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PATENT SPECIFICATION

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(54) IMPROVED KNITTED SOCK

(71) We, FOLETCO LIMITED (formerly Prestige Limited), a Company incorporated under the laws of the State of Victoria, Australia, of 204 Sydney Road, Brunswick, in the State of Victoria, Australia, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with knitted socks for men, women and children. The invention is particularly, but not exclusively, applicable to socks having a leg length not extending above the mid-calf part of the human leg when in normal position during wear. Included in this category of socks are items known as "short socks", "ankle socks", "anklets", "half hose", "crew socks", "below-the-calf socks", "mid-calf socks".

In the period, prior to approximately 1935, socks, as distinct from stockings which reached over the knee, were chiefly of a length reaching to the wearer's knee, or else to the mid-calf part of the wearer's leg, the latter being known as "half-hose". In order to restrain the leg of the knee length socks from slipping down a wearer's leg whilst walking, circular garters generally made from rubber elastic braid were used. The leg of the half-hose type of sock was restrained from slipping by suspenders, attached to the wearer's leg between the knee and calf muscle, and clipped to the sock adjacent to the upper edge thereof.

Approximately forty years ago technology was developed for the laying of rubber elastic thread into the stitches of knitted fabric, and this technology was used to produce socks with such thread laid into a number of knitted courses at or adjacent to the upper edge of socks. The thread so laid into the knitted fabric constituted an elastic band at the upper portion of a sock leg.

The purpose of the elasticated upper region was the incorporation within the sock of means of restraining the leg portion from slipping down a wearer's leg during walking, thus eliminating the need to have extraneous means of restraint as described above. The elasticated upper portion in a below-the-calf sock is stretched when initially placed on the leg and thus grips the leg of a wearer. After a period of wearing, during which the wearer walks with a normal gait and speed, it is usual for a sock to progressively slip down the wearer's leg, forming wrinkles in the fabric of the lower part of the leg of the sock. This slippage commonly occurs even when the elasticated upper portion exerts pressure on the leg of such magnitude as to cause temporary skin indentation and irritation.

It has been the practice to knit a below-the-calf sock with a constant length per course for the yarns (other than the elastic thread in the elasticated upper portion) in the leg fabric, thus giving a constant circumferential tension in the sock as knitted and therefore a decreasing fabric circumferential tension in wear from the uppermost part of the leg to approximately the ankle part, which has further failed to provide a sock with adequate resistance to slipping down the leg of a wearer in use.

It is recognised that the part of the human leg from the mid-calf to the area of minimum girth is approximately the shape of an inverted truncated cone. This shape contributes to the promotion of slippage of the socks during walking as any downward movement of the uppermost portion of the sock on the leg brings that uppermost portion onto a part of the leg of smaller circumference and hence reduces the circumferential tension in the fabric of the uppermost portion of the sock. This reduction in the circumferential tension results in a similar reduction in the frictional grip between the leg and the sock and consequently promotes further slippage. Also as the

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circumferential tension in the lower portion of the sock is lower than in the upper portion of the sock, the lower portion of the sock does not offer any resistance to the downward slippage of the upper portion of the sock.

There has been produced surgical or therapeutic hosiery, sometimes also referred to as "support" stockings or pantyhose. In this sense "support" means that the stocking gives "support" to the leg of the wearer and not that the stocking has a self-supporting or stay-up character. Therapeutic stockings are designed with blood circulation in the leg in mind, and aim at achieving substantially constant circumferential tension in the stocking fabric over the majority of the length of the leg of the wearer. Accordingly stockings designed for therapeutic purposes do not exhibit stay-up qualities.

It is the purpose of the present invention to provide a sock, particularly but not exclusively, one with leg length not extending above the mid-calf portion of a wearer's leg, which provides improved resistance to slipping down the wearer's leg as a result of walking and at the same time cause minimal skin indentation and skin irritation.

The present invention provides a sock constructed to exhibit a selected circumferential tension in the marginal portion at the "top" (as hereinafter defined) of the leg of the sock, the circumferential tension in the sock, in use, progressively increasing from the "top" said marginal portion of the sock to the lower portion of the leg of the sock which fits a statistical average leg at the minimum circumference thereof.

While the circumferential tension at the lower portion of the leg of the sock is relatively high, nevertheless it must not exceed the threshold of discomfort or skin irritation when the sock is on the leg of any wearer.

The progressive increase in circumferential fabric tension may be a constant or varying rate, or it may be step-wise. This may be achieved by varying the stitch length, stitch tension, stitch form, elastic characteristic of the yarn or yarns, or a combination of any two or more thereof.

The progressive increase in circumferential tension from the "top" to lower portion of the sock leg results in any portion of the sock offering resistance to downward movement of the immediate above portion, and thus overall promotes the staying up of the sock on the sock leg.

It will be recognised that in any one population (in the statistical sense) there are considerable variations in dimensions relating to the human leg, and in particular to that part of the calf described above as shaped like an inverted truncated cone.

