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(54) AERODYNAMICALLY ENHANCED APPENDAGE COVERINGS

(57) An aerodynamically enhanced appendage covering (10) includes a first portion (14) that is not subject to significant airflow and a second portion (28) that is positioned to engage significantly more airflow when placed on a moving body (MB). At least a part of the second portion (28) includes an aerodynamically enhanced area. The aerodynamically enhanced area includes a first frontal zone (24), a second turbulence inducing zone (28), and a third rear zone (32). The frontal zone (24) is configured to have a relatively smooth surface for inducing a relatively lesser amount of turbulence on air flowing past than the second zone (28). The second zone (128) has a relatively less smooth surface and includes a plurality of turbulence-inducing features (38) configured for creating a boundary layer (40) for inducing turbulence in air flowing past the second zone (28).

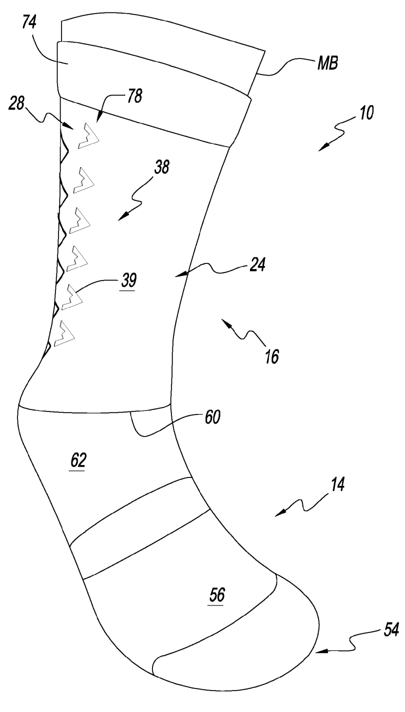

FIG. 5

EP 4 122 341 A1

Description

Priority.

[0001] This application claims benefit to Poertner US Provisional Patent Application for Aerodynamically Enhanced Appendage Coverings, Serial No: 63-225,486, which was filed on 24 July 2021, and Poertner US Provisional Patent Application for Aerodynamically Enhanced Appendage Coverings, Serial No: 63/231,416 which was filed on 10 August 2021, both of which are made a part hereof and are fully incorporated herein.

I. Technical Field of the Invention:

[0002] The present invention relates to apparel items and, in particular, appendage coverings, such as foot and arm coverings such as cloth socks.

II. Background of the Invention:

[0003] There currently exist two primary types of foot coverings. A first type of foot covering is a sock or stocking. A sock has a foot portion that is placed over the user's foot, and is disposed between the user's skin and the user's shoe. The second portion of a sock is the lower leg, or ankle portion which extends upwardly, and covers the lower part of the user's leg and is disposed primarily exteriorly of the user's shoe. The length of leg that the ankle portion covers varies depending upon the type of sock, and may have an upper terminus that is disposed below of the user's ankle, or may have an upper terminus that, like leggings or pantyhose, extend upwardly to cover the user's buttocks or anywhere therebetween.

[0004] A second type of non-shoe leg covering is a shoe covering type sock. A shoe covering type leg covering is similar to a sock, except that the foot portion of the leg covering sock is placed exteriorly over the shoe, rather than interiorly of the shoe as is a conventional sock. These shoe covering type socks are especially prized by persons who are engaged in cold weather outdoor activities, such as by bicycle riders in the winter.

[0005] Foot coverings are used for two primary utilitarian purposes, in addition to fashion related purposes.. The first purpose is for comfort, because placing a sock between the shoe and the foot helps to prevent blisters and the like on the user's skin.

[0006] The second primary purpose is for warmth. For those who work or choose to play outside, the cloth of the sock can provide a degree of warmth during cold weather periods. This is especially true when the sock is made of a material such as wool or some other heat insulating material.

[0007] One area where socks are asked to perform a third function is when socks or other appendage coverings are used in connection with athletic events where the user's leg is traveling swiftly through the air. Examples of such activities include bicycling, running, skating and skiing. In such cases, the sock should preferably enhance the aerodynamic profile of the user wearing the sock, to thereby help the user to reduce drag, and improve performance times.

[0008] For some time, it has been known that aerodynamic enhancement can occur through the choice of certain materials that have good aerodynamic properties than others. For example, it is known that a thin Lycra® brand spandex material has a better aerodynamic properties than a thick cotton material, such as is typically found in athletic tube socks. Lycra® is a registered trademark of the Lycra Company. With Lycra® spandex, the primary aerodynamic enhancement results from the spandex socks being usually thinner than the cotton tube socks. This thinness helps to reduce the profile of the sock when compared to thicker tube stock.

[0009] Additionally, the aerodynamic spandex socks are designed to be tight-fitting to reduce the cross-sectional area of the leg, compared to a tube sock that is thicker, and is also not as tightfitting.

[0010] Another feature of spandex socks that improves their aerodynamic enhancement is the use of vertical ribs, that extend all the way around the circumference of the leg-engaging portion of the spandex sock. Examples of currently available aerodynamically enhanced spandex socks are the Castelli Socks and which can be seen at https://www.castelli-cycling. com/us/aero-sock/p/TR0536SC1

[0011] Notwithstanding the advantages provided by these ribbed spandex socks, room for improvement exists. One problem with the currently existing ribbed spandex socks is that they do not stand up and cling to the leg very well when they get wet. When wet, the ankle portion that extends up the leg tends to crumple, so that it gathers around the ankle. This ankle gathering has both aerodynamic and fashion-related drawbacks.

[0012] Another problem with known spandex socks is that their turbulence inducing ribs extend 360° around the circumference of the sock. The problem with the ribs extending all the way around the circumference of the sock is that such circumferential positioning of the ribs, while effective at inducing boundary layer turbulence to reduce suction drag, tends to increase skin friction drag on the entire circumference of the sock, even areas which otherwise would have maintained flow attachment without the ribs.

[0013] Another problem with known spandex socks relates to the way in which they are constructed. Typically, known spandex -containing socks include a foot portion that is made from a knit material, which is sewn to a spandex portion which comprises the leg or ankle portion. One problem with having to join the two components together is that a seam is formed at the joinder, and this seam comprises a thickened area of the stock.

[0014] One difficulty that arises when creating such a seam-containing two-piece sock is deciding where to position the seam. Ideally, the seam would be positioned low, at about the point where the top of the foot receiving aperture of the shoe is positioned, so that the seam would generally be coextensive with the top of the shoe. This is a preferred place to put the seam because it enables the spandex portion to extend over all of the area of the sock that is exposed to the air, and over which the air flows, as no significant amount of air flows over the portion of the sock that is disposed interiorly of the shoe.

[0015] However, placing the seam at a position adjacent to the top of the foot receiving aperture of the shoe also has drawbacks, because the thickened seam causes the foot and ankle to chafe against the shoe. To avoid this chafing, one typically places the seam so that it is disposed at least an inch or so above the position where the top of the foot receiving aperture of the shoe resides.

[0016] Although this elevated position has benefits from a comfort standpoint, it has drawbacks from an aerodynamic standpoint. By increasing the area of the knitted portion that is exposed to airflow, and thereby decreasing the area of the ribbed spandex portion which is exposed to airflow, the effectiveness of the turbulence inducing features of the spandex is reduced because there is less area over which the spandex ribs can induce turbulence.

[0017] One object of the present invention is to create an appendage covering, such as a sock or arm cover, that has aerodynamic and/or other advantages over socks and arm covers that are presently used and known in the prior art.

III. Summary of the Invention.

[0018] In accordance with the present invention, an aerodynamically enhanced appendage covering is provided comprising a first portion that is not subject to significant airflow and a second portion that is positioned to engage significantly more airflow when placed on a moving body. At least a part of the second portion includes an aerodynamically enhanced area. The aerodynamically enhanced area includes a first frontal zone, a second turbulence inducing zone, and a third rear zone. The frontal zone is configured to have a relatively smooth surface for inducing a relatively lesser amount of turbulence on air flowing past than the second zone. The second zone has a relatively less smooth surface and includes a plurality of turbulence-inducing features are configured for creating a boundary layer for inducing turbulence in air flowing past the second zone.

[0019] The second zone may include a relatively recessed surface portion and a relatively raised surface portion. The turbulence inducing features may be disposed on one of the relatively raised and recessed surface portions, preferably on the raised portion. The relatively raised surface portion may comprise a series of discrete spaced turbulence inducing features.

[0020] Most preferably, the turbulence inducing features comprise a plurality of discrete turbulence inducing features having a thickness greater than the thickness of the area around the turbulence inducing features, so that the turbulence inducing features comprise relatively elevated areas that create turbulence, and preferably create a boundary layer between the covering and the flow of air. The turbulence inducing features may add between about 0.9 and 1.5 mm, preferably between about 1.0 and 1.25 mm, to the thickness of the second zone. Other optional features are defined in the appended dependent claims.

[0021] These and other features and advantages will be described below and appreciated by one skilled in the art upon reading the detailed description and viewing the drawings below.

IV. Brief Description of the Drawings

[0022]

Figure 1 is a front view of the appendage covering of the present invention, shown here illustratively as a stocking that is inserted upon the foot and lower leg of a mannequin;

Figure 1A is a left side view of the stocking;

Figure 1B is a sectional view taken along lines 1B-1B of Fig. 1A.

Figure 2 is a top-frontal view of the foot engaging portion of the stocking shown in Figure 1;

Figure 3 is a top view of the socks of the present invention, illustrating the portions of the leg portion, including the smooth frontal portion, the turbulator including first (left) side and second (right)portions and the smooth, but air directing thickened rear portion.

Figure 4 is a sectional, schematic view, similar to Figure 1B showing how air flows over the stocking of the present invention;

Figure 4A is a sectional, schematic view, similar to Figure 2A, showing how air flows over a prior art stocking

Figure 5 is a right-frontal view of the stocking, taken from a position of approximately 1 o' clock;

Figure 6 is a top view of a turbulator of the present invention;

Figure 7 is a right side perspective view of the stocking, with the upper portion of the leg portion rolled over to expose the interior surface of the leg portion, showing the interior of the thickened turbulators

Figure 8 is a right, side perspective view of the stocking, taken from a position of approximately 3 o'clock showing the three vertically arrayed rows of turbulators;

Figure 9 is a rear-biased right side perspective view taken from a position of approximately 5 o'clock;

Figure 10 is a rear perspective view taken from approximately 6 o'clock;

Figure 11 is a rear-biased left side perspective view taken from approximately 7 o'clock;

Figure 12 is a left side perspective view taken from approximately 9 o'clock; and

Figure 13 is a bottom view, showing the bottom, or plantar surface of the stocking.

