

[54] **STOCKING WITH COMPENSATED KNEE PRESSURE**

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Edward G. Hartigan; **Herbert Knohl**, both of Schaumburg, all of Ill.

[73] Assignee: **The Kendall Company**, Walpole, Mass.

[22] Filed: **Apr. 12, 1973**

[21] Appl. No.: **350,533**

Related U.S. Application Data

[60] Continuation of Ser. No. 91,799, Nov. 23, 1970, abandoned, which is a division of Ser. No. 293,844, Oct. 2, 1972, abandoned.

[52] **U.S. Cl.**..... **66/178 A; 66/189**

[51] **Int. Cl.**..... **D04b 9/52**

[58] **Field of Search**..... **66/178 A, 178 R, 189, 183, 66/172 E, 184**

[56] **References Cited**

UNITED STATES PATENTS

2,962,885	12/1960	Knohl	66/178 A
3,250,092	5/1966	York et al.....	66/178 A X
3,443,404	5/1969	Knohl	66/178 A

FOREIGN PATENTS OR APPLICATIONS

478,647	6/1929	Germany	66/183
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OTHER PUBLICATIONS

Husni et al., Journal of the Americal Medical Associa-

tion, 12/68, Vol. 206, No. 12, pp. 2715-2718.
Medical Surgical Review, 5/70, p. 21.

Primary Examiner—Wm. Carter Reynolds

[57] **ABSTRACT**

A full length stocking of knitted fabric including elastomeric yarn which in the boot portion exerts a compressive effect on the wearer's leg normally gradually decreasing from the ankle to a point well above the knee, that improvement wherein, in the knee area, the compressive effect is reduced to provide an area of reduced but still substantial pressure support in the zone including the knee to a level of pressure, preferably, of less than about 10 mm of mercury and less than the pressure below the knee area, preferably 20 to 80 percent thereof, so that a reduced pressure is exerted on the knee area to avoid restricting pressures on the veins in the sensitive popliteal space, the compressive pressure being increased again above the knee area and thereafter gradually being decreased to the top of the stocking boot. The stocking may be circularly knit, full-fashioned knit, or cut and sewn from a variety of fabrics including powernet, jersey knit with elastomeric inlay, jersey knit with alternating courses of knit and float elastomeric yarn, and all jersey knit with alternating courses of elastomeric yarn. Optional features include an automatic toe-inspection welt, a garter type top and a thigh enlarging insert.

6 Claims, 6 Drawing Figures

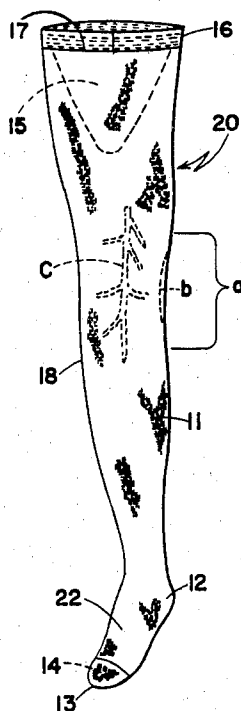


FIG. 1

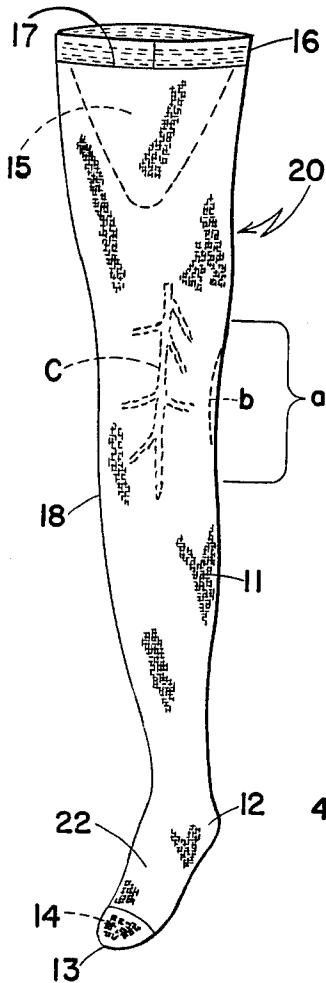
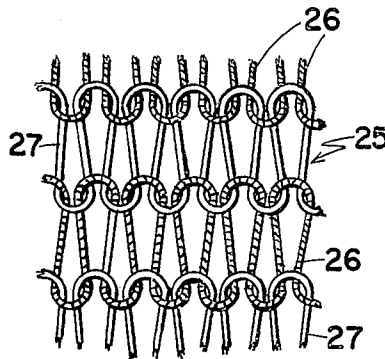