Also it must be accepted, that for any one design of sock, the behaviour as a result of walking may vary according to variations in a wearer's leg dimensions. Indeed for any one design of sock the effectiveness of resistance to slipping down the leg of the wearer as a result of walking may be measured by the percentage of the population which finds that the design possesses this resistance. Thus the present invention has been defined with reference to its performance on a statistical average leg.

To illustrate what is meant by the term circumferential tension, and its progressive increase from the sock "top" to the lower portion of the sock leg, the table below is an example of results obtained on one experimental sock.

Distance from "top" of sock (cm)	Tension per 1 cm width band at various % extensions in fabric circumference (gram weight)					Tension gradient per cm band per cent extension at 40% extension	
	0%	20%	40%	60%	80%	in gram weight	in mN
2.5	0	37	67	97	126	0.15	1.47
7.5	0	43	78	113	148	0.175	1.71
15.0	0	68	116	162	208	0.235	2.35

The progressive increase in tension gradient described above may be continuous or stepwise or may be continuous in parts and stepwise in other parts of the sock. In the case of stepwise increase in tension gradient it will be appreciated that, due to the tapering form of wearers' legs, the actual tensions on wearers' legs may decrease

slightly between stepwise increases. This has been found to be of no disadvantage provided that the magnitudes of the decreases are small and the general trend of progressive increasing tension is maintained from the "top" of the sock to a point corresponding with the wearers' minimum leg circumference.

While the actual circumferential fabric tension at the lower portions of the wearer's legs may be relatively high, nevertheless it should not exceed the threshold of discomfort or skin irritation.

As it has been recognised that friction between a sock fabric and the wearer's skin helps the sock to resist slipping down the leg as a result of walking, then it follows that fabric circumferential tensions must be adequate to give rise to some frictional force even in the upper parts of the leg of the sock where the fabric tensions are relatively low.

The required tension property of the fabric of the sock may be achieved by incorporating elastic threads into the fabric. These threads may be made either wholly or partly of elastomeric material and/or textured or otherwise processed polymeric filament or fibre imparting elastic quality to the thread.

The variation in the tension may be achieved by varying the quantity of elastic thread or by varying the tension in the thread during the actual incorporation thereof into the fabric. The variation in tension may also be obtained by variation in the form or size of stitch used.

The behaviour of the socks in resisting slippage down the leg as a result of walking is assisted by a relatively high fabric-to-skin friction; such can be obtained with the use of spun yarns in the knitted fabric, and particularly but not necessarily, spun yarns containing wool or cotton.

A suitable knitting machine for production of a sock according to the present invention is one in which there is the capability of altering the length of all or some of the yarns fed (knitted or laid) into the knitting needles at each knitted course or at pre-determined intervals during the knitting of the leg of the sock and/or varying the feed pattern for yarns. As an example of the second alternative a particular yarn may be fed into the needles at every course, every second course or not at all.

Knitting machines may have cylinders varying in diameter from approximately $2\frac{1}{2}$ inches (6 cm) to approximately 6 inches (15.2 cm) and may have a number of needles varying from 36 to 280.

Fabric construction may be plain knit (also known as single jersey), rib knit or jacquard knit.

Sock construction may include a heel pocket knitted by a reciprocating action, or it may be of a "tube" type without such heel pocket and with or without yarn knitted or laid into the tube fabric to form a heel patch. Knitting yarns employed in the production of the sock may be any of those commonly used in the present art. Such yarns may be spun from the following fibres:— cotton, wool, acrylic, polyamide, polyester, regenerated cellulose or may be continuous filament yarns of the following types: polyamide, polyester, regenerated cellulose, spandex (segmented polyurethane), rubber (natural or synthetic). In addition knitting may be performed from any mixtures of any two or more of any of the above mentioned fibres or continuous filaments in the form of blended mixtures, twisted mixtures or as core-spun yarns or wrapped fibres or filament yarns.

This invention particularly concerns the leg portion of the sock, the knitting of the leg and the setting of the leg fabric.

After the completion of the knitting of the leg of the sock, the knitting of the heel, foot and toe is performed according to the chosen design of sock, and according to known art. Following completion of knitting the toe opening (if present) is closed by any of the present available means.

It is an optional current practice to place a sock, if it contains some thermoplastic yarn, on a flat metal former of a shape a little larger than that of the sock in a flat relaxed state. Socks fitted to formers are placed in an autoclave and subjected to steam pressure, or in other vessels and subjected to heat, in order to achieve a moulding and setting of the sock fabric and thus a certain shape to the sock. Depending on whether this is done before or after scouring and dyeing it is known as pre-boarding or post-boarding respectively.

The shapes of the metal formers generally used in the industry for the boarding of socks provides sides of the leg that are generally parallel, and there may be a narrowing of the former at the upper end of the sock in order to accommodate an elasticated upper end. In boarding socks constructed according to the present invention

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the preferred shape of the leg of the former to be used for boarding the sock is that of a truncated cone.

While the chief application of this invention will be in the production of socks of the type previously described, nevertheless it is within the scope of this disclosure to include a sock of which the leg extends above the calf of the human leg in the normal position during wear.

Although the circumferential tension is the specific section of the leg tension may vary considerably depending upon the skin-to-sock fabric friction characteristics, which are influenced by the type of yarn and type of knit, the preferred tensions are:

Fabric location	Loop tension per 25.4 millimetre width when loop extended to 125 millimetre	
	Kilogram force	Newton
Corresponding to minimum circumference in wearer's leg	Up to a maximum of 0.70	Up to a maximum of 6.86
Region of sock adjacent to leg opening	Down to a minimum of 0.03	Down to a minimum of 0.29

The tensions quoted are determined by the ASTM method of measuring "Tension and Elongation of Wide Elastic Fabrics, or equivalent" No. D1775-74.

In order to assist in the practical application of the present invention two examples of constructions of sock will now be described with reference to Figs. 1 and 2 of the accompanying drawing.

Example 1.

The sock shown in Fig. 1 is knitted on an Esta, Model JU3 knitting machine fitted with a cylinder of 4 inches diameter and having 176 needles. The sock has in the leg portion between lines A and E a jacquard fabric construction.

Details of yarn and other characteristics of the fabric in the respective section of the leg of the sock are shown in the following table.

Leg Portion of sock (Fig. 1)	Yarns	No. of Courses of Knitting	Stitch size (mm)	No. of courses of Spandex	Length of Spandex (mm) per Course
A - B	back feed : 2/110 dtex stretch nylon	10	6.9 (nylon)	0	0
B - C	back feed : as above front feed : 37 tex cotton	52	7.3 (cotton)	0	0
C - D	back feed : as above front feed : as above inlay : 156 dtex spandex, double wrapped	182	as above	91	145
D - E	back feed : 2/110 dtex stretch nylon front feed : 37 tex cotton	6	6.9 (nylon) 7.3 (cotton)	0	0

This construction results in a stepwise increase in the circumferential tension in the sock.

Example 2.

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The sock shown in Fig. 2 is knitted on a Komet Model TJ2, knitting machine also having a 4 inch diameter cylinder and 176 needles. The sock has in the leg portion between the lines A and F a fabric construction of 1×1 rib type. Characteristics of the fabric in the respective section of the leg portion of the sock are set out in the following table.

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Leg Portion of sock (Fig. 2)	Yarns	No. of Courses of Knitting	Stitch size (mm)	No. of courses of Spandex	Length of Spandex (mm) per Course
A - B	1/15 worsted count blend of wool and nylon with a core of 44 dtex spandex	4	—	3	145
B - C	and 235 dtex spandex double covered with 44 dtex stretch nylon	36	6.5	12	145
C - D		32	6.0	16	145
D - E		116	5.9	116	145
E - F		4	5.9	0	0

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In this example the required variation in circumferential tension is obtained by varying the number of courses of Spandex relative to the total number of courses in the respective sections of the sock.

5 In this specification reference has been made to the circumferential tension progressively increasing from the "top" of the sock to the part of minimum leg diameter, and in this context the "top" related to the upper edge of a half-hose sock. However the invention also has application to a sock having a longer leg length, however in such a sock the circumferential tension must progressively increase from the part of maximum leg diameter (mid-calf area) to the part of minimum diameter. In such a
10 sock the tension in the portion above the part of maximum leg diameter is not so critical in regard to preventing slippage of the sock on the leg. Thus in this specification a reference to "top" should be construed as meaning the upper edge of the sock in the case that the upper edge lies at or below the region of maximum leg diameter but the region of maximum leg diameter in the case of a sock which in use extends
15 above this region of maximum leg diameter.

WHAT WE CLAIM IS:—

20 1. A knitted sock having in use a selected circumferential tension in the marginal portion at the "top" (as hereinbefore defined) of the leg of the sock, the circumferential tension in the sock, in use, progressively increasing from said "top" marginal portion of the sock to a lower portion of the sock which fits the leg at the minimum circumference thereof so that the sock in use resists downward movement on a statistical average leg.

25 2. A sock as claimed in claim 1 wherein the increase in tension is continuous from the marginal to the lower portion.

3. A sock as claimed in claim 1 wherein the increase in tension is step-wise from the marginal to the lower portion.

30 4. A sock as claimed in any one of claims 1 to 3 wherein the increase in tension is achieved by varying the stitch length, stitch tension, stitch form, elastic characteristic of the yarn or yarns, or a combination of any two or more thereof.

5. A sock as claimed in any one of claims 1 to 3 wherein said increase in tension is achieved by knitting a yarn of elastic character into the fabric of the sock and varying the density of said yarn in the fabric.

35 6. A sock as claimed in any one of the preceding claims wherein said selected circumferential tension is in the range up to a maximum of 0.70 kilogram force.

7. A knitted sock substantially as hereinbefore described with reference to the drawing in Example 1 or in Example 2.

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By a direction given under Section 30 of the Patents Act 1977 this application proceeded in the name of
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THE PATENT OFFICE

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