V. Detailed Description of Preferred Embodiment.

[0023] An aerodynamically enhanced appendage covering such as sock 10 is provided comprising a first portion 14 that is not subject to significant airflow and a second portion 16 that is positioned to engage significantly more airflow when placed on a moving body MB. At least a part of the second portion 16 includes an aerodynamically enhanced area 20. The aerodynamically enhanced area 20 includes a first frontal zone 24, a second turbulence inducing zone 28, and a third rear zone 32 (Fig. 3).

[0024] The frontal zone 24 is configured to have a relatively smooth surface 34 for inducing a relatively lesser amount of turbulence on air flowing past than the second zone 28. The second zone 28 has a relatively less smooth surface and includes a plurality of turbulence-inducing features such as turbulators 38 that are configured for creating a boundary layer 40 for inducing turbulence in air flowing past the second zone 28.

[0025] Preferably, the second zone 28 includes a relatively recessed surface portion 42 and a relatively raised surface portion 44. The turbulence inducing features 38 are disposed on one of the relatively raised 44 and recessed 42 surface portions, and most preferably on the raised portions 44. The turbulence inducing features 38 preferably comprise a plurality of discrete spaced turbulators (Fig. 8).

[0026] The turbulators 38 are features that generally have a thickness greater than the thickness of the area around the turbulence-inducing features, so that the turbulators comprise relatively elevated areas that create turbulence, and preferably create a boundary layer 40 (Fig. 4) between the appendaged covering 10 and the flow of air. The surface 39 of the turbulator 38 is also relatively rougher than the non-turbulator areas 41 of the sock 10.

[0027] The third or rear zone 32 generally includes a surface 46 that is smoother than the surface second or side zone 28 to induce a smaller amount of air flow turbulence than is created in the second zone. Preferably the third zone 32 includes a thickened portion 44 disposed at the rear of the sock 10 which serves to help aerodynamically direct the air stream 52 at the rear of the sock 10 so that the air stream 52 flowing along one side of the leg merges more smoothly with the air flowing across the other side of the leg.

[0028] The stocking 10 is a unitarily formed, preferably in a single process, from a single material. Through this process, there is no need to join dissimilar materials together as in the Spandex socks discussed above.

[0029] The foot engaging first portion 14 typically resides within the interior of the shoe (not shown) being worn by the user. Because the foot engaging portion 14 resides within the shoe of the user, very little air flows directly over it during movement, such as when the user is riding the bicycle. For these reasons, the aerodynamics of the foot portion are generally not as important as the aerodynamic properties of the second leg-engaging portion.

[0030] The foot engaging portion includes a toe portion 54. The toe portion 54 is disposed at the distal end of the foot engaging portion. From a manufacturing standpoint, the stocking 10 is typically made as a tube having two open ends. The open distal end is then folded over, with the distal end of the toe 54 being attached to the dorsal surface 56 of the foot engaging portion 14, so that a closed toe sock 10 results.

[0031] The leg portion 16 of the sock 10 extends upwardly from the foot engaging portion 14, and generally comprises that portion of the sock 10 which typically resides exteriorly of the shoe and receives and engages the lower part of the user's leg. However, the leg portion 16 can be of any length and extend any desired distance up the user's leg. Because the leg portion provides superior aerodynamics as compared to the user's naked leg, it is aerodynamically advantageous to have a relatively longer length in the leg portion 16, which may extend 3 inches to 6 inches, 9 inches, or even a greater number of inches up the user's leg.

[0032] In fact, there may be advantages to extending the leg portion 16 all the way up to the interior of the user's pants, or possibly even employ the leg portion 16 to serve as pants for the user in a manner similar to pantyhose.

[0033] There is a line of demarcation between the foot engaging portion 14 and the leg engaging portion 16. This line of demarcation comprises a transition point 60. Unlike the transition point in known Lycra socks, the transition point 60 between the foot engaging portion 14 and the leg engaging portion 16 does not require a seam, since the stocking is unitarily formed from the same material. Because the transition point 60 is seamless, there is no added thickness at the transition point 60. The transition point 60 has relevance since the sock 10 is knitted to form the foot-engaging portion 14 of the sock 10 differently than the leg portion 16.

[0034] This lack of a seam provides design advantages to the manufacturer, and comfort advantages to the user. The design advantage provided to the manufacturer is that the lack of the seam, and the lack of any additional thickness therewith, enables the manufacturer to place the transition line anywhere that he/she chooses, without adding discomfort. Although discomfort would likely not increase even with a thickened seam if the thickened seam were placed exteriorly of the shoe, a thickened seam would likely cause discomfort if the seam were placed interiorly of the shoe. Since the present invention does not have a thickened seam, but rather a non-thickened transition area, the transition area can be placed interiorly of the shoe without adding discomfort to the user.

[0035] From the manufacturer's standpoint, it is advantageous to place the transition point 60 interiorly of the shoe, because that lengthens the leg engaging portion 16. Since the leg engaging portion 16 is designed to provide features, such as turbulators 38, which help the aerodynamic performance of the sock 10, the lengthening of the leg engaging portion 16 provides more area for the manufacturer to provide aerodynamically enhanced materials and features, to thereby help to improve the overall aerodynamic efficiency of the stockings 10.

[0036] It will be noted that the surface 62 of the foot engaging portion 14 is generally smooth and does not include any turbulence-inducing features 38 such as ribs or turbulators 38. A smoother, flatter surface 62 is chosen, because it helps to enhance comfort, and to maintain the thinness of the sock 10.

[0037] The dorsal surface 56 of the foot engaging portion includes a thickened dorsal portion 66. The thickened dorsal portion 66 is co-knitted into the material at this portion to provide a thickening of the sock 10, to provide additional padding. When in use, this thickened dorsal portion 66 is positioned under the point where the user's shoe is strapped. The placement of the thickened area 66 at that position is believed to add additional comfort to the user.

[0038] The leg engaging portion 16 can include a plurality of micro-ribs 72 (shown in Fig. 1). The primary purpose of the micro-ribs 72 is to help the sock 10 stay upright and engaged onto the user's leg. As discussed above, the presently known Lycra socks, even though ribbed, have a tendency to fall down on the user's leg, and not stay in their proper position.

[0039] Because of the unitary knitting and non-Lycra material used with the present invention, the socks 10 of the present invention can employ the micro-ribs 72 to create a sock which will stay properly positioned on the user's leg. A thickened portion 74 that includes additional elastic strength is disposed at the top of the leg portion 16, and helps to maintain the leg portion 16 upright, and properly positioned on the user's leg.

[0040] As shown in Fig. 1, the micro-ribs 72 extend circumferentially around the smooth first frontal zone 24, the side first 28A and second 28B turbulator containing zone 28, and most of the smooth rear zone 32. The size of the micro-ribs 72 are minimized (when compared to the ribs of the Lycra Socks) to minimize the turbulence induced by the micro-ribs 72. The smooth leg engaging front zone 24 is designed to embrace the air, without inducing more turbulence than necessary. Inducing turbulence on this smooth front engaging zone 24 does not aid in the aerodynamic efficiency.

[0041] However, it will be noted that the side turbulator containing zones 28A, 28B include three rows 78, 80, 82 of six discrete turbulators 38. These turbulators 38 are shown in the drawings (Fig. 1A) to include a front vertically arrayed first row 78, a middle vertically arrayed second row 80, and a rear vertically arrayed third row 82 of six individual discrete turbulators 38. Turbulators 38 take on the appearance that has similarities to a B2 Spirit Bomber as shown best in Fig. 6 with a pointed narrow leading end 86, and a wider trailing end 88 that comprises three rear-pointing arrow-shaped members.

[0042] In cross-section, the turbulators 38 preferably each add about 1 to 1.25 millimeters of additional thickness to the base thickness of the socks 10. This additional thickness adds turbulence to the air flowing around the first and second sides 28A, 28B of the second zone 28, which introduces turbulence into the boundary layer. By creating a turbulent boundary layer, aerodynamic efficiency is improved, as the airflow is better able to remain attached to the sock 10 surface downstream, resulting in a reduction in the pressure wake behind the sock, as shown in Fig. 4, when compared to a sock that does not include turbulators, as shown in Fig. 4A.

[0043] As shown in Figures 10 and 11, a thickened rear member 50 is disposed approximately at 6 o'clock (180° from the front of the sock 10) which helps to pull together the air streams flowing around the respective left and right sides 280 of the user 286 sock 10, as shown in Fig. 4.

[0044] As discussed above, one aspect of the present invention is that the sock 10 is made in a single knit process that is made from a single material. Through the use of the single knitting process, with a single material, one can place the turbulence-inducing features 38 wherever one wants to along the body of the sock 10, as it is all the same sock 10.

[0045] Preferably, the yarn material from which the sock is knitted comprises a nylon yarn. Most preferably, the nylon yarn comprises a Q-skin® yarn that is manufactured by Fulgar SPA of Strada Casaloldo, 55, 46042 Castel Goffredo (MN)-Italy, whose website is www.fulgar.com. The Q-skin material is described as being a polyamide 6.6 fiber in which silver ions are inserted directly during the spinning process. The presence of the silver limits the bacterial growth, which helps to reduce odor. Fulgar states that the Q-skin material provides the wearer with breathability, freshness, hygiene, and comfort.

[0046] The nylon material is preferably knit using a 200-needle Jacquard knitting machine (not shown). The Jacquard type knitting machine allows one to bring in and drop out additional needles of yarn so that as you are knitting the sock, one can change the thickness of the sock by changing the number of needles being used to vary the thickness or pattern of the sock. See www.xdknitmachinery.com.

[0047] Preferably, the material is knitted so that the turbulators 38 have approximately somewhere between 1.0 and 1.25 millimeters of additional thickness when compared to the rest of the sock. Essentially, by varying the number of needles, one can vary the thickness, and by using a greater number of needles, one can increase the thickness of the material.

[0048] As is common in the industry, the yarn itself is created by Fulgar, or some other yarn manufacturer, and then sent to a fabric manufacturer, who knits the yarn to form a piece of fabric, and then shapes or forms into a fabric item having a desired size and shape for the desired finished product, such as shirts or stockings.

[0049] As shown in the drawings, the foot-engaging first portion 14 of the sock 10 is generally knit to have a smooth exterior surface. In deciding the pattern, one tries to achieve a balance between flexibility, comfort, strength, and ability to hold the sock up on the leg. For the foot-engaging portion, one does not need to be overly concerned with holding the socks up, as they will naturally hold themselves onto the generally horizontally-disposed foot of the user.

[0050] Additionally, one need not be overly concerned with the aerodynamic properties of the foot engaging first portion 14 aerodynamic properties, since the foot portion is generally disposed inside the shoe and, as such, is not exposed to flowing air and will have little aerodynamic impact during use.

[0051] However, considerations of the pattern that is knitted on the second portion 16 that engages the leg and ankle of the user are different. On the leg and ankle portion 16, the ability of the sock 10 to hold on to the leg is more important along with the appropriate aerodynamic properties of the leg portion 16.

