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(54) Title: ADAPTABLE SHOE

(57) Abstract: The disclosed subject matter at-least illustrates an apparatus in a footwear (100) for selectively adapting at least a portion of footwear's sole (102). The apparatus comprises a control-system (300) for selecting a sole-face from amongst a plurality of sole-faces (108); and an actuator to move the selected sole-face (108) through at least one opening in the footwear's sole (102).

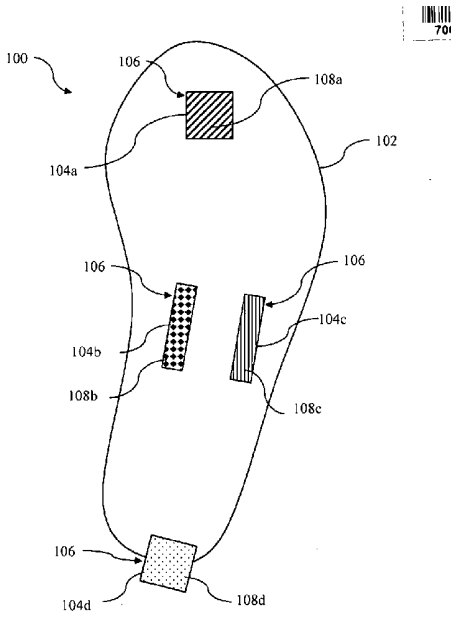
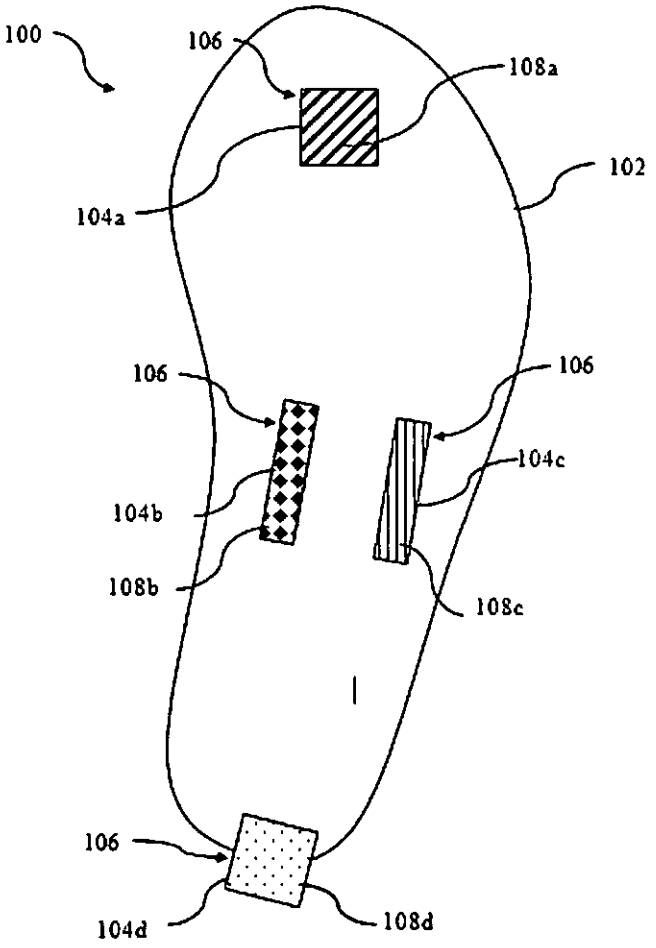


Figure 1

ABSTRACT

APPARATUS IN FOOTWEAR FOR ADAPTING FOOTWEAR'S SOLE

The disclosed subject matter at-least illustrates an apparatus in a footwear (100) for selectively adapting at least a portion of footwear's sole (102). The apparatus comprises a control-system (300) for selecting a sole-face from amongst a plurality of sole-faces (108); and an actuator to move the selected sole-face (108) through at least one opening in the footwear's sole (102).



We claim:

1. An apparatus in a footwear (100) for selectively adapting at least a portion of footwear's sole (102), the apparatus comprising:

a control-system (300) for selecting a sole-face from amongst a plurality of sole-faces (108); and

an actuator to move the selected sole face (108) through at least one opening (104) in the footwear's sole (102).

2. The apparatus as claimed in claim 1, wherein the plurality of sole-faces (108) are arranged in a sole-hub (106).

3. The apparatus as claimed in claim 2, wherein the actuator actuates the sole-hub (106) such that only one sole face (108) is moved at a time through the at least one opening (104) in the footwear's sole (102).

4. The apparatus as claimed in claim 1, wherein each of the plurality of sole faces (108) comprises: ridges, spikes, studs, lugs, deep-pattern, less-pattern, or a combination thereof.

5. The apparatus as claimed in claim 1, wherein each of the plurality of sole faces (108) is defined by one or more of the following constructional features: material, depth, pattern, and size.

6. The apparatus as claimed in claim 1, wherein the control-system is an electronic control system (300) comprising:

at-least one sensor (304, 306, 308, 310); and

a controller (302) to automatically select the sole face (108) to be moved based on output of the at least one sensor (304, 306, 308, 310) and trigger movement of the selected sole face (108) through the at least one opening (104).

7. The apparatus as claimed in claim 6, wherein the at least one sensor (304, 306, 308, 310) comprises: a motion sensor, a pressure sensor, a moisture sensor, a temperature sensor, or a combination thereof.

8 The apparatus as claimed in claim 1, wherein the actuator is an electrical actuator configured to be trigged by an electronic-control system (300) acting as said control system and thereby move the selected sole face (108) through at least one opening (104) in the footwear's sole (102).

9. The apparatus as claimed in any of preceding claims, further comprising:

a mechanical-control (202) to facilitate a manual-selection of the sole-face by a user and thereby override any automatic-selection of the sole face (108) by the control-system (300).

10. A footwear comprising the arrangement as claimed in any one of claims 1-9.

Dated this 30th day of March 2017,

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TECHNICAL FIELD

[0001] The disclosed subject matter relates to footwear and in particular, relates to a mechanism in a footwear assembly.

BACKGROUND

[0002] Footwear such as shoes are known to exist in various forms and shapes for fulfilling daily-life purposes like running, walking, trekking, playing, dancing etc. In addition, it is quite usual to find multiple traits in a same human-being, e.g. fitness-freak, sportsman, dancer, white-collar professional etc. Accordingly, it is quite usual to see a person buying different types of footwear for undertaking different tasks such as professional-duties or pursuing different hobbies.

[0003] Typically, a different type of footwear such as shoes differs from one another mainly in respect of the type of sole or more specifically the patterns described within the sole. In an example, 'trekking-shoes' are known to have "rubber-sole" with deep lugs/indentations to give a secure footing upon rocky terrain. 'Soccer' shoes are known to a hard-sole with spikes/studs to provide increased traction upon grass-fields. Jogging/Walking shoes have a rubber sole with flat or minimal depth-patterns. As a part of formal-wear, formal-shoes have a hard-sole with minimal depth-patterns. As may be evident, not only a person is compelled to buy different sets for shoes for pursuing different interests, but also happens to incur incidental expenses, since housing different sets of shoes at home requires an even larger wardrobe. In addition, in case a particular interest/activity is not followed frequently, one or more type of footwear ends up 'unused' for a long time and accordingly leads to under-utilization of resources.

[0004] Moreover, even if it means pursuing a single hobby such as trekking or playing through a single type of footwear, one encounters all sorts of different types of ground-surfaces contacting the footwear. As may be well understood, single footwear may not be suited for

contacting all sorts of ground-surfaces and often ends up either getting damaged. In other scenario, a lack of grip between the footwear and the ground surface may also cause injury to the wearer.

[0005] Hence, there lies a need for an improved multi-purpose footwear

SUMMARY

[0006] This summary is provided to introduce a selection of concepts in a simplified format that is further described in the detailed description of the present disclosure. This summary is neither intended to identify key or essential inventive concepts of the disclosure, nor is it intended for determining the scope of the invention or disclosure.

[0007] In an embodiment, the disclosed subject matter illustrates an apparatus in a footwear for selectively adapting at least a portion of footwear's sole. The apparatus comprises a control-system for selecting a sole-face from amongst a plurality of sole-faces; and an actuator to move the selected sole-face through at least one opening in the footwear's sole.