FIG. 2

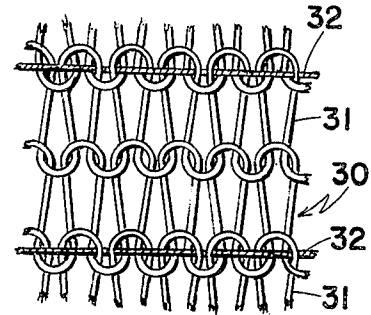


FIG. 3

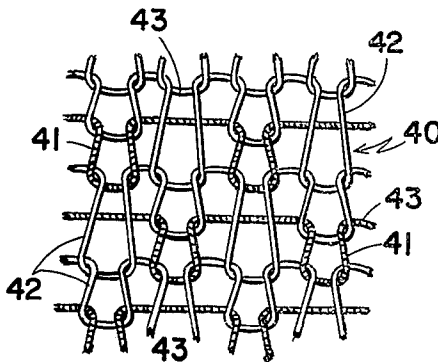


FIG. 4

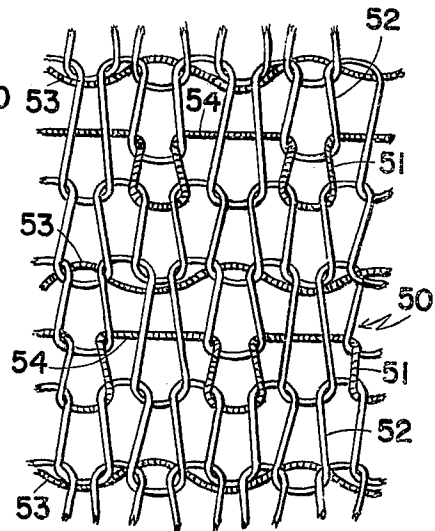


FIG. 5

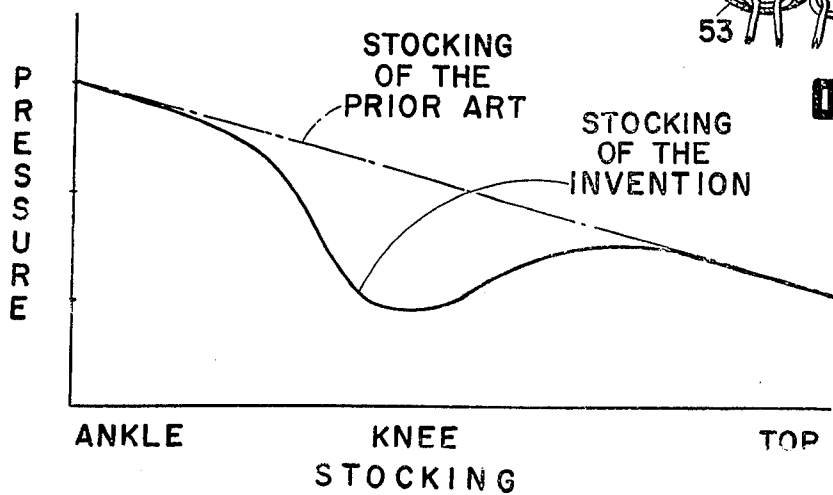


FIG. 6

STOCKING WITH COMPENSATED KNEE PRESSURE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of application, Ser. No. 91,799 now abandoned, filed Nov. 23, 1970 of which Ser. No. 293,844 now abandoned, filed Oct. 2, 1972, is a division.