[0052] It has been found by the applicant, that micro-ribs 72 are useful in holding the sock up onto the leg. However, when designing the ribs 72, it has been found that preferably very small or "micro-ribs" are preferably used. Small ribs 72 are used because it is desired to provide the smoothest surface possible which still has enough ribs to enable the sock to hold up on the leg.

[0053] As will be discussed below, the applicants believe that they have achieved a maximized aerodynamic efficiency, while providing a primarily smooth surface on the ankle or leg-engaging second portion 16 of the sock 10, while selectively placing the turbulence-inducing turbulators 38 in places where they can have the most profound and positive aerodynamic effect. One feature that one does wish to pay particular attention to on the foot first engaging portion 14 is breathability, and the cross-hatched surface of the first portion 14 as shown in the photographs that accompanied the above-referenced provisional applications does help to enhance breathability.

[0054] These provisional applications are incorporated by reference in their entirety into this application. Figs. 3 and 4 show the leg-engaging portion 16 that is exposed to flowing air, and includes the turbulators 38, or aerodynamically enhancing the flow of air past the leg portion.

[0055] There are three primary zones of the second portion 16, including the front zone 24, the rear zone 32, and the two side zones 28A, 28B. The side zone 28 includes a first side turbulator-containing zone 28A and a second side turbulator-containing zone 28B. Generally, the first and second side turbulator-containing zones 28A, 28B are generally similar.

[0056] As a point of reference, see line W-W (Fig. 3) which comprises a laterally-extending diameter line which extends through the thickest part of the leg.

[0057] In cross-section, it will be noted that the leg is somewhat oval shaped. The front zone 24 is designed to be a smooth air-engaging surface. As discussed above, the front smooth air-engaging zone 24 contains no turbulators 38, but does contain micro-ribs, which although detracting from the smoothness of the surface, enhance the sock by improving the sock's 10 ability to stay up and engage with the user's leg, especially when the sock 10 gets wet.

[0058] It will be noted that the front zone 24 is defined generally between lines A-A and is disposed generally at the front of the leg. The front section 24 is preferably generally smooth, because the airflow around the front zone 24 is generally the laminar.

[0059] Generally, separation takes place predominantly at about lines W-W which are the thickest portions of the leg. However, it has been found that the first set of turbulators 38 should be positioned not at the widest point, W-W of the leg, but rather be disposed a little forwardly of the center line W-W. It has been found by the applicants, that the first turbulator is preferably located at about 20 degrees forward from the diameter line W-W at about the position of line B.

[0060] There are several reasons that the applicants have found enhanced aerodynamic efficiency occurs when placing the turbulator forwardly of the center diameter line W-W. One of the reasons relates to the angle of the leg as it moves through the air when riding a bicycle. Because the leg is moving, and because the air often comes from variable directions, the area of maximum air split, which is the area where you have air separation, will not always be aligned at the center line point W-W, but may be forwardly of that.

[0061] By placing the turbulators 38 at about 20 degrees in front of the center line W-W, the socks 10 have a better ability to create turbulence in crosswinds and the like, or when the user has his/her leg canted at an angled position, and not straight forward. The second, or turbulator containing zone 28 is positioned in the areas between lines A and C, and the rear zone is the area generally between lines C-C (Fig. 3).

[0062] In the drawings, it is shown that the turbulators include a first (forward) 78, second (middle) 80, and third (rearward) 82 array of vertically disposed discrete turbulators 38. Each of the arrays comprises six individual "stealth bomber" shaped turbulators 38. Of the three rows of turbulators 38, the row that has the greatest influence on the airflow is the first, or forward, set 78 of turbulators 38. It is believed that the second 80 and third 82 rows of turbulators 38 also create turbulence, but do have as large of an impact on the airflow of the first row 78 of turbulators 38.

[0063] The rear zone 32 of the sock 10 is generally smooth except that it should have a raised portion shown as the ribbon-shaped thickened rear member 44 that is disposed at the back center of the sock 10, approximately 180 degrees from the leading edge of the stocking 10. It has been found that placing a thickened portion 44 at the rear of the sock helps to improve airflow by discharging the air that flows off the back of the sock in the laminar matter, to thereby reduce turbulence at the rear of the sock 10.

[0064] As shown in Fig. 4A, turbulence TR at the rear of the sock is a significant contributor to aerodynamic drag. By reducing this turbulence TR, one helps to significantly reduce aerodynamic drag. In Fig. 4A, it will be noted that the large turbulent zone TR extends behind the sock, which is much larger and more turbulent than the turbulent zone that exists behind the socks with the turbulator 38 (Fig. 4).

[0065] The turbulence that is downstream in the flow of air, and is shown to be a much greater area in Fig. 4A (the prior art) than the present invention, causes drag on the object flowing through the air. This drag is referred to as suction drag. In order to increase aerodynamic efficiency, one wants to reduce the size of this suction drag area. As will be noted, the sock without the turbulator (Fig. 4A) has a larger suction drag area than the sock with the turbulators (Fig. 4) and, as such, creates more suction drag, when compared to the sock of the present invention with a turbulator (Fig. 4).

[0066] This reduction in suction drag is believed to be a significant contributor to the increased aerodynamic efficiency of the sock 10 of the present invention when compared to the prior art socks 98 (Fig. 4A). The aerodynamic efficiency of the sock of the present invention has been shown by testing conducted by applicants.

[0067] This testing demonstrated that the aerodynamically enhanced sock 10 of the present invention is faster than the standard knit sock. This "fastness" is measured by watts of energy saved. Depending upon the speed at which the sock 10-containing leg is going through the air, and the angle of the leg to the wind, the applicants have found that the aerodynamic sock of the present invention (Fig. 4) is approximately four to nine watts faster than a knit sock 98 such as is shown in Fig. 4A.

[0068] When compared to the fastest known Lycra socks, the sock of the present invention is either on par or possibly significantly faster than the Lycra-type aerodynamic socks discussed above.

[0069] However, even if the sock of the present invention was no more aerodynamically efficient than the known Lycra sock, it is likely that the sock of the present inventions would still have advantages which make it a better choice than the Lycra socks.

[0070] One advantage is that, unlike the Lycra sock, the design and material of the present invention are significantly more likely to engage the leg, and not fall down during use, and especially when the sock gets wet.

[0071] A further advantage, is that the sock 10 of the present invention is believed to be much less expensive to produce than the two-piece Lycra sock. This can provide a significant cost advantage to the manufacturer, and possibly the user.

[0072] Your attention is now directed to Fig. 6, which shows one of the turbulators 38 that, as described above, bears a top profile reminiscent of that of a Stealth bomber. The turbulator includes a leading point 86, and first and second leading edges 87 and 89, three rear-corner points 92, 94, and 96, and two interior corners 100 and 102.

[0073] The three trailing corners 92, 94, and 96 form micro-vortices that want to curl over the surface to introduce energy into the flow of air thereover, which causes the air to want to stick down onto the surface. In this regard, faster and higher flow rates cause the airstream to be much more difficult to separate from the surface than lower energy flow.

[0074] The two interior corners at the back, 100 and 102, actually create a small suction that wants to pull the air flow down against the sock even more. These corners 100, 102 induce a little negative pressure that wants to turn the air down. The trailing edge center point 94 can actually form additional micro-vortices to help pull the airstream down onto the surface of the sock.

[0075] The turbulators induce turbulence with the turbulators and because of the suction, that turbulence is held against the surface of the sock, and reducing the ability of the air flow to separate from the sock. Points 92, 94, and 96 create the turbulence, and interior corners 100 and 102 serve as suction vortices that hold down the flow.

[0076] In this manner there is created a turbulence-inducing member which is not only efficient in creating turbulence, but also helps to maintain the turbulence-containing airflow close to the surface of the sock.

[0077] Upwind of the turbulator 38 the flow of air is laminar. As the air flow moves around the leg, it starts to separate. In terms of energy, you have relatively low surface energy flow at the front zone 24of the sock, but the flow direction is pushing on the surface. As the air flows around the sides 28A, 28B of the sock 10, the air wants to accelerate. If there is not enough energy in the flow, it separates and creates a big suction area TR (Fig. 4A) behind the leg that, in most cases, would be about the cross-sectional area of the leg. Using the turbulator to induce these little vortices, you are adding energy to the flow, which makes the airflow want to stick down close to the sock 10, and ride the sock around the curve at the rear of the leg. If this is done properly, the end result is to provide a suction zone behind the back of the leg, that has an area of less than half the frontal area of the leg.

[0078] The turbulator 38 puts energy into the flow, to thereby reduce overall aerodynamic drag. Although you are probably adding about one or two percent of skin drag by the use of the turbulators 38, you are still reducing the suction and pressure drag by about as much as half at the rear (downwind) portion of the leg. The net result is that a little bit of investment in increased skin drag results in a significant savings of drag overall. It is believed that you are probably adding about three percent of skin friction drag while achieving a 15 percent savings.

[0079] It is also helpful to use a yarn with a high thread count that is very elastic. A very thin yarn should be used at the frontal area 24 of the sock and a relatively thicker yarn should be used to form the turbulators 38.

[0080] Having described the invention in detail with reference to certain preferred embodiments, it will be appreciated that the description rendered herein should not be viewed as limiting the scope of the protection afforded to the invention.

Claims

1. An aerodynamically enhanced appendage covering (10) comprising a first portion (14) that is not subject to significant airflow and a second portion (16) that is positioned to engage significantly more airflow when placed on a moving body (MB), at least a part of the second portion (16) including an aerodynamically enhanced area,
   the aerodynamically enhanced area including a first frontal zone (24), a second turbulence inducing zone (28), and a third rear zone (32), the frontal zone (24) being configured to have a relatively smooth surface for inducing a relatively lesser amount of turbulence on air flowing past than the second zone, the second zone (28) having a relatively less smooth surface and including a plurality of turbulence inducing features (38) configured for creating a boundary layer (40) for inducing turbulence in air flowing past the second zone (28).

2. The appendage covering of claim 1 wherein the second zone (28) includes a relatively recessed surface portion (42) and a relatively raised surface portion.

3. The appendage covering of claim 2 wherein the turbulence inducing features (38) are disposed on the relatively recessed surface portion (42).

4. The appendage covering of claim 2 wherein the turbulence inducing features (38) are disposed on the relatively raised surface portion.

5. The appendage covering of any preceding claim wherein the turbulence inducing features (38) comprise a plurality of discrete turbulence inducing features (38).

6. The appendage covering of claim 5 wherein the turbulence inducing features (38) comprise at least two rows (78, 80, 82) of discrete turbulence inducing features (38).

7. The appendage covering of any preceding claim wherein the turbulence inducing features (38) have a generally delta-like shape with a narrow leading end (86) and a relatively wider trailing end (88).

8. The appendage covering of any preceding claim wherein the third zone (32) of the aerodynamically enhanced area includes a relatively smoother surface than the surface of the second zone (28).

