE
DE 102004033611	A1	16-02-2006	NONE
US 898951	A	15-09-1908	NONE
DE 3415705	A1	31-10-1985	NONE
US 250108	A	29-11-1881	NONE

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

Continuation of Box II.2

Claims Nos.: 15, 16

Rule 6.2(a) PCT

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.