BACKGROUND OF THE INVENTION

Full length therapeutic stockings and so-called tired-leg stockings which contain elastomeric yarn in the leg or boot portion are well known. They have been constructed extending in lengths ranging from midthigh to the gluteal furrow in a great many constructions from a great variety of elastic fabrics. For instance, they have been made from powernet fabric cut out to simulate the shapes of full-fashioned stockings, being sewn up the back in the same way with various flatlock and over-edge stitching. Likewise full-fashioned stockings incorporating elastomeric yarns both in the knitted stitches and inlaid in non-elastomeric stitches are well known. Stockings with inlaid elastomeric yarn, both circular knit and full-fashioned knit, are discussed in the Herbert Knohl patent RE 25,046, the original of which issued Dec. 6, 1960. But other elastic stocking constructions, including jersey knit courses of non-elastomeric yarns alternating with knit and float courses of elastomeric yarns and constructions comprising alternating courses of jersey stitches of non-elastomeric yarns and elastomeric yarns, have appeared. U.S. Pat. No. 3,287,938, issued Nov. 29, 1966 to Herbert Knohl, describes various run-resistant stockings with inlaid elastomeric yarn.

But while all of such stockings are intended to exert a compressive force upon the wearer's legs when worn, the construction of such stockings prior to this invention has been such as to gradually reduce the compressive force on the wearer's legs from the ankle to the stocking top, presumably to stimulate circulation of the blood and avoid any tourniquet effect.

But numerous investigators have warned against the danger of compressing the leg at the knee and the popliteal space at the back of the knee. This portion of the limb is exceptionally susceptible to pressure because of the presence of numerous superficial and deep leg veins and the constant flexing of the knee joint when walking, sitting, etc. Husni, in an article entitled "Pressure bandaging of the Lower Extremity" in the *Journal of the American Medical Association* 206, 12, pages 2715-2718, Dec. 1968, states that the application of pressure dressings around the knee joint with or without bandaging the entire leg effected a remarkable increase in the resting venous pressure in all cases. The pressure returned to normal only when the bandaging pressure approximated 10 mm of mercury. Phlebograms obtained with pressure dressings around the knee joint demonstrated severe compression of the normal popliteal vein in every case.

SUMMARY OF THE INVENTION

A primary subject of this invention is the provision, in a properly fitted full length stocking of knitted fabric including elastomeric yarn which in the boot portion exerts a compressive effect on the wearer's leg normally gradually decreasing from the ankle to a point

well above the knee, that improvement wherein, the knee area, the compressive effect is reduced to provide an area of reduced but still substantial pressure support in the zone including the knee to a level of pressure, preferably of less than about 10 mm of mercury and less than the pressure below the knee area, preferably 20 to 80 percent thereof, so that a reduced pressure is exerted on the knee area to avoid restricting pressures on the veins in the sensitive popliteal space, the compressive pressure being increased again above the knee area and thereafter gradually being decreased to the top of the stocking boot. In other words, the object is to modify the usual pressure profile, which gradually reduces the pressure from the ankle to the stocking top, to compensate for the sensitive popliteal area by reducing the pressure substantially in the knee area only.

The primary object of the invention may be achieved with a number of fabrics containing elastomeric yarn. A method of circular-knitting a preferred stocking of the invention containing inlaid elastomeric yarn in knitted stitches of natural fiber yarns of synthetic yarns is given in Example 1. Where other sizes of stockings are to be prepared, as, for instance, small, large and extra large, the pressures exerted on the leg should be substantially similar; the leg sizes, however, would be in proportion in accordance with the standard stocking size charts. The pressure measured by well-known measuring devices, such as that illustrated in Knohl patent RE 25,046 reissued Oct. 3, 1961, preferably should not exceed about 10 mm of mercury in the knee area.

Where other fabrics are employed in the stockings of the invention, the usual method for knitting the fabric may be employed. In general, where a therapeutic stocking used in the treatment of varicosities is involved, a pressure of about 27 mm of mercury at the ankle reduced gradually to about 10 mm of mercury at the upper thigh is standard, but in the stocking of this invention the pressure in the knee area is reduced from the standard pressure profile to not more than about 10 mm of mercury. With so-called tired-leg stockings and therapeutic stockings used in hospitals for the prophylactic treatment of thromboembolic disease, the pressure generally is somewhat less throughout the leg. T.E.D. stockings generally have a profile gradually diminishing from about 19 mm of mercury at the ankle to about 9 mm of mercury at the upper thigh. Tired-leg stockings generally follow the same pressure profile as T.E.D. stockings, varying both above and below the T.E.D. pressures depending on the particular constructions. But the stockings of this invention in such T.E.D. and tired-leg stockings also depart from the pressure profile by reducing the pressure in the knee area to about 20 to 80 percent of that below, preferably to not more than about 10 mm of mercury, while still maintaining a substantial pressure support in the knee area. The compressive pressure is increased again above the knee area and then is decreased to the top of the stocking boot.