9. The appendage covering of any preceding claim wherein the second, turbulence inducing zone (28) is disposed between the first (24) and third (32) zones and wherein the third zone (32) includes a third zone raised portion (50) configured and positioned for directing a pair of air streams flowing past the second zone (28) to merge at the rear of the appendage covering (10).

10. The appendage covering of any preceding claim wherein the appendage covering (10), when placed on a body, has an upwind side and a downwind side, the first zone (24) is disposed at the upwind side of the appendage covering (10), and the third zone (32) is disposed at the downwind side, and the second zone (28) is disposed between the first (24) and third zones (32).

11. The appendage covering of claim 10 wherein the appendage covering includes an imaginary plane (W-W) extending laterally to the direction of airflow, and generally bisecting the appendage covering (10), wherein the turbulence inducing features are disposed on the second zone (28) between about 45 degrees upwind of the plane (W-W) and 45 degrees downwind of the plane (W-W).

12. The appendage covering of claim 11 wherein the turbulence inducing features (38) are disposed between about 25 degrees upwind of the plane (W-W) and 25 degrees downwind of the plane (W-W).

13. The appendage covering of claim 9 or any of claims 10 to 12 when dependent on claim 9 wherein the third zone raised portion (50) is ribbon shaped and extends in a direction generally perpendicular to the direction of flow of the air streams.

14. The appendage covering of any preceding claim wherein the first portion (14) and second portion (16) meet at a transition area that contains no seam.

15. The appendage covering of any preceding claim wherein the turbulence inducing features (38) add between about 0.9 and 1.5 mm, preferably between about 1.0 and 1.25 mm, to the thickness of the second zone (28).