[0008] In yet another implementation, the control-system comprises a selector-switch for receiving a user-command to manually select the sole-face from amongst the plurality of sole-faces. In said implementation, the actuator is a mechanical-actuator provided to move the selected sole-face through at-least one opening in the footwear's sole.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] These and other features, aspects, and advantages of the present disclosure will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0010] **FIG. 1** illustrates a schematic illustration of a footwear provided with an apparatus in accordance with an embodiment of the disclosed subject matter;

[0011] **FIG. 2** illustrates an exemplary sole-hub forming a part of the apparatus within the footwear of Fig. 1, in accordance with an embodiment of the disclosed subject matter;

[0012] **FIG. 3** illustrates an orientation of the exemplary sole-hub connected to an exemplary control system, in accordance with an embodiment of the disclosed subject matter;

[0013] **FIG. 4** illustrates an exemplary change in position of the sole-hub, in accordance with an embodiment of the disclosed subject matter;

[0014] **FIG. 5** illustrates another type of orientation of an exemplary sole-hub, in accordance with an embodiment of the disclosed subject matter;

[0015] **FIG. 6** illustrates yet another exemplary sole-hub, in accordance with an embodiment of the disclosed subject matter;

[0016] **FIG. 7** illustrates another exemplary control-system forming a part of the apparatus in the footwear of Fig. 1, in accordance with an embodiment of the disclosed subject matter; and

[0017] **FIG. 8** illustrates an exemplary computing-system forming a basis of the exemplary control-system as referred in Fig. 7, in accordance with an embodiment of the disclosed subject matter.

[0018] The elements in the drawings are illustrated for simplicity and may not have been necessarily been drawn to scale. Furthermore, in terms of the construction of the device, one or more components of the device may have been represented in the drawings by conventional symbols, and the drawings may show only those specific details that are pertinent to understanding the embodiments of the present disclosure so as not to obscure the drawings with details that will be readily apparent to those of ordinary skill in the art having benefit of the description herein.

DETAILED DESCRIPTION

[0019] For the purpose of promoting an understanding of the principles of the present disclosure, reference will now be made to the embodiment illustrated in the drawings and

specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the present disclosure is thereby intended, such alterations and further modifications in the illustrated system, and such further applications of the principles of the present disclosure as illustrated therein being contemplated as would normally occur to one skilled in the art to which the present disclosure relates.

[0020] The foregoing general description and the following detailed description are explanatory of the present disclosure and are not intended to be restrictive thereof.

[0021] Reference throughout this specification to "an aspect", "another aspect" or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present disclosure. Thus, appearances of the phrase "in an embodiment", "in another embodiment" and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

[0022] **FIG. 1** illustrates a schematic diagram of a footwear 100 provided with an apparatus in accordance with an exemplary embodiment of the invention. Specifically, the figure 1 depicts a bottom or sole 102 of the footwear 100, which in turn may be a shoe, slipper, sandal etc. According to an implementation, the sole 102 may be a plain-sole. According to another implementation, the sole 102 may be a sole with a pattern. According to yet another implementation, the sole 102 may be a combination of plain and patterned sole.

[0023] In order to facilitate an operation of the apparatus in the footwear 100, the sole 102 comprises one or more opening defing compartments 104 a, 104b, 104c, 104d. According to an embodiment, the compartment 104 may be openings or cavities carved out within the sole 102. According to exemplary embodiment, the cavities may extend through the thickness of the sole 102 and thereby act as perforations within the sole 102.

[0024] The compartments 104 may be provided on any part of the sole 102. The compartments may be provided at the front part, central part or rear part of the sole 102.

According to an implementation, the shape of one or more compartments 104 may be similar to each other. According to another implementation, the shape of one or more compartments 104 may be different than each other. The shape of the compartments 104 may be shapes such as but not limited to a square, rectangle, triangle, pentagon, hexagon etc. According to an embodiment, the size of one or more compartments 104 may be similar to each other. According to another embodiment, the size of one or more compartments 104 may be different than each other.

[0025] Further, each of the compartment 104(a, 104b, 104c, 104d acts as an enclosure for a sole-hub 106, which is a set of sole-faces 108 a, 108b, 108c, 108d. As shown in the figure 1, such sole-faces 108 stand exposed through the compartments 104 within the sole 102.

[0026] **FIG. 2** illustrates the exemplary sole-hub 106 forming a part of the apparatus in the footwear 100, in accordance with an embodiment of the disclosed subject matter. The sole-hub 106 may be a polygonal block (rectangular block as shown in Fig. 2a, tetrahedron of Fig. 2b or octahedron of Fig. 2c etc.) having a plurality of planar-surfaces supporting the number of sole-faces 108. Each of said planar surface of the sole-hub 106 defines a unique sole-face 108. In other implementation, the sole hub 106 may be an elongated strip or thin-sheet as shown in Fig. 2d, such that the different sole-faces 108 are aligned longitudinally along the length of sheet.

[0027] According to an embodiment, the sole-faces 108 may include common sole-patterns such as spikes, studs, deep patterns, less patterns etc. or a combination thereof. Alternatively, each of the plurality of sole faces 108 is defined by one or more of the constructional features: material, depth, pattern, and size. The plurality of sole faces 108 enable an adequate-grip of the footwear 100 upon the ground-surface based on different terrain and applications.

[0028] **FIG. 3** illustrates an orientation of the exemplary sole-hub 106 along with an exemplary control-system 202, in accordance with an embodiment of the disclosed subject matter. The position or orientation of the sole-hub 106 corresponds to an initial-state, wherein the sole-hub 106 may be rotatable so as to enable one of the sole-faces 108 to face the

compartment 104. According to an exemplary embodiment the control-system 202 may be a mechanical-control system or a selector-switch such as but not limited to a rotary knob. The knob may be provided at the exterior of the footwear 100 for user-access, such that a user-command or action or rotates the knob . A shaft 204 may be provided for enabling a motion-transmitting means between the control system 202 and the sole hub 106. In other example, a push-button may be provided as the control system 202 to replace the sole-face 108. According to an embodiment, the sole-face 108 may be relaced in the compartment 104 with actuation of the push-button switch by the user. The mechanical actuator may employ other required elements to generate mechanical actions e.g. torsion-spring, conical-spring, helical-spring, gears, levers, etc.

[0029] **FIG. 4** illustrates an exemplary arrangement for changing the position of the exemplary sole-hub 106, in accordance with an embodiment of the disclosed subject matter. As illustrated, the sole-hub 106 having a desired sole-face in the compartment 104 may undergoes a translation-motion or a downward linear-motion to protrude through the compartment 104 and accordingly aligns as a part of the sole 102. According to an examoplary embodiment, all the openings may have same type of sole-face 108 protruding through the opening 104 at a particular-instant. According to another examoplary embodiment, the openings may have diffrent type of sole-face 108 protruding through the opening 104 at a particular-instant.

[0030] **FIG. 5** illustrates another type of orientation of the exemplary sole-hub 106 along with the exemplary control system 202, in accordance with an embodiment of the disclosed subject matter. As may be seen, the sole-hub 106 may remain oriented at the same vertical level as that of the compartment 104 and rotatable therein to change the sole-faces 108. Accordingly, the translation or downward motion as otherwise illustrated in Fig. 4 may not be needed and only the rotary motion is required to select the sole-face 108 and simultaneously align the selected sole-face 108 with sole 102.

[0031] **FIG. 6** illustrates yet another exemplary sole-hub 106, in accordance with an embodiment of the disclosed subject matter. As illustrated, the sole-hub 106 may be an elongated or linear-strip 106 having a plurality of sole-faces 108 extending longitudinally. Accordingly, the linear-strip 106 may be moved linearly such that a selected sole-face 108 faces the compartment 104. Once required sole-face 108 is selected, the sole-hub 106 may be lowered to align the selected sole-face 108 with the compartment 104. In another scenario, the sole-hub 106 may be aligned at the same vertical level as that of the compartment 104 and accordingly need not require any lowering. As may be understood, the control system in the form of selector-switch 202 may be actuated (rotated or pushed) to trigger the mechanical-actuator (e.g. a pulley arrangement) to eventually result in the linear motion for the elongated strip based sole hub 106.