Where stockings are to be knitted on the full-fashioned machine and seamed up the back, the blank should possess the stretch characteristics outlined in Example 1. If the stocking has too high pressure in a particular area of a properly fitted stocking, the blank must be increased in width in that area to give the proper pressure.

Where a particular circular knitting machine utilized is incapable of making a properly fitting stocking in the

upper thigh, a slit of about six inches either at the front fold or the back fold is made in the stocking and a triangular insert is sewn in by an overedging or flatlock seam to widen the upper thigh. The fabric need not be the same as the fabric of the stocking but it should be elastic. If there is difficulty in keeping some of the stockings up, a garterlike band of elastic preferably with a rigid or foamed elastic surface may be utilized by being sewn to project above the stocking welt.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of a typical stocking of the invention showing optional features such as toe inspection opening, thigh enlarging insert and garter top, as the stocking would appear on the wearer's right leg;

FIGS. 2, 3, 4, and 5 illustrate enlarged portions of typical elastomeric yarn-containing fabrics useful as the boot fabric in garments of the invention; and

FIG. 6 is a graphical illustration of the invention. Referring now to the drawings in more detail.

FIG. 1 is an illustration of the appearance of a typical full length stocking 20 of the invention as it would appear on a right leg viewed from the front. The boot portion 11 of the stocking is of elastic fabric containing both elastomeric and non-elastomeric yarns, such as of nylon, cotton, silk, polypropylene or rayon. The boot includes an upper thigh portion, preferably, but not necessarily, with a substantially triangular insert 15, a lower thigh portion, a knee portion 18, a calf portion, and an instep portion. The foot 22 (except for the heel and toe) of the stocking is preferably similar fabric to the boot and this same fabric may be used in the heel 12 and the toe 13. Preferably, however, the heel and toe are made of so-called stretch synthetic yarn such as nylon stretch yarn and without elastomeric yarn except for an optional toe inspection opening welt. In the embodiment shown in FIG. 1, the under portion of toe 13 includes an opening surrounded by a double fabric elastic welt 14 similar to that illustrated and described in the Herbert Knohl et al. U.S. Pat. No. 3,453,843 entitled "Toe Inspection Foot Garment" issued July 8, 1969, but this feature may be eliminated, in which case the entire toe may be made from stretch synthetic yarn. At the top of the stockings, an optional garterlike band 16, fastened by flatlock or overedge stitches 17 to the stocking proper, helps to retain the stocking in place. The area *a* of FIG. 1 generally delineates the knee area of reduced pressure support which is incorporated in the stockings of this invention to alleviate restricting pressures on the great saphenous vein *b* which is quite close to the surface, the popliteal vein *c* and the medial and lateral superior veins. All of these veins are restricted in cross sectional area when the knee is bent while subject to excessive compressive forces due to inadequate fabric and/or stretchability to comfortably accommodate the increased volume in the bent knee.

FIG. 2 illustrates a typical fabric 25 suitable for the boot portion of the stockings of the invention. The knit fabric has alternate course rounds of jersey stitches of synthetic or natural yarns 27 and intermediate course rounds of stitches of covered elastomeric yarn 26 such as nylon covered spandex.

FIG. 3 is the preferred typical fabric 30 suitable for the boot portion of the stockings of the invention. The knit fabric of course rounds of jersey stitches of synthetic and/or natural fiber yarns 31 has inlaid in every other course round an elastomeric yarn 32 which may

be either bare or covered, preferably the latter when the knitted stitches are of nylon or other synthetic material and preferably bare when the knitted stitches are cotton.