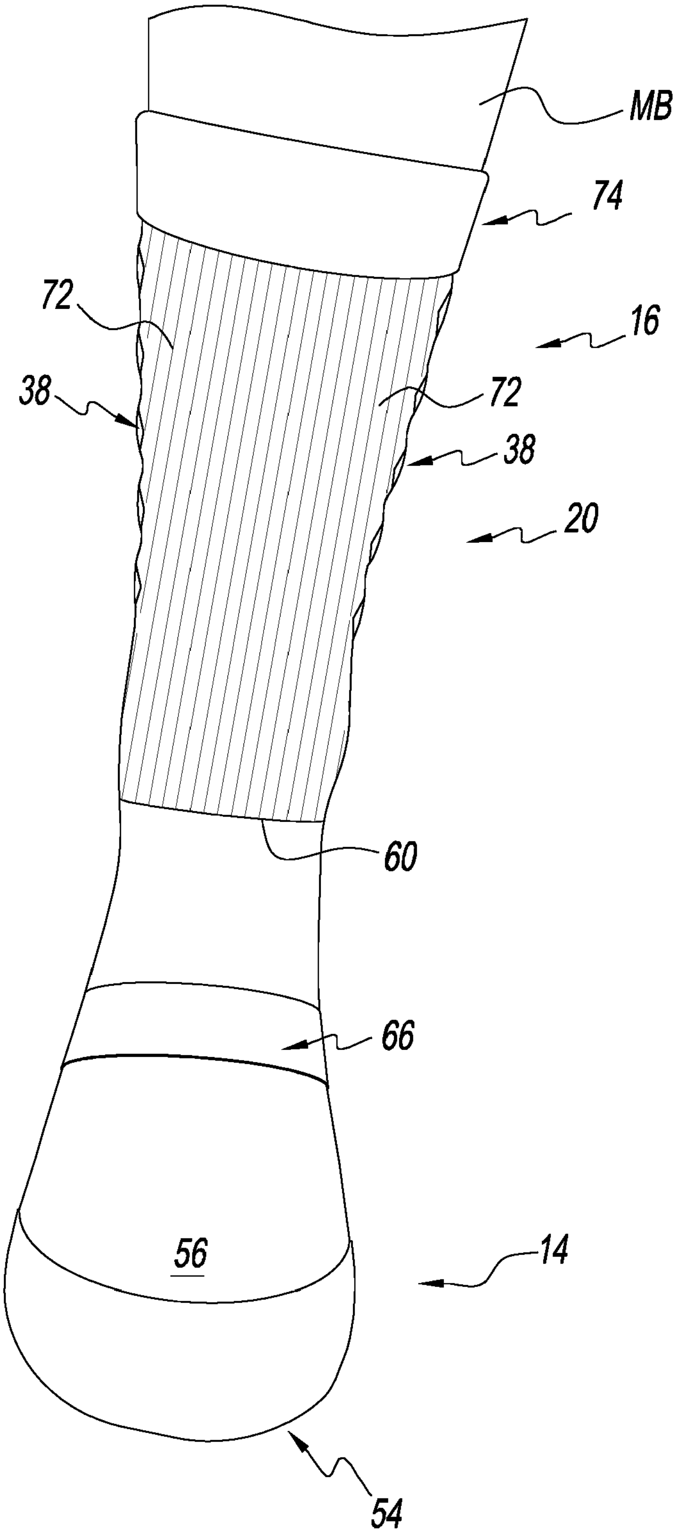

FIG. 1

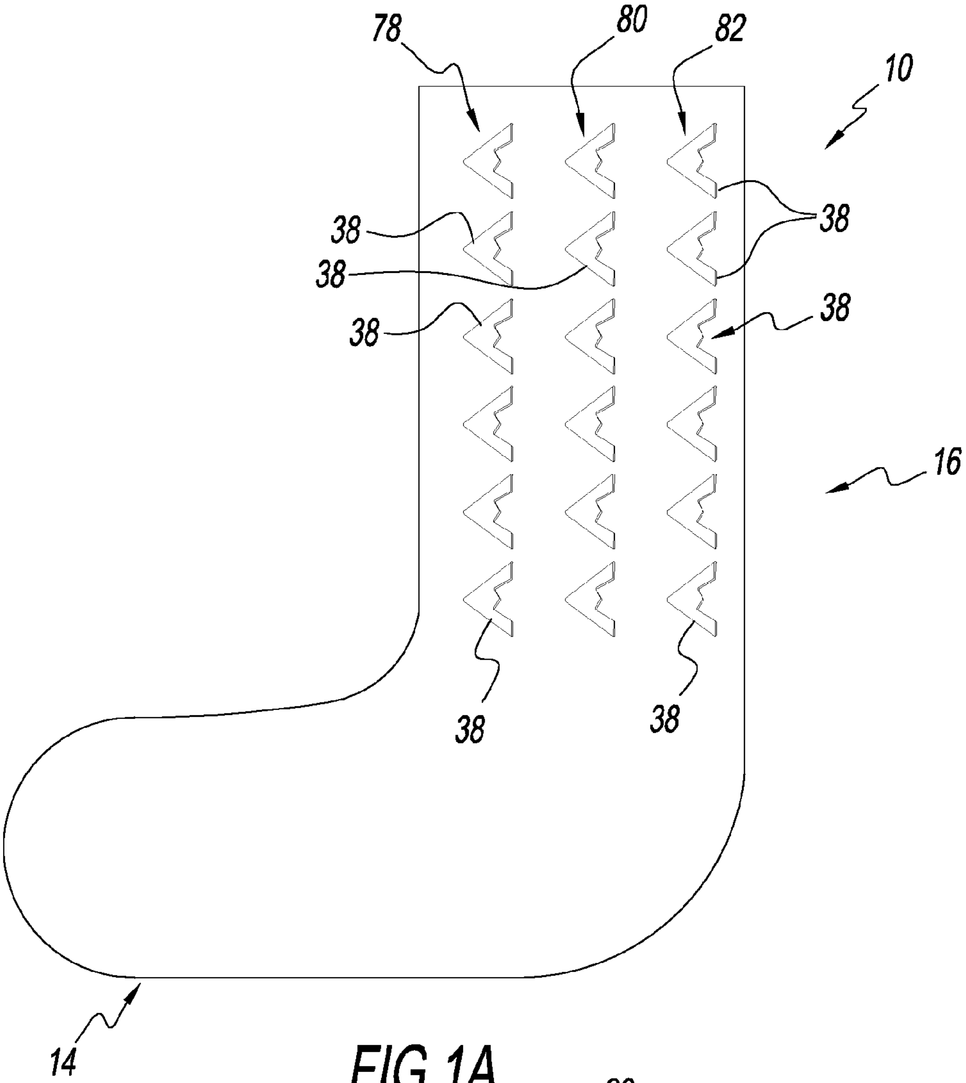
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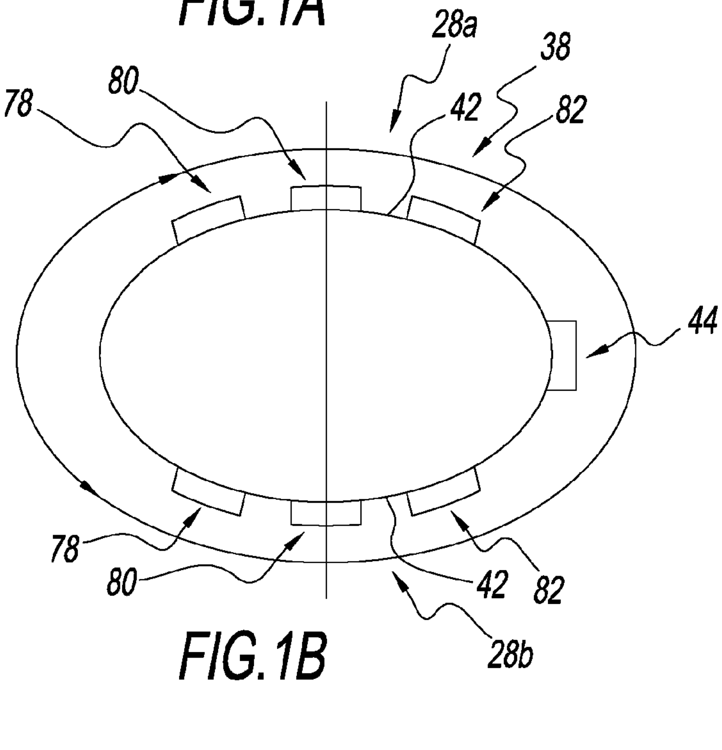
FIG.1A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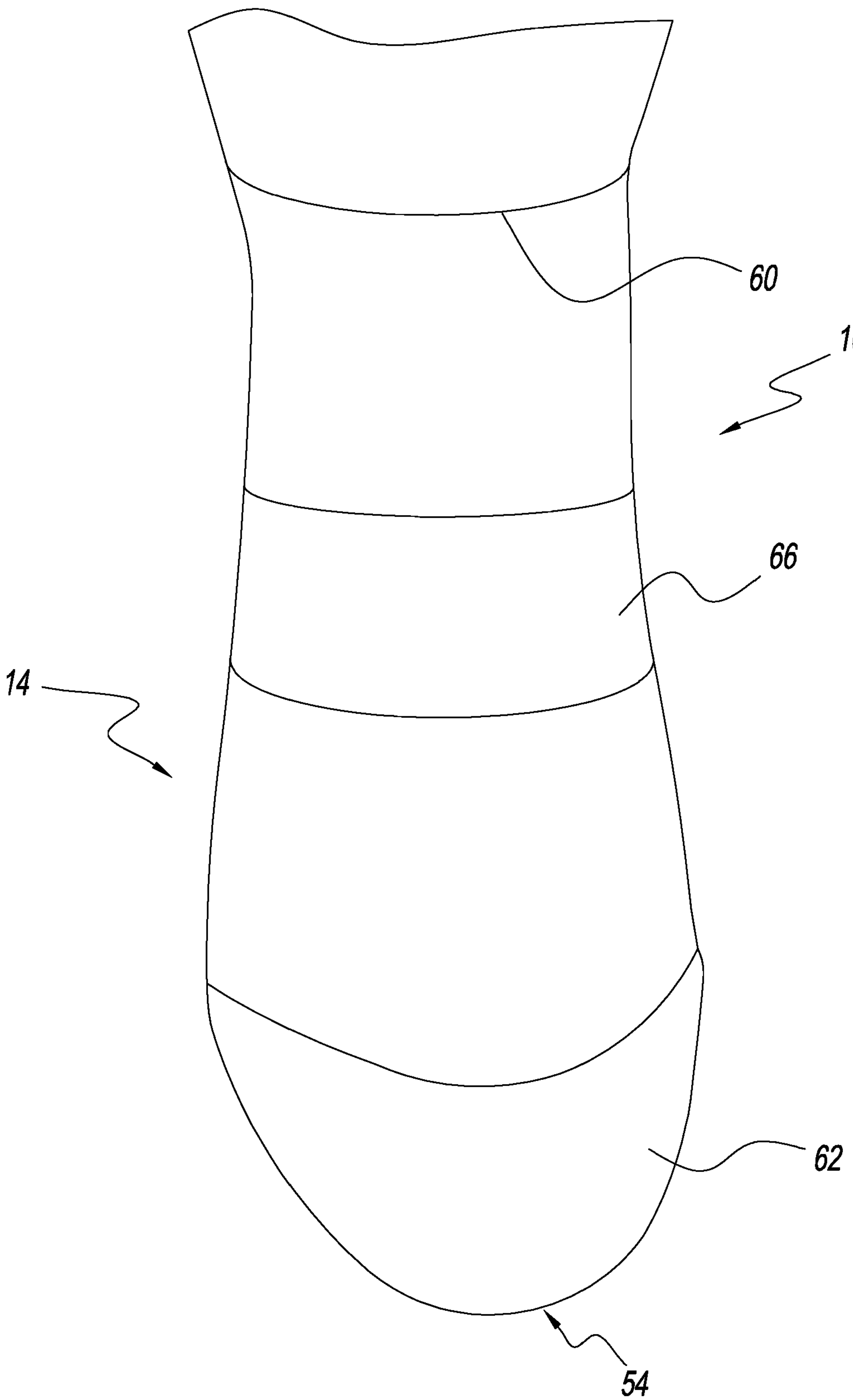
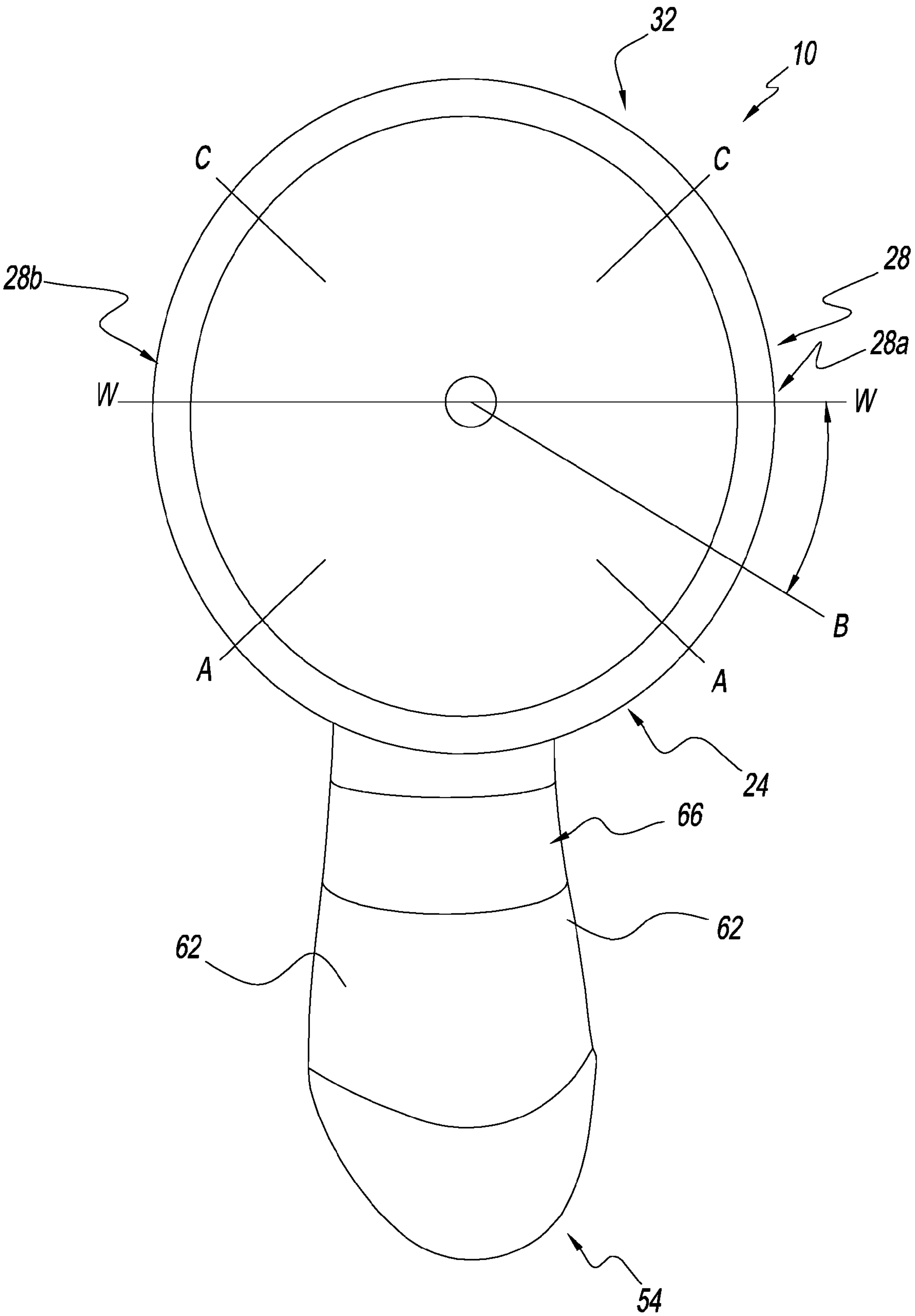


FIG. 2



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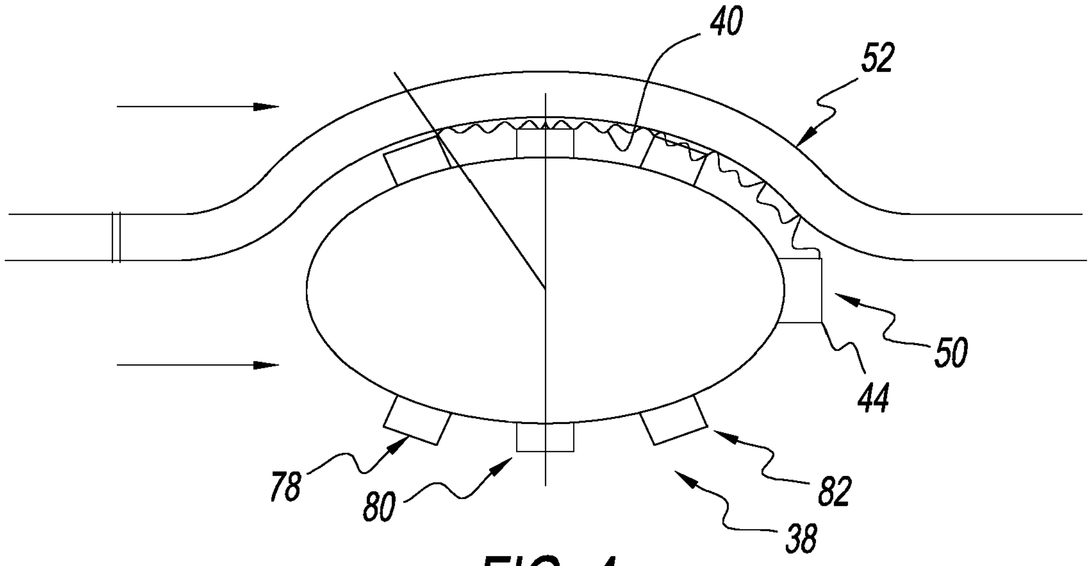


FIG. 4

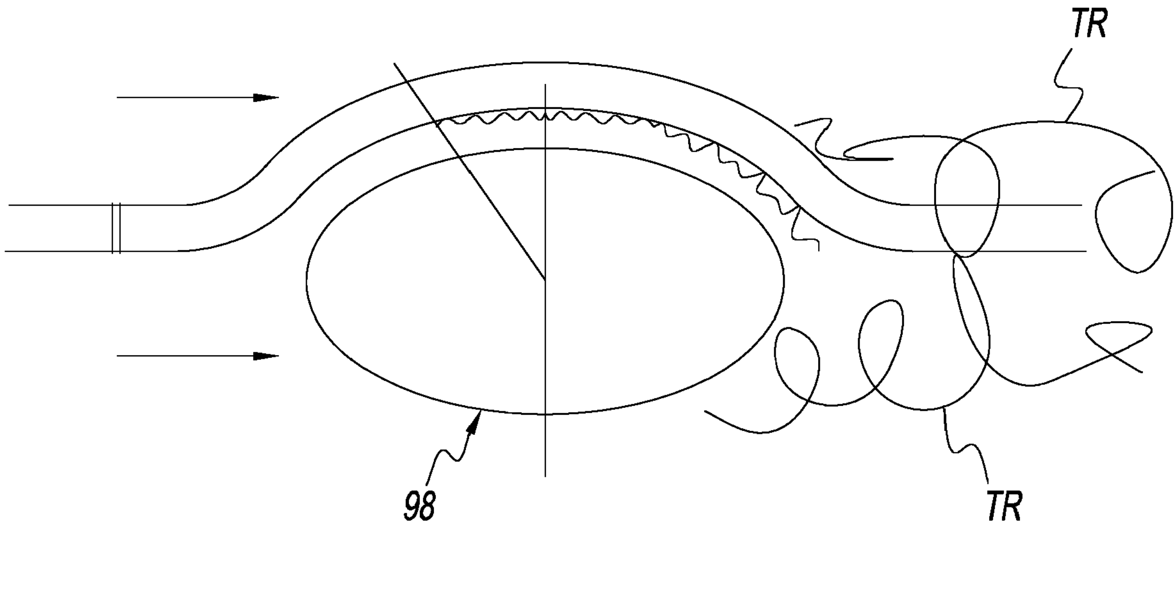
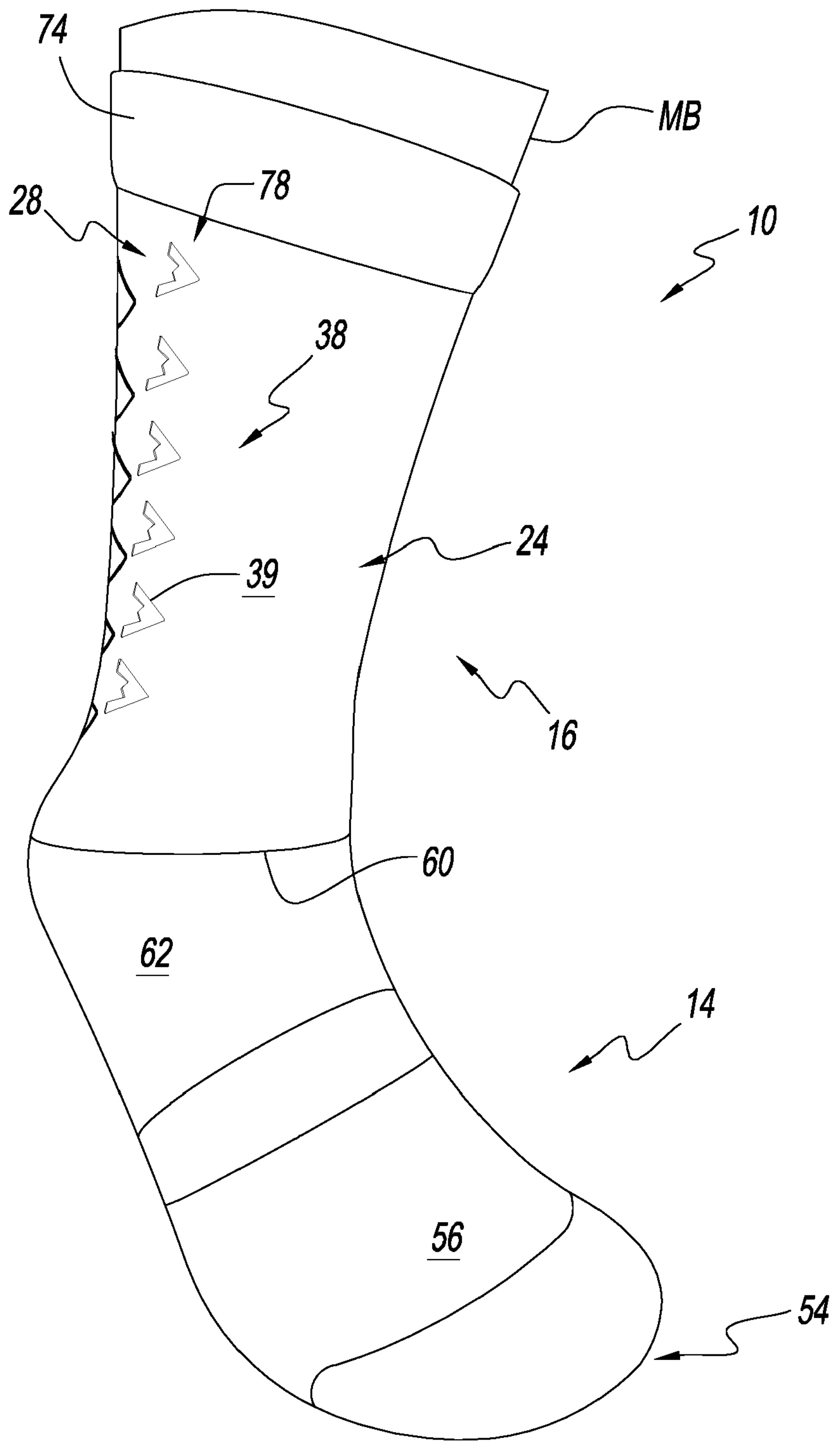


FIG. 4A



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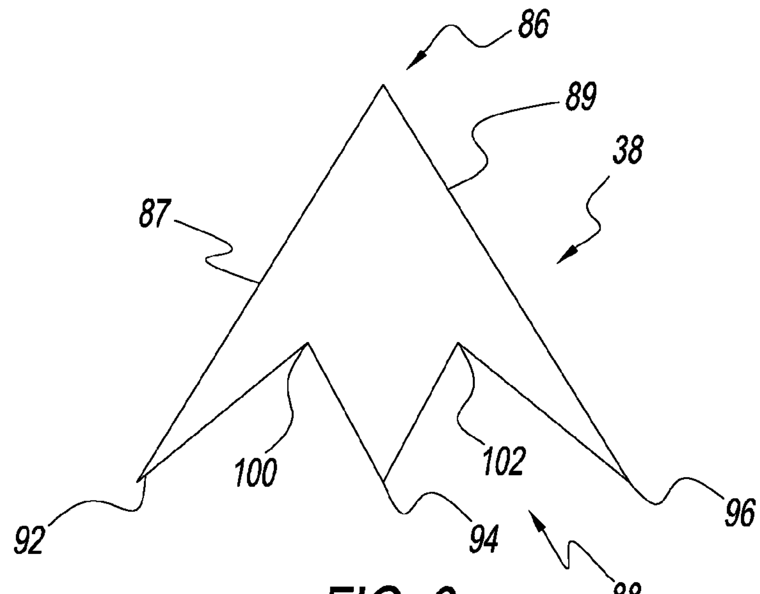

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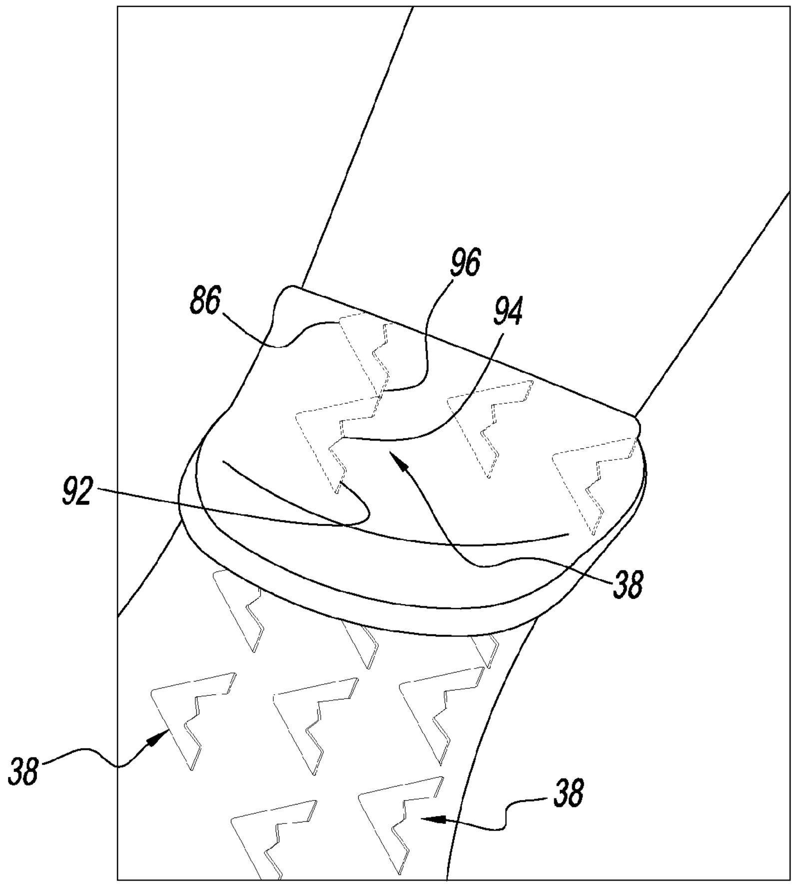