[0032] Further, while the description of the preceding figures 3 till 6 illustrates a single sole-hub 106 getting aligned with the compartment 104, such description may be extended to cover presence of multiple sole-hubs 106 with respect to the plurality of compartments 104 within the sole 102. In such a scenario, actuation of a single control-system or selector switch 202 causes alignment of a unique sole-face 108 with each compartment 104. In other example, actuation of the selector-switch 202 results in alignment of the same sole-face 108 with each compartment 104.

[0033] **FIG. 7** illustrates another exemplary control-system 300 according to an embodiment of the disclosed subject matter. The control-system 300 may be an electronic control system that automatically actuates the sole-hub 106 and changes the sole-face 108, thereby enabling the footwear 100 to automatically adapt itself against various circumstances, e.g. current-terrain conditions, environmental-conditions, physiological parameters, etc. According to exemplary embodiment of the disclosure, the actuator connected to the control system 300 may be an electric actuator such as a motor to generate rotary and/or linear motions

for moving (e.g. rotating and/or linearly moving) the sole hub 106 to select the sole face 108 and, optionally, position the selected sole-face 108 in the respective-compartment 104.

[0034] According to exemplary embodiment, the electronic control-system 300 may includes a 302controller 302, for automatically-selecting one or more sole-faces 108 and one or more sensors. According to an embodiment, onr or more sensors may be selected from a group comprising motion/speed sensor 304, pressure-sensor 306, moisture sensor 308, temperature-sensor 310, magnetometer sensor 312, etc. According to another embodiment, the controller may be a microcontroller. According to yet another embodiment, the controller 302 may automatically select one or more sole-faces 108 based on inputs from one or more sensors 304, 306, 308, 310.

[0035] According to an embodiment, the sensor may be a motion/speed sensor 304. The motion-sensor 304 may measure the walking or running speed of the user wearing the footwear 100 and thereafter sends the measured information to the controller 302. The controller 302 may select the appropriate sole face 108 based on the information received from the motion sensor 304. Examples of motion sensor 304 in accordance with the disclosed subject matter include MEMS (micro-electromechanical system) based accelerometer for handling axis-based motion sensing, MEMS based gyroscopes for assisting the accelerometer with an understanding as to which direction the footwear is oriented, and passive infra-red sensors for detecting motion of the substance external to the footwear (e.g. for detecting motion of the other footwear in the pair).

[0036] According to another embodiment, the sensor may be a pressure-sensor 306. The pressure sensor 306 measures the pressure being applied on the footwear 100 while the user is wearing the footwear 100. The pressure sensor 306 may send the pressure information to the controller 302. Examples of pressure sensors 306 may include MEMS (micro electro-mechanical systems) based Altimeter & Barometer for detecting the ambient atmospheric-pressure and

thereby facilitating measurement of pressure-changes within the footwear. Accordingly, the controller 302 may select the appropriate sole face 108 based on the information received from the pressure-sensor 306.

[0037] According to yet another embodiment, the sensor may be a moisture-sensor 308. The moisture sensor 308 may measure the wetness on the surface and sends the information to the controller 302. According to an embodiment, the controller 302 may select the appropriate sole-face 108 based on the information received from the moisture-sensor 308.

[0038] According to yet another embodiment, the sensor may be a temperature-sensor 310 for measuring the temperature within the footwear 100 as well ambient temperature. The controller 302 may select the appropriate sole-face 108 based on the information received from the temperature-sensor 308.

[0039] According to yet another embodiment, the sensor may be a magnetometer sensor 312 and the electronic control-system 300 may further comprises a navigation-arrangement 314 comprising one or more of a GPS receiver, and/or an electronic compass implemented through MEMS based magnetometer 312. In addition, the control-system 300 may further comprise an ambient light sensor for determining the luminosity around the footwear.

[0040] According to an embodiment, the controller 302 may rely upon any combination of readings from the plurality of sensors 304, 306, 308, 310, 312, and the navigation arrangement 314 to select any sole-face 108 based thereupon. Overall, the controller 302 may be pre-configured with the criteria pertaining to selection of appropriate sole face 108 based on various type of sensor-output and navigation-arrangements. In an example, a weighted mean of the reading from the sensors 304, 306, 308, 310, 312 may be calculated and thereafter a particular sole-face 108 may be selected based on said calculation and current position of the footwear 100 as determined by the arrangement 314.

[0041] According to yet another embodiment, the electronic control system 300 may be dispersed across any location within the sole 102, e.g. front, rear, center or anywhere else within the assembly of the footwear 100. In an example, the control-system 300 may be incorporated within a heel-block located at the exterior of the sole 102.

[0042] In an implementation, despite the presence of control system 300, the footwear 100 may still have the mechanical control system as the selector switch 302 within the footwear 100. Any manual actuation of the selector switch 302 by the user (for the purposes of selecting sole-faces 108 and adapting the sole 102) may override the controller's 302 actions. For example, a manually selected sole-face 108 based on 'spike' may override an automatically done selection of the sole-face based 'lugs'.

[0043] In a further implementation, the footwear 100 may includes a battery for rendering a power source for the plurality of sensors 304 till 310, navigation arrangement 314, and the controller 302. Such battery may be charged based on the movement of the footwear 100.

[0044] In yet another implementation, an electronic-display may be provided as a part of electronic control system 300 to depict the various sensors reading, display for aiding navigation and currently chosen sole–face 108 as selected by the electronic control system 300

[0045] In an implementation, the electronic control system 300 may be capable of wirelessly-interacting with various communication devices such as a smartphone via BT/BLE Module. Accordingly, a user may access the control system 300 through a mobile-app. In other example, the electronic control system 300 may be capable of wirelessly-interacting with a radio access network (RAN) through LTE/NB-IoT Module based protocols such that data from the electronic control system 100 may be communicated over long ranges through radio technologies while using least system resources.

[0046] In yet another implementation, the footwear 100 further comprises a graphical user-interface (GUI) for manually selecting a desired sole-face 108 as another type of electronic

control system 300. According to an embodiment, the GUI may be a touch-sensitive surface for sending inputs. According to another embodiment, the GUI may be supplemented with keypad or buttons to select the desired sole face 108. When the user selects the desired sole-face 108, the electrical actuator (e.g. motor) may be triggered to align the selected sole face 108 with the compartment 104.

[0047] Further, GUI based electronic control system may be connected to the ambient light sensor to automatically adjust its brightness upon sensing ambient light. The GUI may also be connected to the navigation arrangement 314 within the footwear 100 to also act as a navigation-display.

[0048] **FIG. 8** illustrates an exemplary computing-system 400 representing the electronic control system 300 as referred in Fig. 7, in accordance with an embodiment of the disclosed subject matter.

[0049] The computer-system 400 may include a processor 402 e.g., a central processing unit (CPU), a graphics processing unit (GPU), or both. The processor 402 may be one or more general processors, digital signal processors, application specific integrated circuits, field programmable gate arrays, servers, networks, digital circuits, analog circuits, combinations thereof, or other now known or later developed devices for analyzing and processing data The processor 402 may implement a software program, such as code generated manually (i.e., programmed).

[0050] The computer system 400 may include a memory 404. The memory 404 may include, but is not limited to computer readable storage media such as various types of volatile and non-volatile storage media, including but not limited to random access memory, read-only memory, programmable read-only memory, electrically programmable read-only memory, electrically erasable read-only memory, flash memory, magnetic tape or disk, optical media and the like. In one example, the memory 404 includes a cache or random access memory for the processor 402.

In alternative examples, the memory 404 is separate from the processor 402, such as a cache memory of a processor, the system memory, or other memory. The memory 404 may be an external storage device or database for storing data. The memory 404 may be operable to store instructions executable by the processor 402. The computer system 400 may also include a disk or optical drive unit 406. Various units/components may be connected to each other through a bus 408. The functions, acts or tasks illustrated in the figures or described may be performed by the programmed processor 402 executing the instructions stored in the memory 404. The functions, acts or tasks are independent of the particular type of instructions set, storage media, processor or processing strategy and may be performed by software, hardware, integrated circuits, firm-ware, micro-code and the like, operating alone or in combination. Likewise, processing strategies may include multiprocessing, multitasking, parallel processing and the like.

[0051] As illustrated, the computer system 400 may be supplemented by a touch-sensitive display unit 410 (e.g. GUI for manual selection of the sole-faces 108), for outputting determined information as well as receiving a user's touch-gesture based inputs, such as drag and drop, single tap, multiple-taps, etc. The display 410 may act as an interface for the user to see the functioning of the processor 402, or specifically as an interface with the software stored in the memory 404 or in the drive unit 406.