FIG. 4 is another typical fabric 40 suitable for the boot portion of the stockings of the invention. Covered elastomeric yarns 41 are formed into course rounds of knitted jersey stitches alternating with floats 43, the floats being across different wales in the adjacent rounds. Yarns 42 which are formed into course rounds of jersey stitches may be synthetic stretch yarns but preferably are normal spun natural or synthetic yarns or synthetic multifilament yarns

FIG. 5 is another of the more suitable typical fabrics 50 useful in the boot portion of the stockings of the invention. In this construction, covered elastomeric yarns 51 are formed into course rounds of knitted jersey stitches alternating with floats 54, the floats being across different wales in adjacent rounds. Yarns 52, which may be of stretch synthetic construction or the usual stocking yarns of natural or synthetic fibers or synthetic multi-filaments, are formed into jersey course rounds. Elastomeric yarn 53, which preferably is covered but which may be bare, is inlaid in a jersey course preferably so that a jersey course separates the elastomeric inlaid yarn from the knit and float elastomeric yarn.

FIG. 1 also shows the optional circular garterlike band 16 which is secured to the narrow welted knitted stocking top (and to the top of insert 15 if included) by overedge stitching 17. Band 16 projects above the knitted portion. The stocking 20 optionally may be enlarged in the upper thigh by a roughly triangular insert 15 sewn to the edges of a front or rear slit in the stocking be overedge stitches 17.

EXAMPLE 1

Medium Size

Using 10 filament stretch nylon 30/2 yarn, made up and knitted an automatic welt having a fully stretched circumference of 39 inches in the usual manner using a 401 needle Scott & Williams AMF 3 $\frac{3}{4}$ inches stocking knitting machine. Immediately after the transfer, exchanged yarns to 70/1, 17 filament Z-twist nylon 66 yarn on one feed and 70/1, 17 filament S-twist nylon 66 yarn on the other feed. The frame circumference is controlled by controlling the stitch size with the usual stitch control system incorporated in the knitting machine. Frame circumference fully stretched measured 42 inches. This frame was maintained to a point approximately at the upper calf at which time the frame was reduced abruptly but preferably within 5 to 10 courses to 32 inches fully stretched. This frame was maintained for approximately 120 course rounds. The frame thereafter was gradually reduced at a constant rate by reducing stitch size until at the ankle the frame circumference measured 28 inches fully stretched. Thereafter for 150 course rounds the frame remained at 28 inches circumference fully stretched. Thereafter the frame was gradually increased to the midpoint of the instep at which point the frame measured 32 inches in circumference fully stretched. Thereafter a reciprocated heel was knitted in the usual manner. After completion of the heel, circular motion was resumed, the stitch size being gradually reduced to a point between the heel and the toe to a circumference of 28 inches

fully stretched. This circumference was maintained to the ring toe. Thereafter the ring toe including run-resist courses were knitted in the usual manner. Thereafter a reciprocated toe was knitted in the usual manner.

After the nylon frame was properly knitting, the elastomeric yarn was incorporated as follows: Immediately following completion of the top welt, the inlay feed was activated and a single covered elastomeric yarn having a 280 denier spandex core and covering of 70/1, 34 filament stretch nylon 66 was inlaid in the course of jersey stitches knitted-off on the center feed. The elastomer should be metered in at a rate sufficient to produce a fabric having a fully stretched circumference of 38 inches. For this purpose, the knitting machine is equipped with an elastomeric thread furnishing device, such as is described in U.S. Pat. No. 3,209,558, for metering the elastomeric yarn into the knitting machine at a predetermined rate. Knitting the frame including the inlaid elastomeric yarn continued at that stretched circumference to a point just above the calf, at which point the amount of metered elastomeric yarn was gradually reduced to the point at the upper calf where the circumference was 27 inches fully stretched. The elastic yarn metering rate was maintained constant for about 100 nylon courses. At this point, the elastic yarn metering rate is decreased gradually until the circumferential stretch reaches 22 inches, which produces the support function of the ankle area. Thereafter the elastomeric yarn was gradually increased per round to the midpoint of the instep, at which point the stocking had a fully stretched circumference of 26 inches. At that point the elastomeric yarn was taken out and the reciprocated heel knitted. After completion of the heel, the elastomeric yarn was reintroduced in the usual manner and gradually decreased in amount per round to a point between the heel and toe, at which point the stocking foot fully stretched measured 22 inches in circumference. The elastomeric yarn was fed at this latter rate constantly for 60 course rounds, after which the elastomeric yarn rate was gradually increased to the ring toe, at which point the elastomeric yarn was taken out and the ring toe including run-resist courses were knitted in the usual manner. Thereafter a reciprocated toe was knitted and the toe opening in the sole under the base of the toes was stitched closed.