FIG. 7

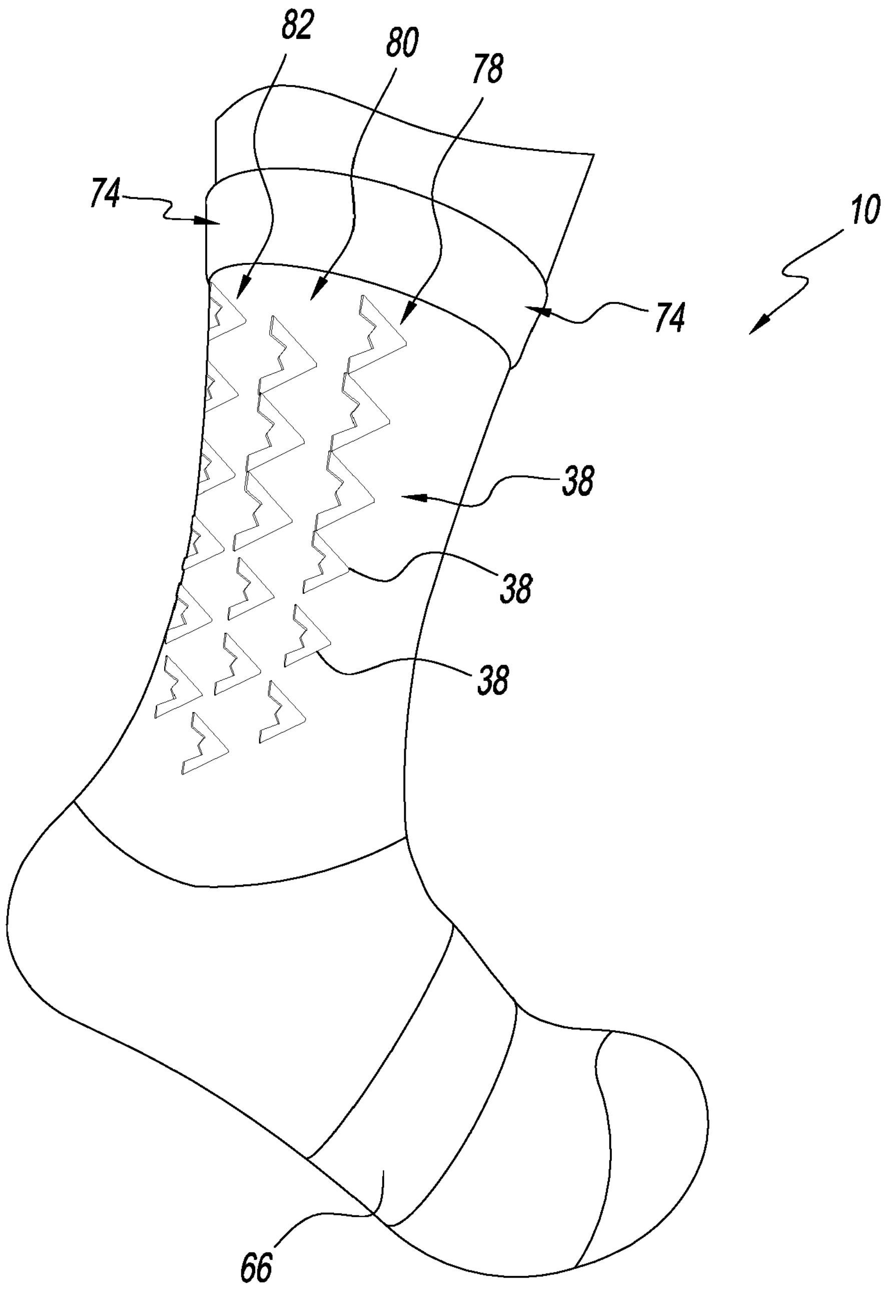

FIG. 8

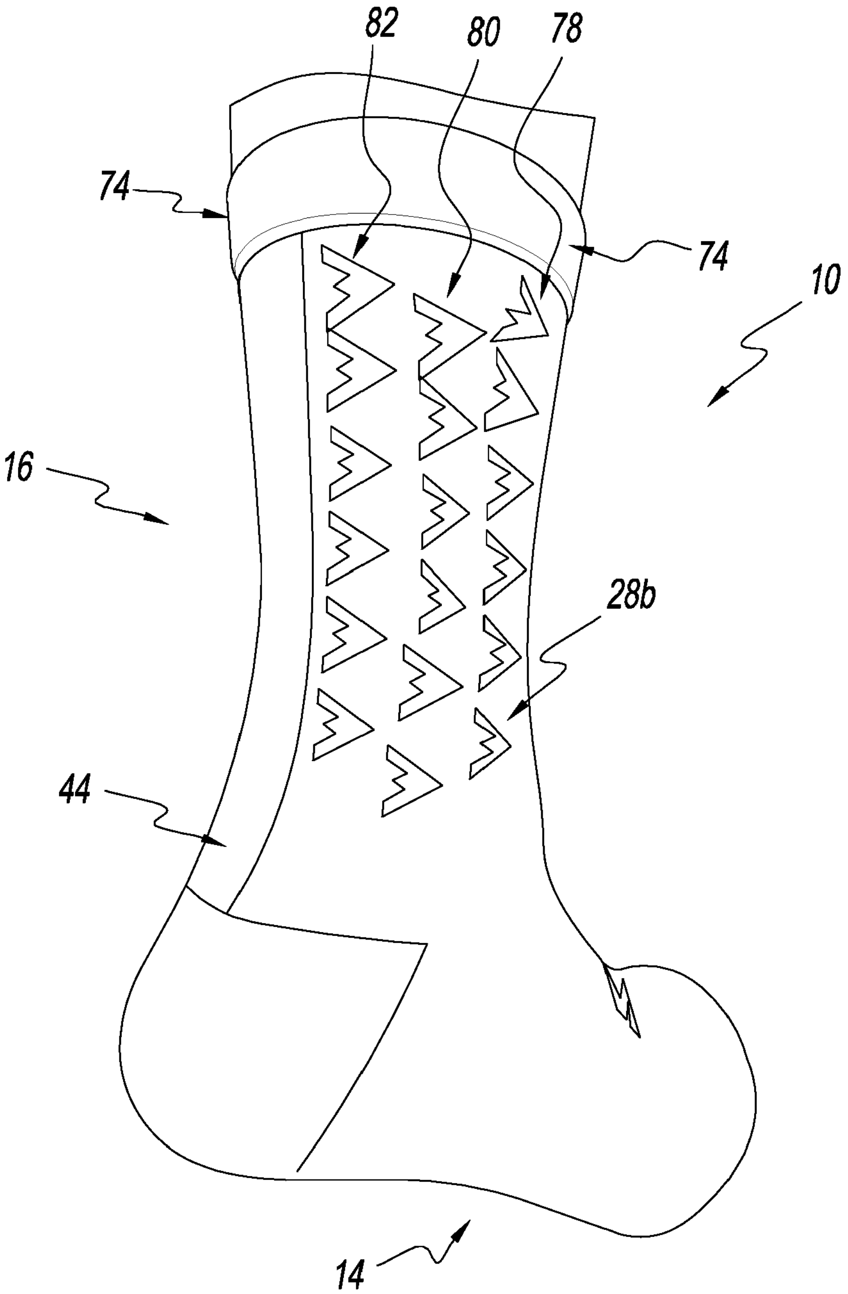

FIG. 9

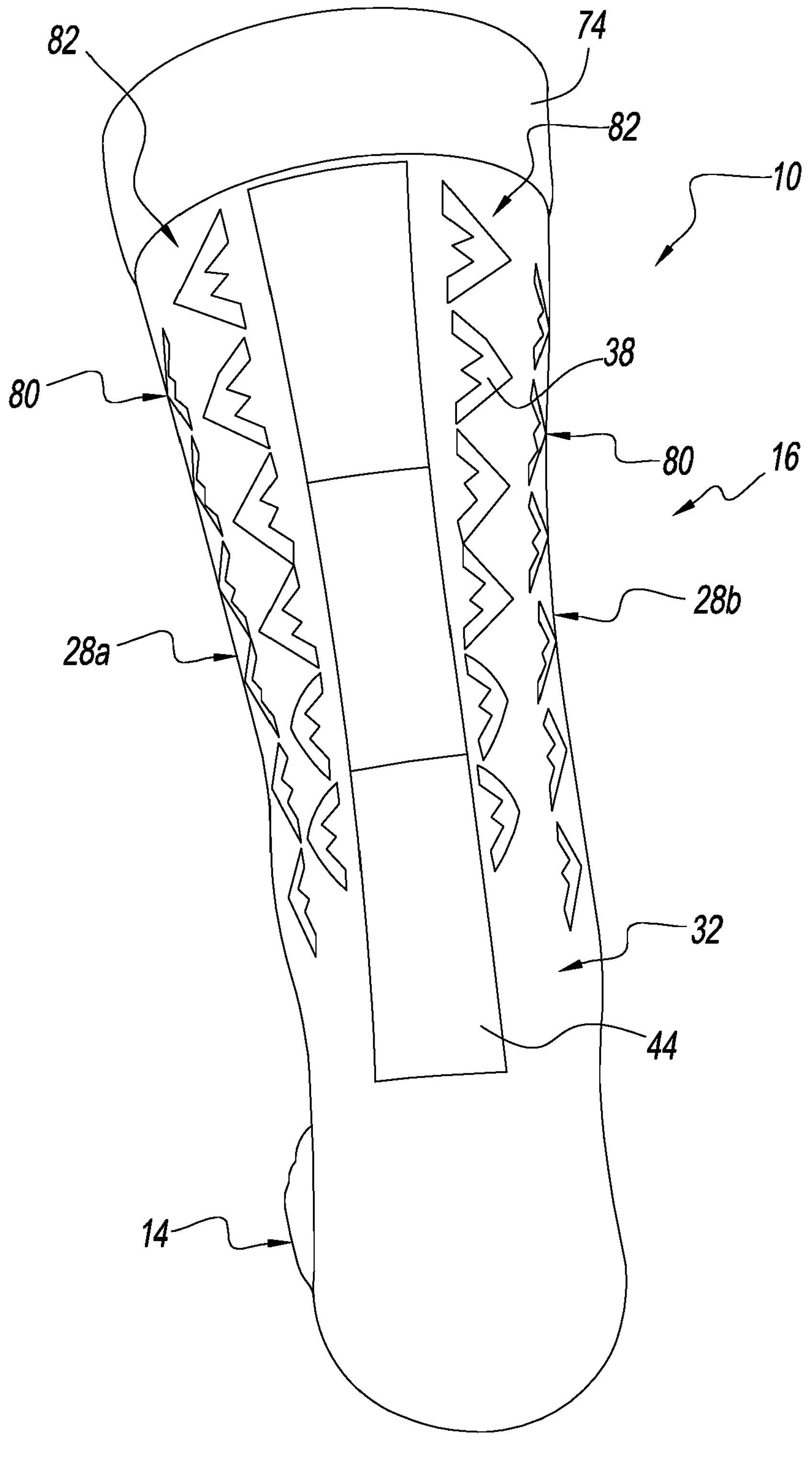

FIG. 10

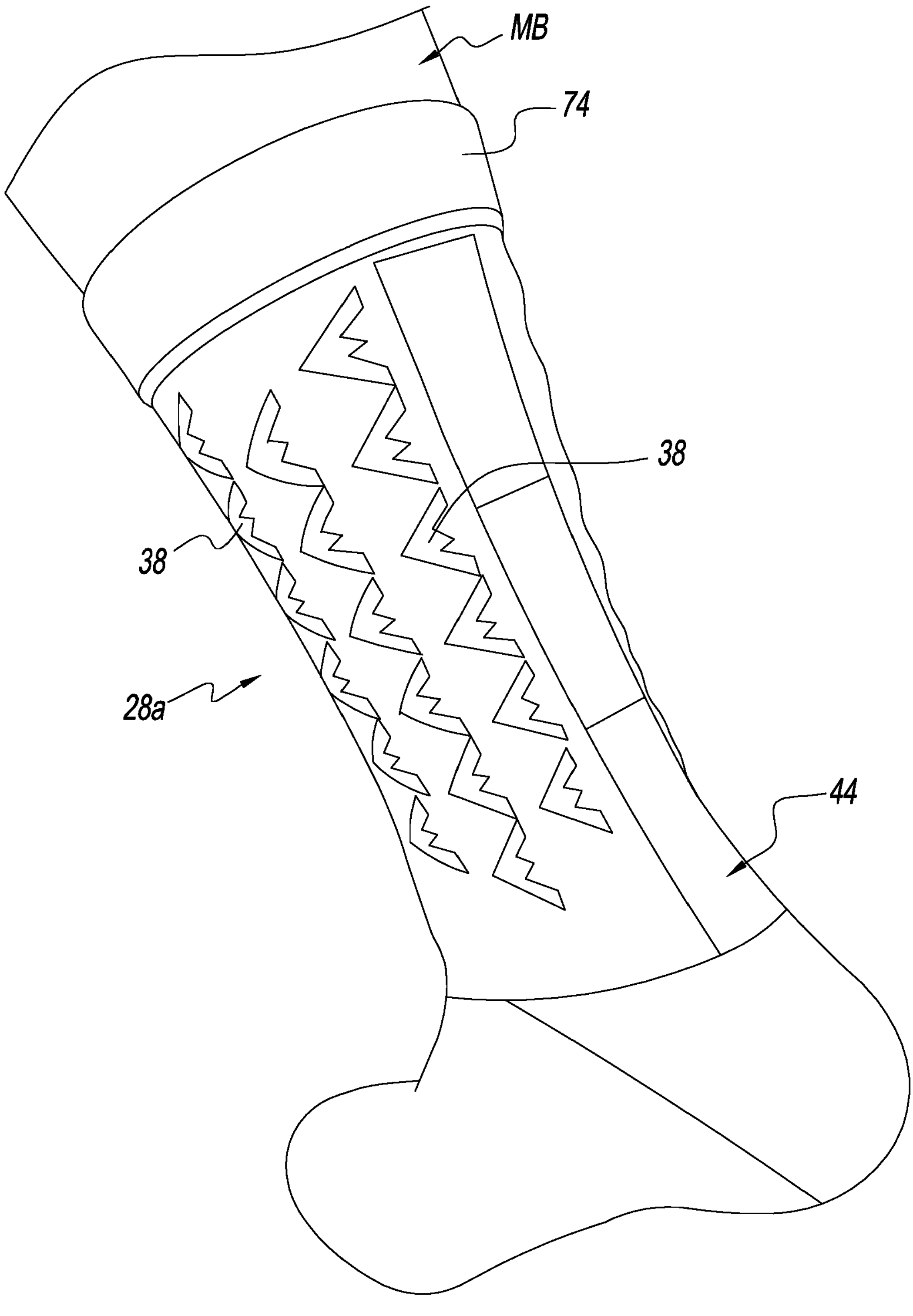

FIG. 11

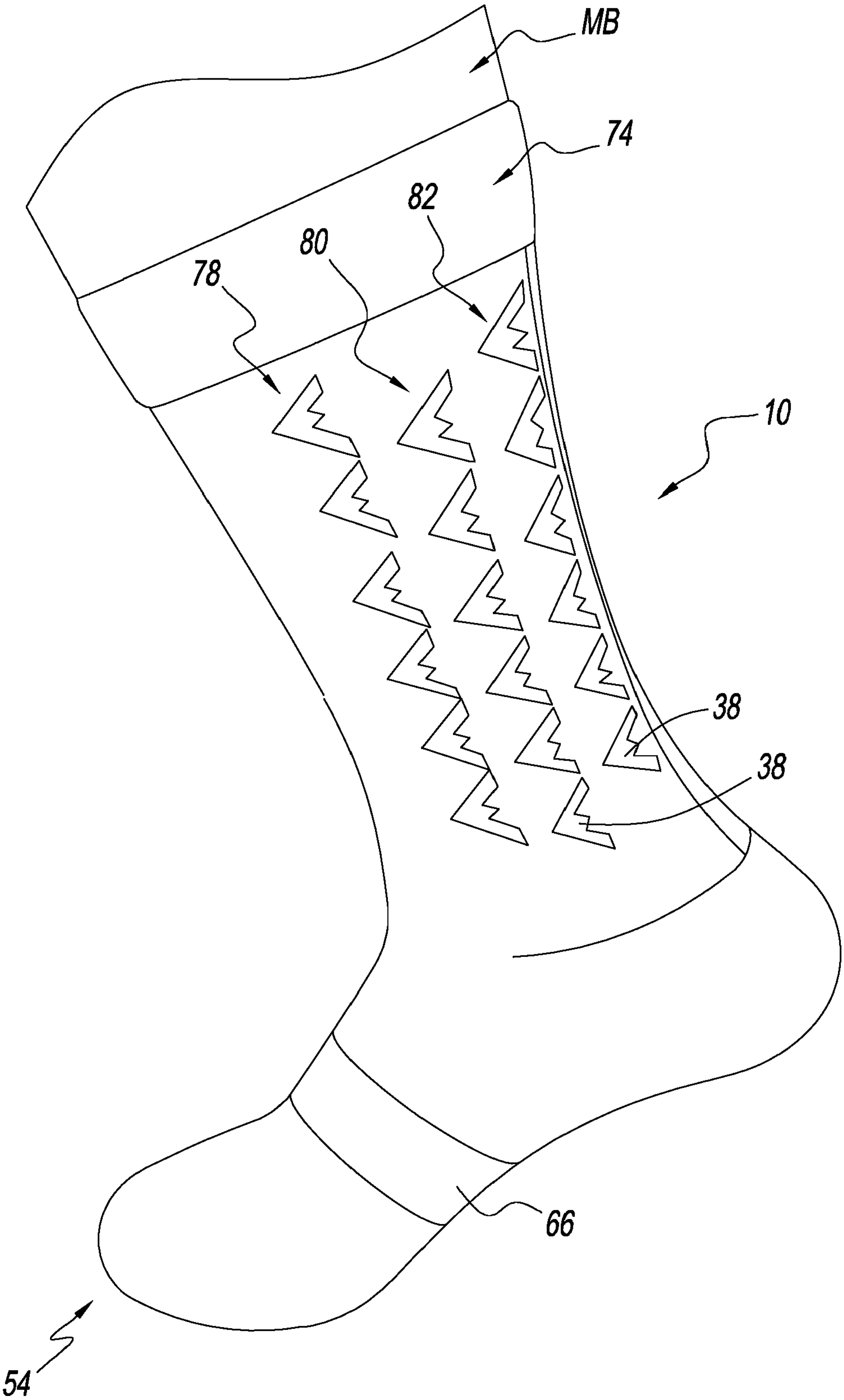

FIG.12

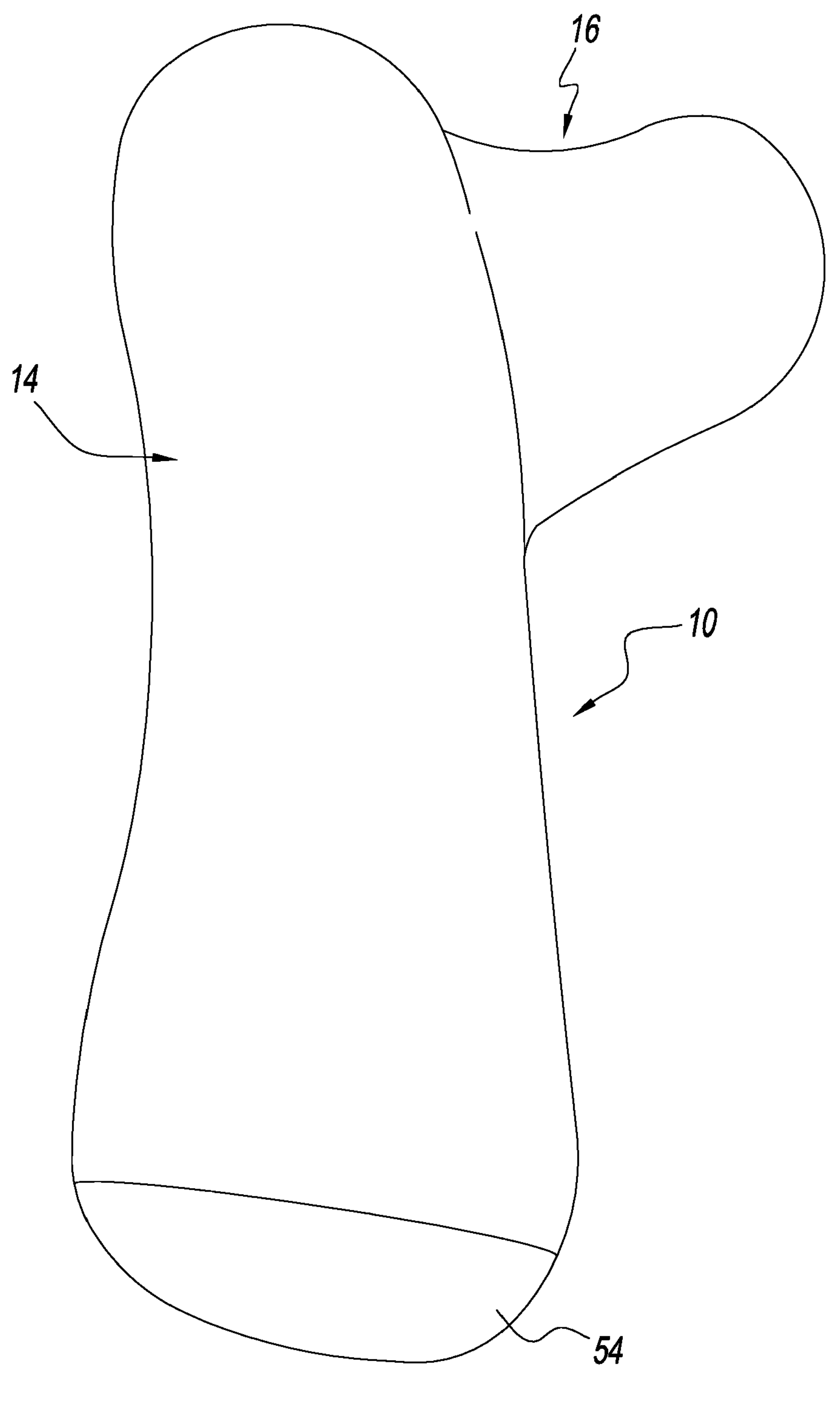

FIG. 13

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EUROPEAN SEARCH REPORT

Application Number
EP 22 18 6594

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2016/302495 A1 (SMART SIMON [GB]) 20 October 2016 (2016-10-20) * the whole document * -----	1,2,4-7, 9-12,14, 15	INV. A41B11/00
X	US 2008/189825 A1 (WRIGHT STEVEN P [US] ET AL) 14 August 2008 (2008-08-14) * the whole document * -----	1-3, 8-11,13, 14	
X	EP 3 311 686 A1 (SMART AERO TECH LIMITED [GB]) 25 April 2018 (2018-04-25) * the whole document * -----	1-3,5-7, 9-12,14	
X	US 2018/035727 A1 (CUMISKEY MARK [US] ET AL) 8 February 2018 (2018-02-08) * the whole document * -----	1-6,8, 10,14	

TECHNICAL FIELDS SEARCHED (IPC)

A41D
A41B

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	15 November 2022	Debard, Michel

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 22 18 6594

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15-11-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2016302495 A1	20-10-2016	EP 3085258 A1	26-10-2016
		ES 2731884 T3	19-11-2019
		GB 2537815 A	02-11-2016
		US 2016302495 A1	20-10-2016
US 2008189825 A1	14-08-2008	US 2008189825 A1	14-08-2008
		US 2011162122 A1	07-07-2011
		US 2012192334 A1	02-08-2012
		US 2013133123 A1	30-05-2013
		US 2014230122 A1	21-08-2014
EP 3311686 A1	25-04-2018	EP 3311686 A1	25-04-2018
		GB 2555570 A	09-05-2018
		US 2018103704 A1	19-04-2018
US 2018035727 A1	08-02-2018	US 2018035727 A1	08-02-2018
		US 2019059467 A1	28-02-2019
		US 2019082752 A1	21-03-2019

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 63225486 A, Poertner **[0001]**
- US 63231416, Poertner **[0001]**