[0052] Additionally, the computer system 400 may include an input device 412 configured to allow a user to interact with any of the components of system 400. The disk drive unit 406 may include a computer-readable medium 418 in which one or more sets of instructions 414, e.g. software, can be embedded. Further, the instructions 414 may embody one or more of the methods or logic as described. In a particular example, the instructions 414 may reside completely, or at least partially, within the memory 404 or within the processor 402 during execution by the computer system 400.

[0053] The present disclosure contemplates a computer-readable medium that includes instructions 414 or receives and executes instructions responsive to a propagated signal so that a device connected to a network 416 can communicate voice, video, audio, images or any other data over the network 416. Further, the instructions 414 may be transmitted or received over the network 416 via a communication port or interface 420 or using a bus 408. The communication port or interface 420 may be a part of the processor 1102 or may be a separate component. The communication port 1120 may be created in software or may be a physical connection in hardware. The communication port 420 may be configured to connect with a network 416, external media, the display 410, or any other components in computing system 400, or combinations thereof. The connection with the network 416 may be established wirelessly as discussed later. Likewise, the additional connections with other components of the system 400 may be established wirelessly. The network 416 may alternatively be directly connected to the bus 408.

[0054] The present disclosure illustrates a foot-wear for automatically providing multiple-utilities to the user without requiring any user-intervention.

[0055] At-least by virtue of aforesaid description of figures, the disclosed subject matter provides a smart-footwear that has an adaptive sole-configuration configured to change dynamically based on either the user-command or surface/terrain conditions. Such smart-footwear provides wearers with different soles for a particular type/design of footwear. Overall the disclosed subject matter facilitates multi-faceted footwear usable for many scenarios, wherein the footwear also facilitates safety for the wearer across diverse applications, without compromising upon the safety of the user.

[0056] While specific language has been used to describe the disclosure, any limitations arising on account of the same are not intended. As would be apparent to a person in the art,

various working modifications may be made to the method in order to implement the inventive concept as taught herein.

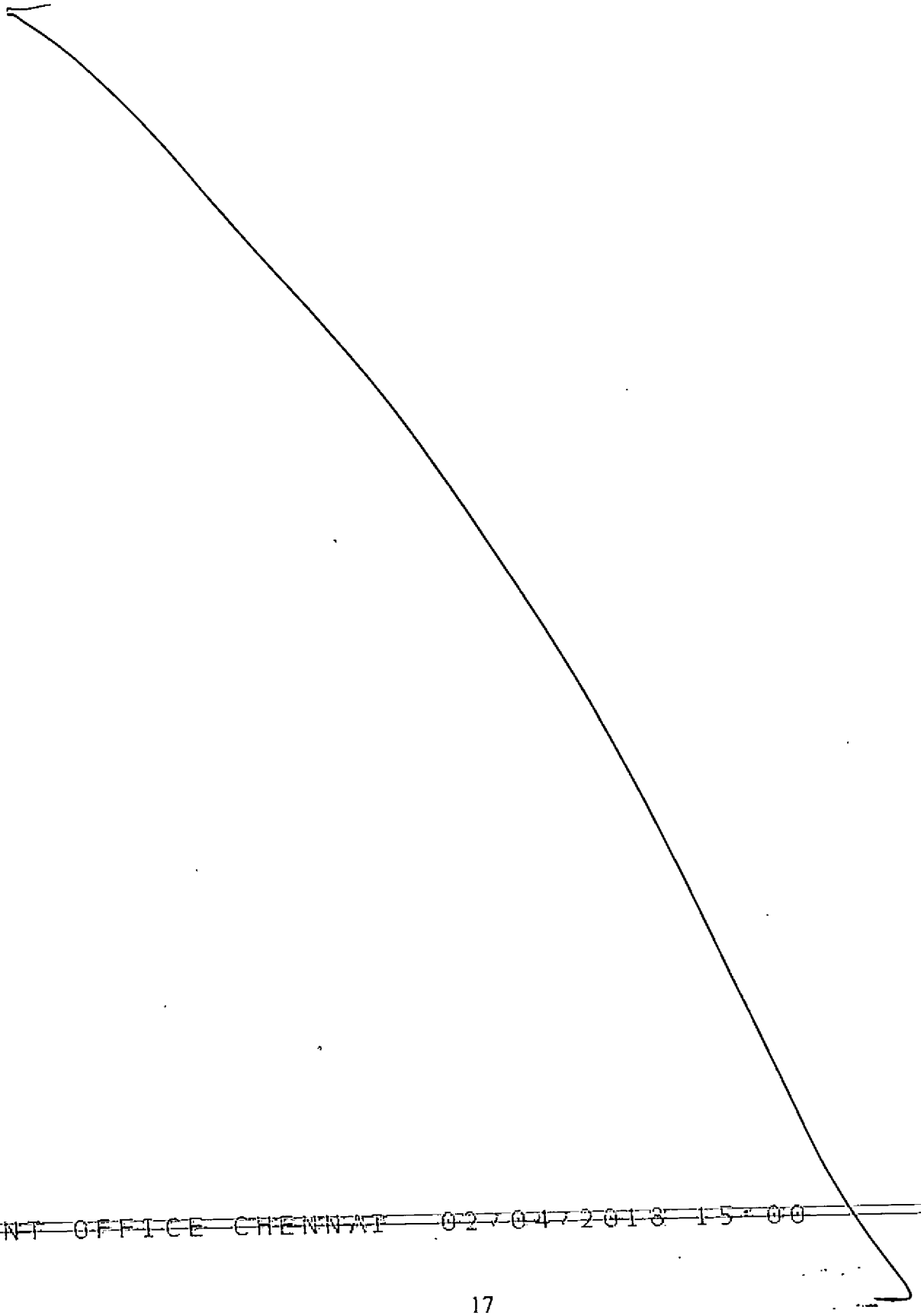
[0057] It is understood that the above description is intended to be illustrative, and not restrictive. It is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined in the appended claims. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein," respectively.

[0058] The drawings and the foregoing description give examples of embodiments. Those skilled in the art will appreciate that one or more of the described elements may well be combined into a single functional element. Alternatively, certain elements may be split into multiple functional elements. Elements from one embodiment may be added to another embodiment. For example, orders of processes described herein may be changed and are not limited to the manner described herein.

[0059] Moreover, the actions of any flow diagram need not be implemented in the order shown; nor do all of the acts necessarily need to be performed. Also, those acts that are not dependent on other acts may be performed in parallel with the other acts. The scope of embodiments is by no means limited by these specific examples. Numerous variations, whether explicitly given in the specification or not, such as differences in structure, dimension, and use of material, are possible. The scope of embodiments is at least as broad as given by the following claims.

[0060] Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems,

and any component(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature or component of any or all the claims.



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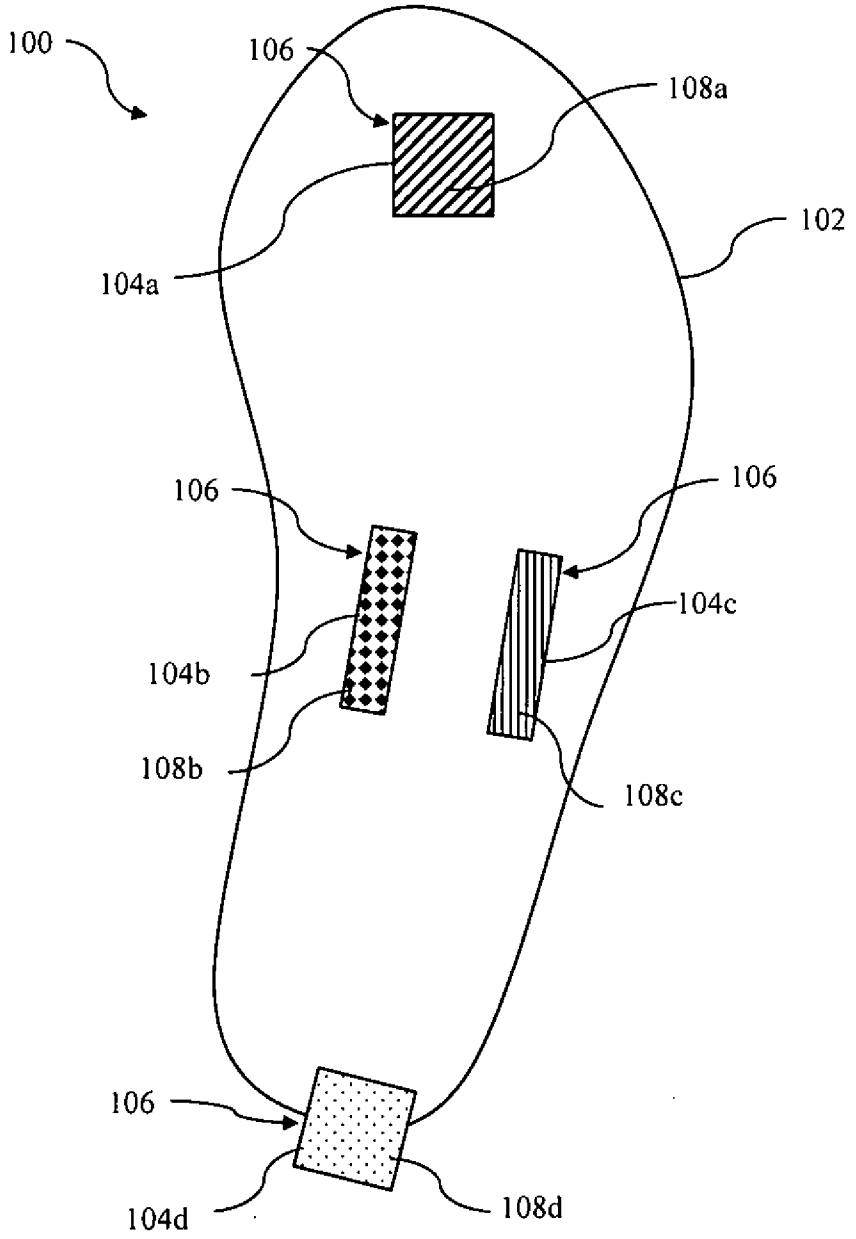

Figure 1

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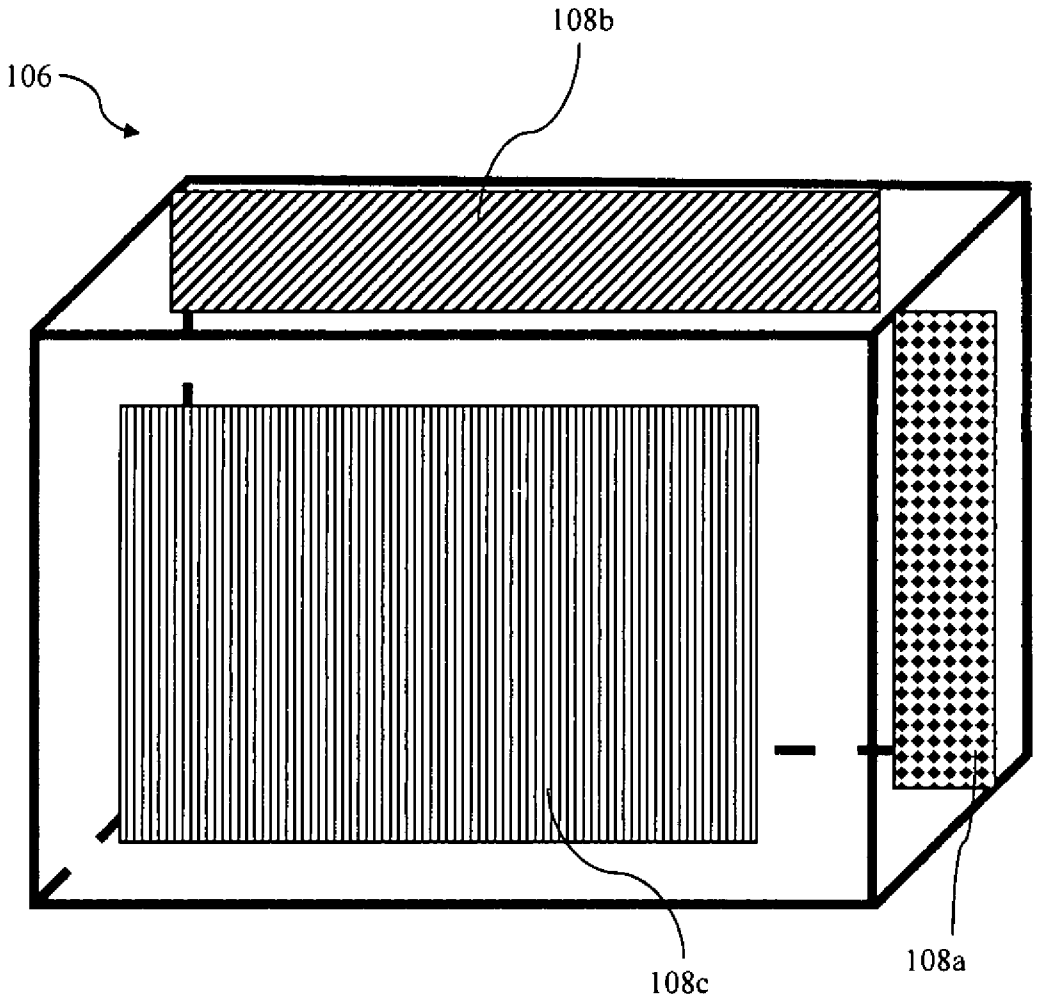

Figure 2a

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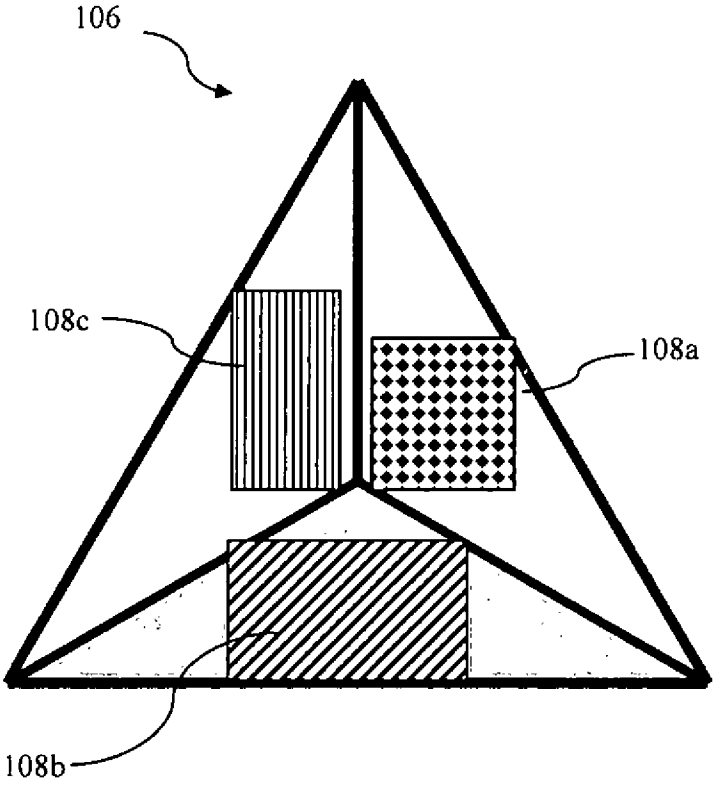

Figure 2b

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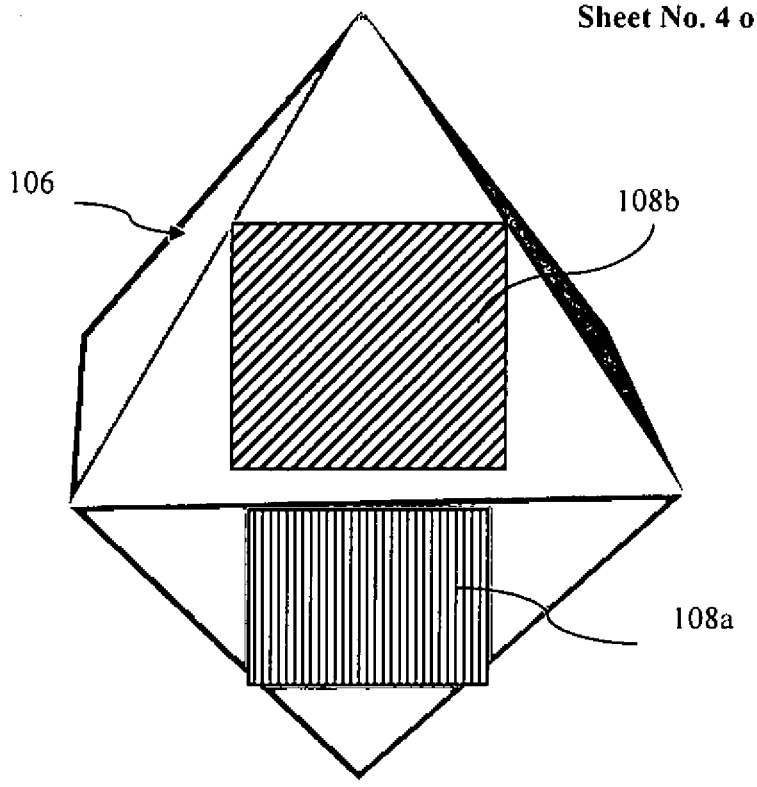

Figure 2c

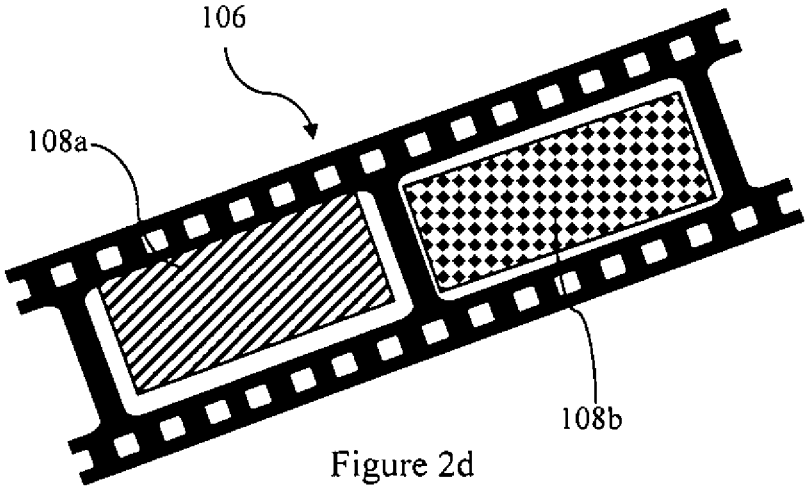

Figure 2d

Mohammed Faisal (INPA No: 1941)
Head, IPR Dept.
L&T Technology Services Limited
DLF 3rd Block 2nd Floor,
Manapakkam, Chennai – 600089

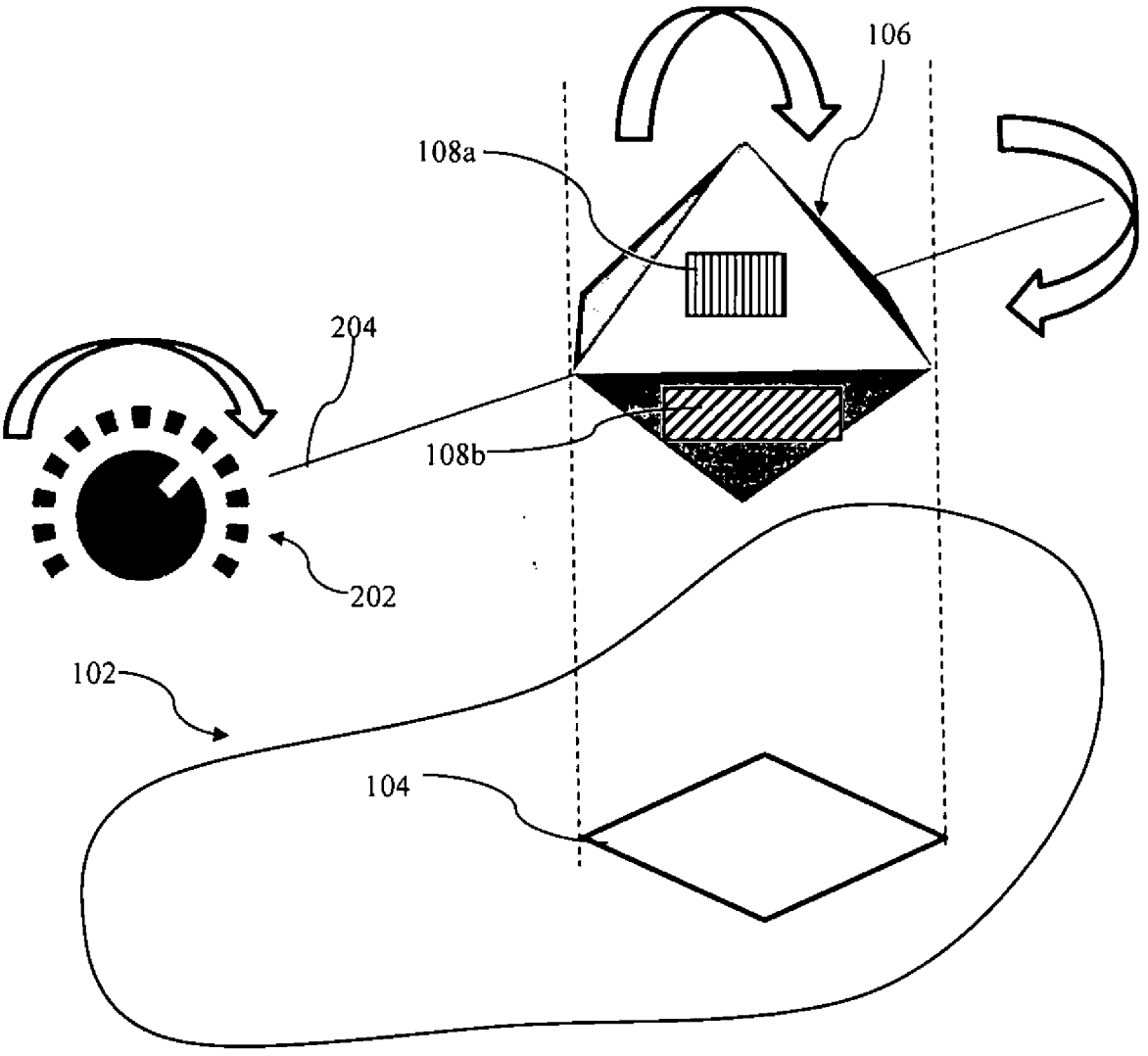

Figure 3

Mohammed Faisal (INPA No: 1941)
Head, IPR Dept.
L&T Technology Services Limited
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai – 600089

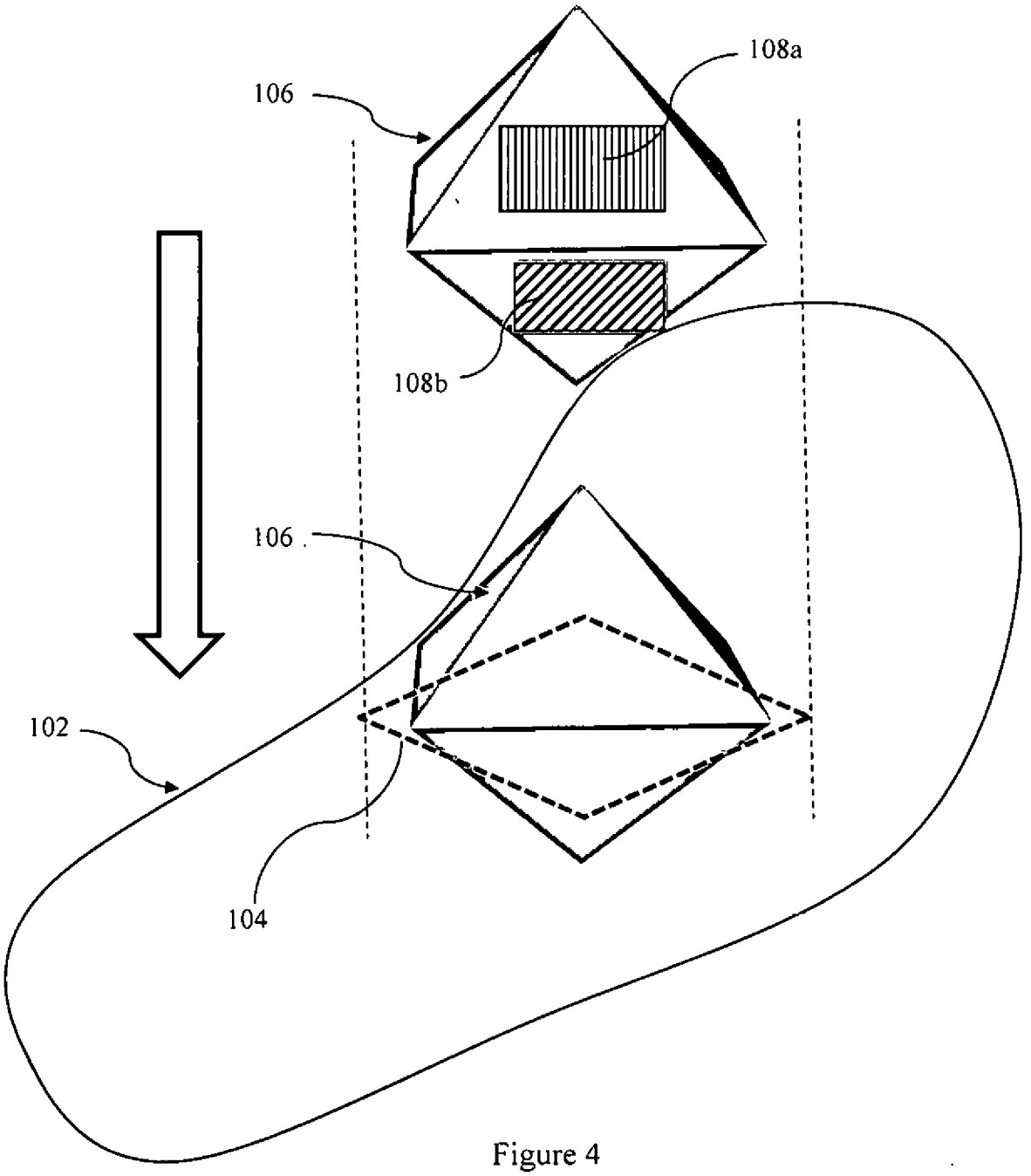

Figure 4

Mohammed Faisal (INPA No: 1941)
Head, IPR Dept.
L&T Technology Services Limited
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai – 600089

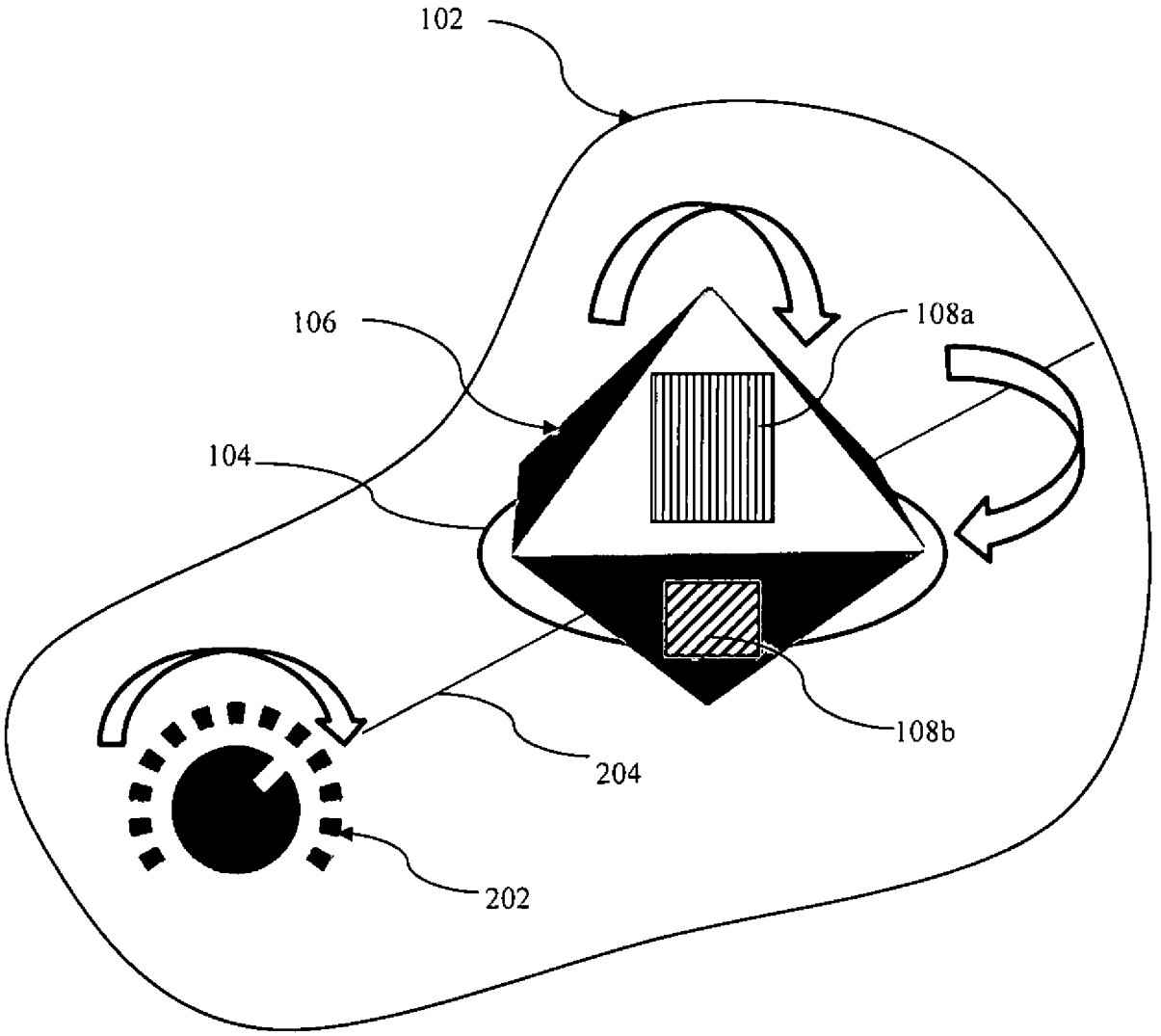

Figure 5

Mohammed Faisal (INPA No: 1941)
Head, IPR Dept.
L&T Technology Services Limited
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai – 600089

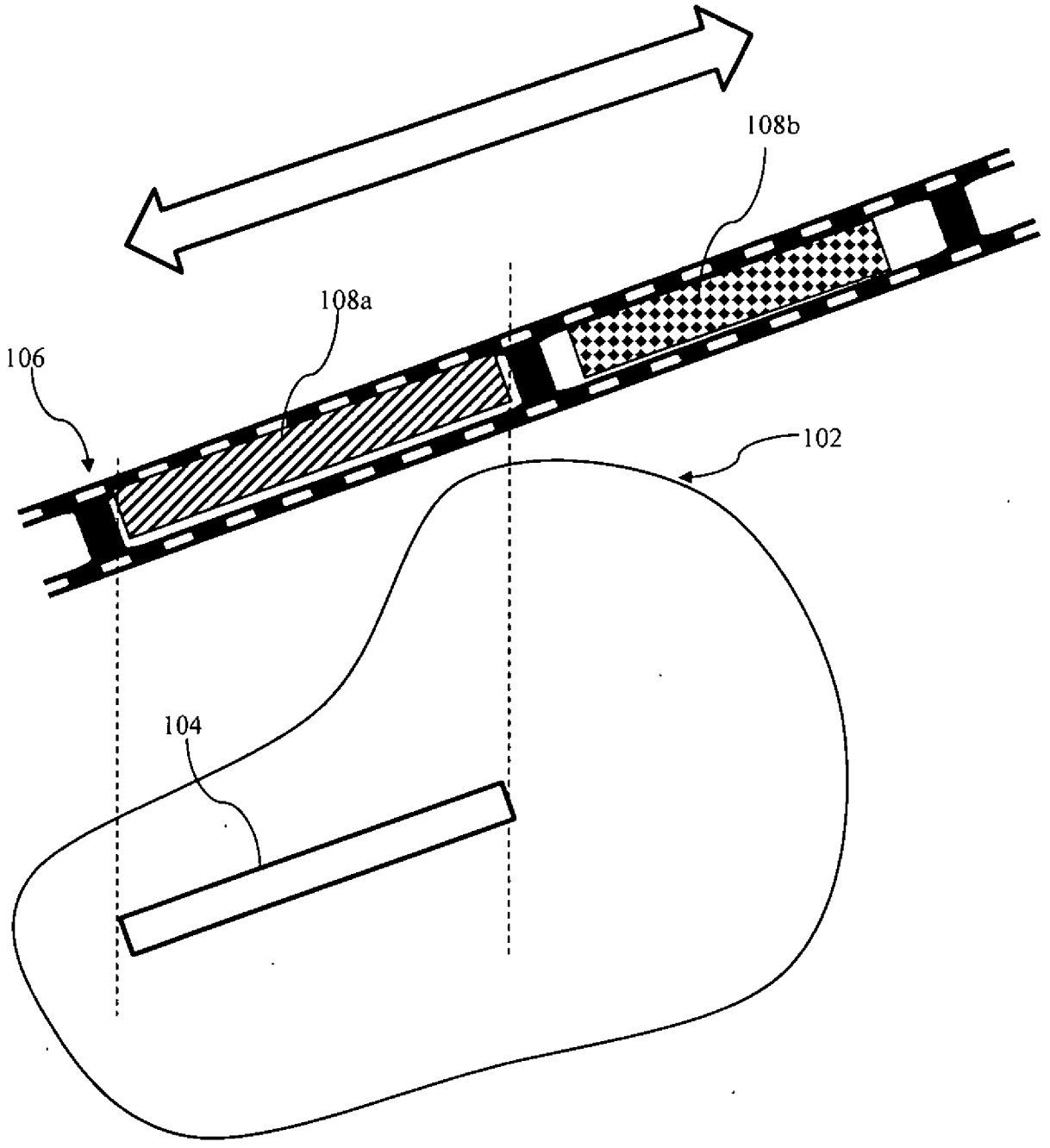

Figure 6

Mohammed Faisal (INPA No: 1941)
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L&T Technology Services Limited
DLF 3rd Block, 2nd Floor,
Mahapakkam, Chennai - 600089

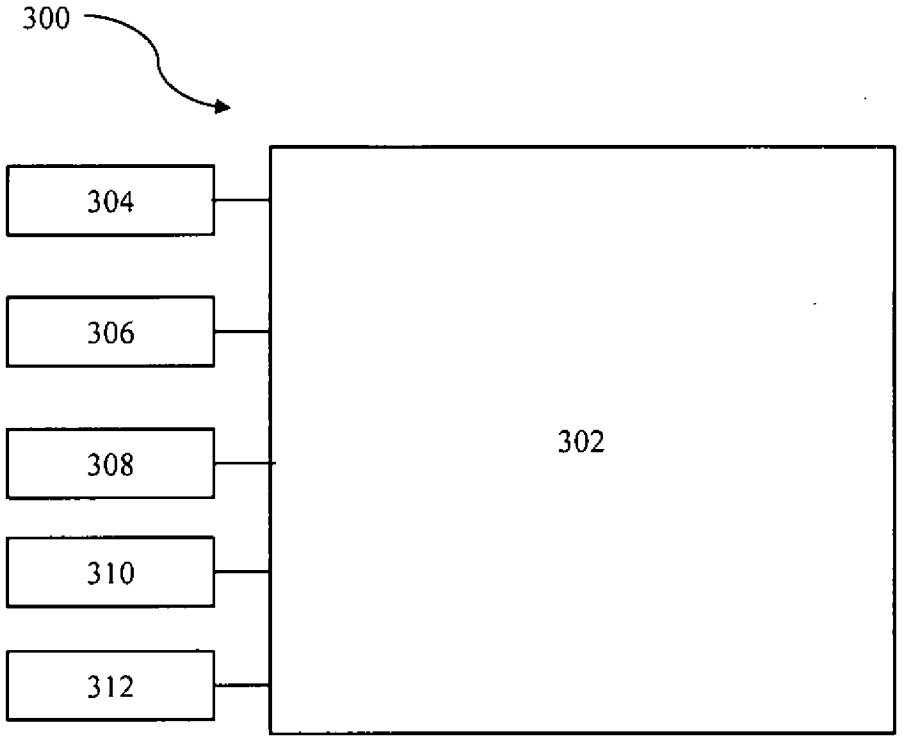

Figure 7

Mohammed Faisal (INPA No: 1941)
Head, IPR Dept.
L&T Technology Services Limited
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai – 600089

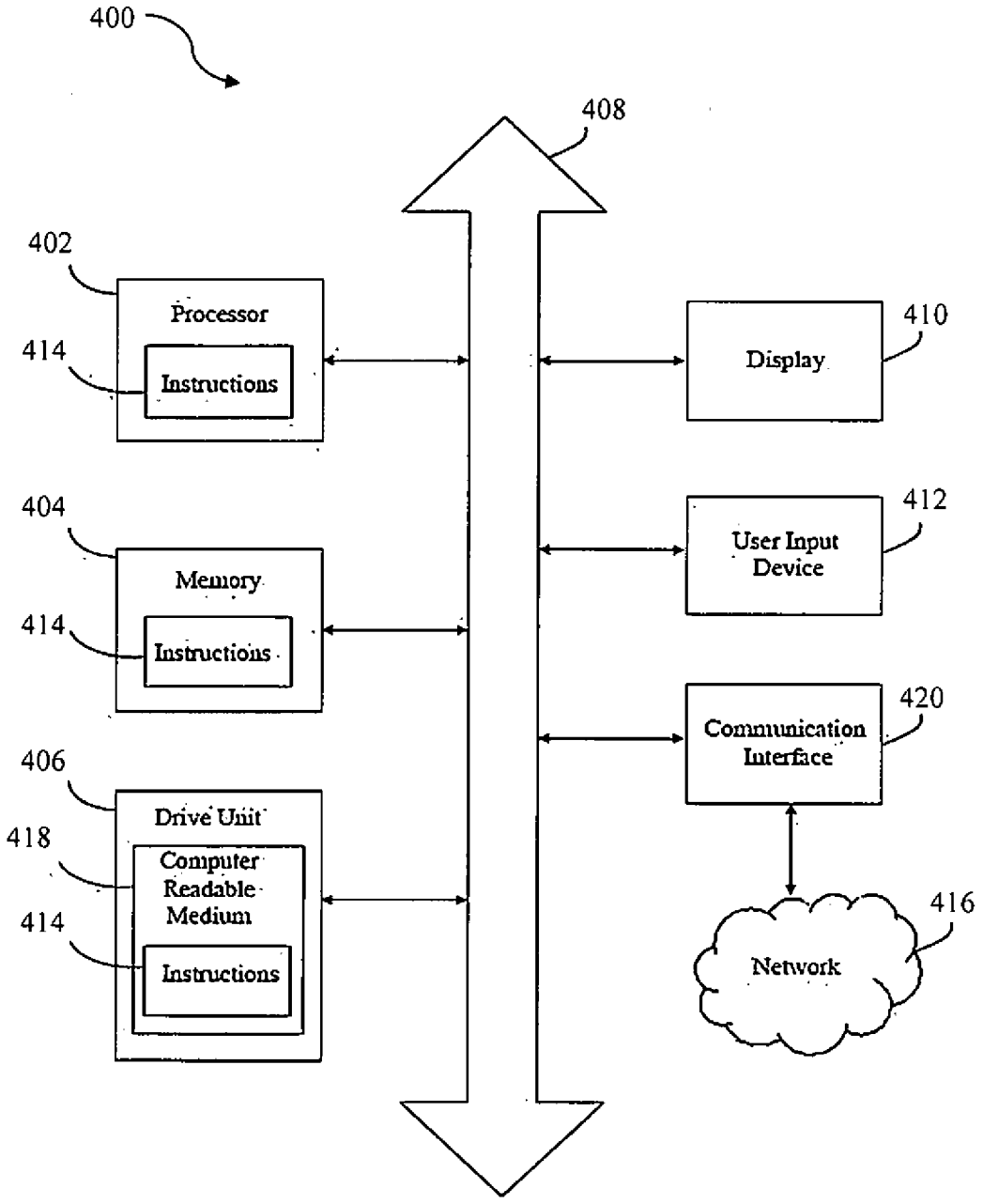

Figure 8

Mohammed Faisal (INPA No: 1941)
Head, IPR Dept.
L&T Technology Services Limited
DLF 3rd Block, 2nd Floor,
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