EXAMPLE 2

Medium Size

Knitted exactly similar to Example 1 but after the reciprocated toe was knitted with the stocking still on the needles, one of the toe yarns was replaced by an elastomeric yarn with a 40 denier spandex core with a 30 denier 26 filament, as is set forth in Example 1, of U.S. Pat. No. 3,453,843, and a half inch tube of elastic fabric in the form of an automatic weltowns knitted. The elastomeric yarn at that point was replaced by a 140 denier bare spandex yarn and the yarn at the left feed was replaced by a 80/1 cotton yarn. The center feed with the bare spandex was set to knit and float while the left feed knitted knit and tuck stitches with the cotton yarn to give a fully stretched circumference of 17 to 18 inches. About one-eighth to three-sixteenth of the tab was knitted and the stocking was cast off. The tab rolled upon itself, as is illustrated in FIG. 10. As is well known in the knitted compressive stocking art, a variety of factors affect the compressive effect on any spe-

cific location on the leg. With a circular knit stocking as herein described, among these are:

1. Leg diameter ($2 \times \text{Radius}$) at a specific location;
2. Knitting machine cylinder diameter;
3. Stocking frame size;
4. Knitted yarn tension;
5. Inlaid elastomeric yarn tension;
6. Utilization of triangular shape insert or gusset; and
7. Heat treatment during boarding. All of these factors will effect the compressive nature of the stocking.

Once the desired leg diameter is known, various of the other above factors are chosen to provide the desired pressure profile, as set forth in the specification. In the upper part of the stocking from the welt, the triangular shaped insert or gusset, as explained above and in U.S. Pat. No. 3,728,875, can be used to control the upwardly decreasing pressure in the upper thigh area as described.

The combination of nylon and elastomer stretch change size are chosen in relation to the leg diameter and change size are chosen in relation to the leg diameter and the well known Law of LaPlace as it relates to pressure. The Law of LaPlace states that the pressure, or compression, exerted on any point on a cylindrical surface can be calculated by the formula: Pressure is equal to tension/radius ($P = T/R$) where:

Pressure equals force/unit area,

Tension equals force/unit length, and

Radius equals the radius of a cylindrical surface (leg) at the point of interest.

It follows that a decreased knee pressure and upwardly increase in pressure above the knee area is provided in the stocking herein described, since the diameter of the nylon and elastomeric frame size, because of the decreasing diameter of the lower thigh towards the knee area, will also decrease tension. Therefore, in accordance with the above formula of LaPlace, $P = T/R$, The specific structure of the stocking in relation to the decreasing leg radius ($R = D/2$) from the lower thigh into the knee area decreases the tension in the knitted structure (T) with a resultant decrease thereby in pressure (P) in the knee, or as stated in the reverse direction, the compressive pressure being increased again above the knee area. This is because, in the lower end of the knee area, the frame circumference is reduced in size abruptly and the amount of metered elastomeric yarn was gradually reduced to a point at the upper calf where the circumference is 27 inches fully stretched in order to produce the desired relationship between lower knee pressure and high calf pressure.

The well known practice of boarding, referred to, for example, in said U.S. Pat. NO. 3,728,875, as well as in U.S. Pat. Nos. 2,962,885 and 3,250,092, which is usually resorted to for appearance reasons, may also be used for control of the compressive pressure in any desired area of the stocking.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment is that illustrated in FIG.

1. The stocking in the large and extra large sizes particularly would need an upper thigh insert as indicated. An upper thigh insert may not be necessary in the smaller stocking sizes, as noted above. The method described in Example 1 is applicable, as are the yarns and the preferred machine.

In FIG. 6 is graphically illustrated both the prior art stocking, which in the boot portion exerts a compressive effect on the wearer's leg normally gradually decreasing from the ankle to a point well above the knee, and the stocking of the invention, wherein in the knee area the compressive effect is reduced to provide an area of reduced but still substantial support in the zone including the knee to a level of pressure less than the pressure below the knee area so that a reduced pressure is exerted on the knee area to avoid restricting pressures on the veins in the sensitive popliteal space, the compressive pressure being increased again above the knee area and thereafter gradually being decreased to the top of the stocking boot.

We claim:

1. In a properly fitted full length stocking including a boot portion, said stocking being of knitted fabric including elastomeric yarn which in said boot portion exerts a compressive pressure on the wearer's leg normally gradually decreasing from the ankle to a point well above the knee,

that improvement wherein

in the knee area the compressive pressure is reduced to provide an area of reduced but still substantial pressure support in the zone including the knee to a level of pressure less than the pressure below the knee area so that a reduced pressure is exerted on the knee area to avoid restricting pressures on the veins in the sensitive popliteal space,

the compressive pressure being increased again above the knee area and thereafter gradually being decreased to the top of the stocking boot.

2. The stocking of claim 1 wherein the knitted fabric of the boot portion is knitted of jersey stitches of non-elastomeric yarn such as nylon, cotton, silk, polypropylene or rayon, and the elastomeric yarn is inlaid in

the knitted stitches.

3. The stocking of claim 1 wherein the knitted fabric of the boot portion includes courses of jersey stitches of non-elastomeric yarn alternating with courses of jersey stitches of covered elastomeric yarn.

4. The stocking of claim 1 wherein the knitted fabric of the boot portion is knitted of courses of jersey stitches of non-elastomeric yarn alternating with courses of covered elastomeric yarn knitted of jersey stitches and floats in alternating order, nearest adjacent of said knit and float courses having the floats across different wales of said knitted fabric.

5. In a properly fitted full length stocking including a boot portion, said stocking being of knitted fabric including elastomeric yarn which in said boot portion exerts a compressive pressure on the wearer's legs normally gradually decreasing from the ankle to a point well above the knee,

that improvement wherein

in the knee area the compressive pressure is reduced to provide an area of reduced but still substantial pressure support in the zone including the knee to a level of pressure 20 to 80 percent of the pressure below the knee area so a reduced pressure is exerted on the knee area to avoid restricting pressures on the veins in the sensitive popliteal space, the compressive pressure being increased again above the knee area and thereafter gradually being decreased to the top of the stocking boot.

6. In a stocking as claimed in claim 5, wherein in the knee area the compressive effect is reduced to provide an area of reduced but still substantial pressure support in the zone including the knee to a level of pressure of less than about 10 mm of mercury.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,889,494
DATED : June 17, 1975
INVENTOR(S) : Donald Patience, Edward G. Hartigan and
Herbert Knohl

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

The Heading should read as follows:

Inventors: Donald Patience, Barrington; Edward G.
Hartigan, Schaumburg, both of Illinois;
Herbert Knohl, Seneca, So. Carolina.

Col. 1, line 3, "CROSS-REFERENCE" should be
--CROSS-REFERENCES--;

line 48, "constnt" should be
--constant--.

Col. 2, line 1, after "wherein", insert --in--;

line 21, "stiches" should be --stitches--;
and "natual" should be --natural--; and "of" (second
occurrence) should be --or--;

line 28, after "in" insert --the--;

line 42, "thromboemobic" should be
--thromboembolic--.

Col. 3, line 44 "stockings" should be --stocking--;

line 59, "stiches" should be --stitches--.

Col. 4, line 35, "be" should be --by--.

Col. 5, line 56 "weltowns" should be --welt
was--.

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,889,494
DATED : June 17, 1975
INVENTOR(S) : Donald Patience, Edward G. Hartigan and
Herbert Knohl

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

(Page 2)

Col. 6, line 15, delete the word "an";

line 18, "described" should be --desired--;

lines 21-22, delete the words "and change size are chosen in relation to the leg diameter";

line 24, change "an" to --at--;

line 39, "The" should be --the--.

Col. 7, line 7, after "substantial" insert --pressure--.

Col. 8, line 16, "legs" should be --leg--;

line 24, after "so", insert --that--;

line 31, "effect" should be --pressure--.

Signed and Sealed this

twenty-third Day of December 1975

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks