April 28, 1959 H. KNOHL 2,883,842

SURGICAL STOCKING

Filed Sept. 1, 1955 2 Sheets-Sheet 1

Fig. 1.

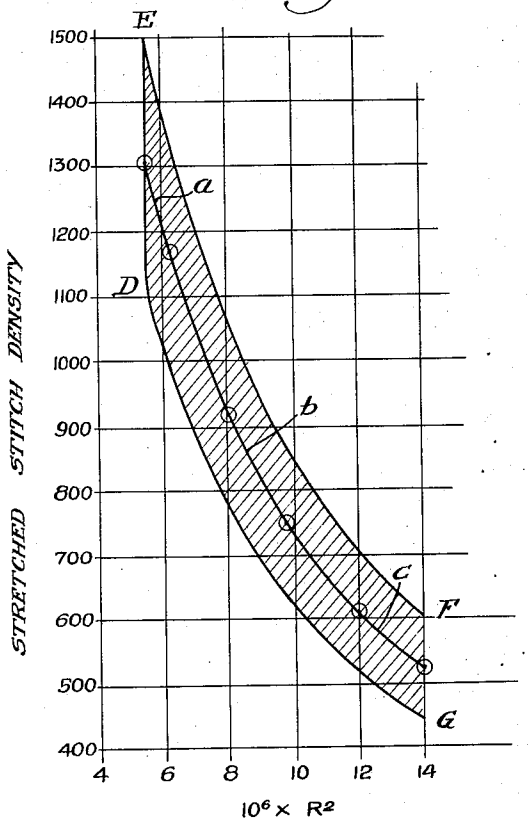
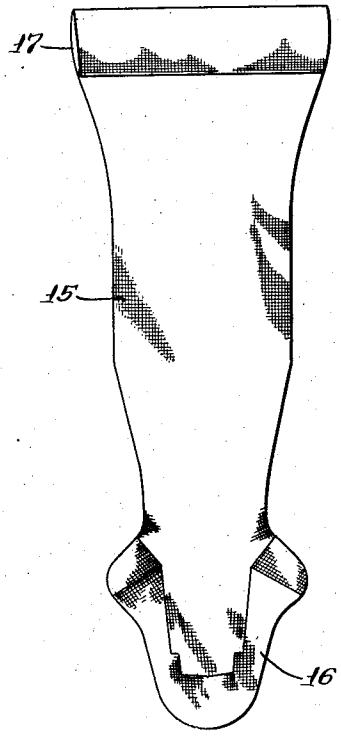


Fig. 3.



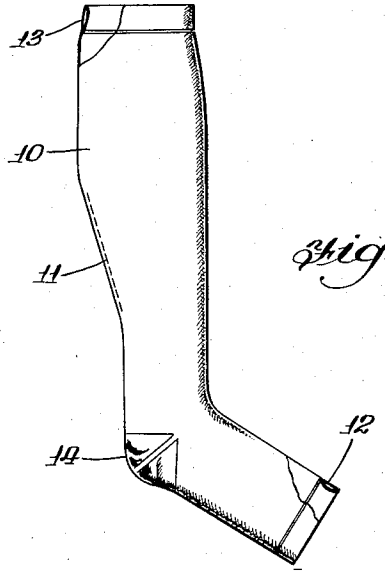


Fig. 2.

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SURGICAL STOCKING

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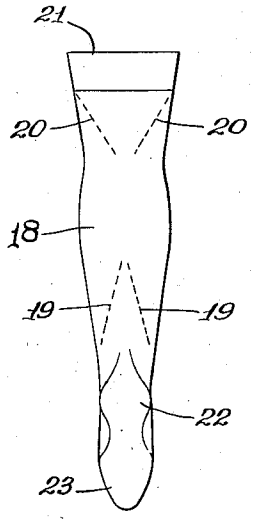


Fig. 4.

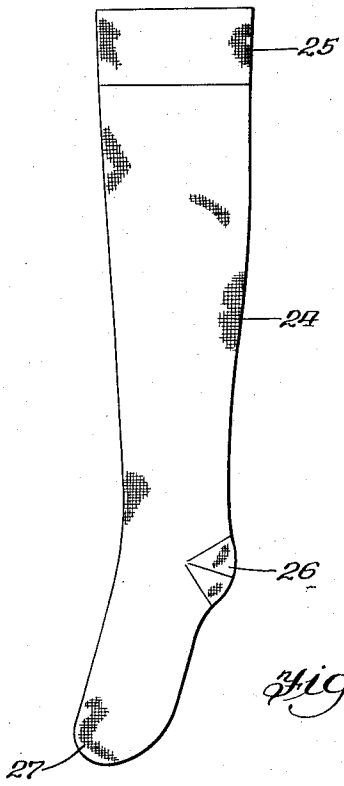
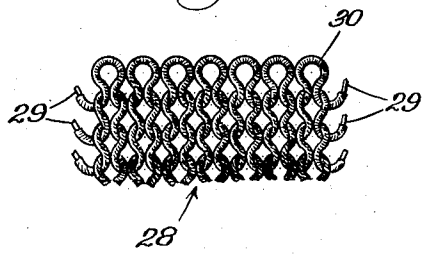


Fig. 5.

Fig. 6.



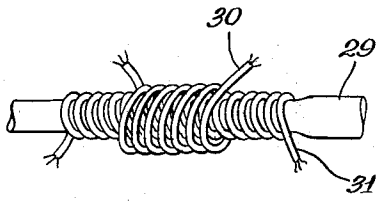


Fig. 7.

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United States Patent Office 2,883,842 Patented Apr. 28, 1959

2,883,842

SURGICAL STOCKING

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Application September 1, 1955, Serial No. 531,926

7 Claims. (Cl. 66—178)

This invention is concerned with knitted elastic stockings, particularly with fully functional, practical very sheer elastic stockings made from very thin-cored elastic yarns.

Sheer elastic stockings have been the objective of elastic stocking manufacturers ever since the possibility of extremely small diameter elastic cores was indicated by the process described in the Hopkinson and Gibbons U.S. Patent No. 1,545,257 over thirty years ago. Another U.S. patent, the Adamson patent, No. 1,822,847, demonstrated the feasibility of wrapping very fine elastic cores with cotton and silk to produce yarns of predetermined and limited capacity to stretch of the type utilized today in knitted elastic stockings.

Yet despite the promise displayed by these patents in the direction of elastic stocking sheerness and the manifest demand for greater sheerness, substantially no proggress was made thereafter in that direction. Until the introduction of the stockings of this invention, the finest yarn utilized in elastic stockings was of the minimum core diameter suggested by Adamson about 25 years ago, that is, .008 inch.

The specifications for proper elastic stockings are quite rigid with respect to pressure support, too little pressure support being ineffective in the treatment of varicosities and too much pressure support being uncomfortable to the wearer. It is generally conceded that proper pressure support should be in the range of 18 to 24 millimeters of mercury when measured similar to the way blood pressure is measured but using a glass injection syringe for inflation and with the inflatable tube replaced by an inflatable bag having about a square inch of stocking contact area. The bag, placed between the wearer's leg and the elastic stocking, is inflated, after which the syringe is detached to allow the air to exhaust. The syringe is then set at 5 cc. and again attached whereupon 5 cc. of air is forced into the tubes and bag. The pressure is read in millimeters of mercury.

As a practical matter, elastic stockings must meet certain standards as to limp dimensions and maximum stretch in order to be easily put on, especially by elderly persons, and as to bursting strength in order to be sufficiently durable. Generally speaking, stockings which have a circumference on the leg greater than 250% of the limp circumference are not preferred because of the difficulty of putting them on. Likewise, preferred stockings should have a minimum of 6 inches of excess circumferential stretch over the leg dimensions to make them easier to put on and to prevent wrinkling in the instep and under knee portions. Such wrinkles have a tourniquet effect.

Because of the increased difficulty with which elastic stockings may be donned, however, the bursting strength of elastic stocking fabric should be as high as is consistent with the yarn used. As a practical matter, one must stay within the limits for tensile strength of both the core and the wrapping. Generally, the different components are designed to break substantially simultaneously.

It is the object of this invention to provide fully functional sheer elastic stockings of practical bursting strength and of all types including circular seamless elastic stockings, full fashioned elastic stockings, elastic stockings knitted on the Burson knitting machine, and elastic stockings knitted on the Reymes-Cole knitting machine in which the elastic cores of the body yarns are as fine in the relaxed condition before wrapping as .005 to .007 inch diameter or finer and in which the stockings when worn, approach in sheerness and appearance the most sheer nylon stockings.

In the figures:

Figure 1 represents a curve demonstrating the relationship between the stretched stitch density of the elastic stockings of this invention and the square of the radius of the elastic core of the yarns forming the body of the stocking.

Figure 2 represents a typical elastic stocking of this invention as knitted on the Burson knitting machine.

Figure 3 represents a typical full fashioned elastic stocking blank made in accordance with this invention.

Figure 4 illustrates a typical elastic stocking of this invention as knitted on a Reymes-Cole knitting machine.

Figure 5 illustrates a typical seamless elastic stocking of this invention.

Figure 6 illustrates a portion of typical fabric forming the body of the stockings of this invention.

Figure 7 illustrates a typical manner of wrapping an elastic core to make elastic stocking yarns.

It is recognized that circular knit seamless elastic stockings present a very difficult problem in obtaining proper functionality because of the fact that the number of wales must remain constant. Generally proper pressure support can only be obtained when the size of the machine and the size of the yarn are properly matched. As a general rule, when the yarn core is reduced in diameter, a slightly larger machine with more needles is indicated. But given the proper machine, circular knit stockings may be knitted in accordance with this invention. Preferably the ankle portion is given a rather high (but still proper) support pressure and the support falls off gradually but still within the acceptable range as the stitches are lengthened up the leg.

But the more desirable types of elastic stockings are wale fashioned such as the full fashioned stockings and the stockings knitted on the Burson knitting machine as illustrated in the Adamson U.S. Patent No. 2,013,396 and the stocking illustrated in the Reymes-Cole U.S. Patent No. 2,703,970. With such wale fashioned stockings, the pressure support at any point of the stocking can be closely controlled in accordance with this invention so as to give the proper functionality.

As revealed in the Adamson Patent Nos. 1,822,847 and 2,013,396, elastic cores made from suitably compounded concentrated rubber latex when wrapped with one or more relatively inelastic helical windings provide elastic yarns having a capacity to stretch elastically at least in the range 100% to 170% which yarns are suitable for elastic stockings.

When the stockings of this invention were first conceived, it was considered that if a fine elastic yarn having substantially the stretch characteristics suggested by the above mentioned Adamson Patent No. 1,822,847 or of any suitable elastic yarn hitherto used, were supplied, one might substitute one yarn for the other and thus produce a satisfactory stocking. Accordingly, a fine yarn (.00625 inch relaxed diameter core) was produced to my specification which, although it had reduced maximum stretch, had a modulus comparable to the coarser yarn (0.1 inch relaxed diameter core). This seeming incongruity is ex-

plained by the fact that whereas the coarse yarn had its core elongated in wrapping to a length about 1½ times its unstretched length, the fine yarn had its core elongated in wrapping to a length about 2½ or more times its unstretched length.

But contrary to expectations, when the fine elastic yarn was substituted for the coarser elastic yarn, the elastic stocking produced was not a functional elastic stocking. Its limp dimensions were appreciably less (ankle circumference 5 inches as opposed to 6¼ inches) than those of the coarser yarn stocking, its pressure support was inadequate (10 millimeters of mercury) and its maximum stretch twice that necessary. It appeared that although the stocking was smaller than the coarser counterpart in relaxed or limp condition it was functionally too large. Efforts to correct this deficiency by further reducing the size resulted in a stocking just short of satisfactory pressure support whose limp ankle circumference with 50 wales removed was only 2⅞ inches, a dimension which is impractical from the commercial standpoint because such a stocking would be almost impossible to put on an average 9 inch circumference ankle. This stocking when stretched to its maximum, possessed a stretched stitch density of only 171 stitches per square inch. The fabric burst when tested on a Mullen Tensile Tester when the pressure upon it reached 20 pounds per square inch. In view of the small limp diameter, such low bursting strength would further add to the impracticality of this particular stocking.

It then occurred to me in contradiction of the teaching apparently indicated by this experiment, that is, in contradiction to the teaching that reducing the wales per inch on the leg increases the pressure support, that perhaps there was an area where increasing the wales per square inch on the leg would also increase the pressure support. Strangely enough, although this theory was not sufficiently broad to cover the actual results, it proved to be not only basically correct but the stockings produced were more practical elastic stockings from every standpoint. I later discovered that the real key to the problem of using fine-cored elastic yarns to produce practical, fully functional elastic stockings is in increasing the stretched stitch density. For purposes of this invention, stretched stitch density is defined as the stitches per square inch in a fully stretched elastic stocking. Stretch stitch density is preferably increased both by shortening the stitches and utilizing a finer gauge machine. But one may increase the stretched stitch density without changing the gauge either by increasing the tension on the yarn while knitting or by shortening the stitches or both. At any rate, I have discovered that with regard to elastic stockings knitted of yarns comprising elastic cores covered with one or more helical windings and having a capacity to stretch elastically at least 100% and up to about 170% optimum functionality as well as practicality exists in a range of stretched stitch densities and that this range is a function of the core diameter with the density increasing inversely as the square of the relaxed core radius:

$$\text{Stretched Stitched Density} = \frac{C}{R^2} = \frac{.0073243}{R^2}$$

This relationship is expressed in the curve ABC of Figure 1. It is to be understood, however, that satisfactory fabric strength, pressure support and adequate maximum stretch may be obtained by using stretched stitch densities as indicated by the shaded area, DEFG of the curve.

Referring now to the remaining figures:

In Fig. 2 is illustrated a typical below-the-knee elastic stocking **10**, in accordance with this invention knitted on the well known Burson knitting machine. The open toe is finished with an automatic welt **12**. The heel **14** is preferably formed of inelastic yarns. This type of stocking is fashioned by adding wales, the addition of which is indicated at **11**. The top of the stocking is finished with a welt **13**. Stockings knitted on the Burson knitting machine may, of course, be made full length and full footed in accordance with this invention.

In Fig. 3 is illustrated a typical example of a full fashioned elastic stocking **15** in accordance with this invention. The blank edges are seamed together from the toe midpoint under the foot, around the heel and up the back in the usual well known manner. The foot portion **16** preferably is made of nylon or other non-elastic yarns or it may be made from stretch nylon. The welt **17** is preferably of the usual nylon or other non-elastic yarn.

In Fig. 4 is a typical elastic stocking **18** knitted on the Reymes-Cole knitting machine and made in accordance with this invention. This stocking is a seamless wale fashioned stocking preferably with fashioning in two sections indicated at **19** and **20**. The heel **22** and toe **23** may be formed in the usual manner for seamless stockings or they may be formed as is indicated in Reymes-Cole U.S. Patent 2,703,972. The stocking is preferably finished with a non-elastic yarn such as nylon.

In Fig. 5 is illustrated a typical seamless elastic stocking **24** knitted in accordance with this invention. The toe **27** and heel portion **26** are preferably of stretch nylon. The welt **25** is of typical loosely knitted nylon or other non-elastic yarns.

Fig. 6 illustrates an enlarged view of a section of typical fabric **28**, made in accordance with this invention, showing the cores **29** and the outer wrapping **30**.

Fig. 7 illustrates a greatly enlarged portion of elastic yarn showing the core **29**, the outer wrapping **30**, and the inner wrapping **31**. The wrappings **30** and **31** preferably are multifilaments.

Having determined the relaxed core diameter which it is desired to use, the gauge of the machine which would be suitable for making the indicated stretch stitch density may be determined as follows: Find the stretched stitch density for that core either from the curve of Figure 1 or from the formula

$$\frac{.0073243}{R^2}$$

Take the square root of this stretched stitch density and multiply the result by 2. The gauge is the nearest figure divisible by 3. For instance, with a core of .005 inch diameter, the optimum stretch stitch density is 1171 stitches per square inch. The square root of this figure is approximately 34.3 which would indicate a 69 gauge machine. Similarly, with a .00625 inch diameter core, the optimum stretch stitch density is 750. The square root of this figure, 26.7 multiplied by 2 would indicate a 54 gauge machine. Again, it should be emphasized that it is not necessary to have the optimum gauge for knitting properly functional elastic stockings. One may use a finer gauge machine within limits and adjust the stretched stitch density by knitting longer stitches and/or by reducing the tension on the yarn while knitting. Similarly, one may use a coarser gauge machine within limits and increase the tension and/or knit shorter stitches.

Once having selected the proper machine and the yarn, a sample swatch or tube of material is knitted and fully stretched to obtain the stretched stitch density. If the density obtained is too low, the stitches should be shortened to obtain the proper stretched stitch density. Usually it is not necessary to adjust the tension but the proper density may be obtained at least in part by tension if that is desired. Likewise, if the density is too high, longer stitches should be knitted and/or any unnecessary tension relieved to lower the stretched stitch density to the desired level.

Now select the circumference measurements of the particular size leg it is desired to fit with the stocking and add six inches to each measurement. The six inches represents the excess stretch which the stocking should

have. Now fully stretch the sample with the proper stretched stitch density by applying coursewise force and count the needle wales in a given coursewise length. The number of needles to use for a particular portion of the stocking may be found by applying the ratio:

$$\frac{\text{Stretched needle wales}}{\text{Stretched length}} = \frac{\text{needles to use}}{\text{leg circumference} + 6 \text{ inches}}$$

Elastic stockings having stretched stitch densities in accordance with this invention preferably have bursting strengths in the range of about 28 to 40 pounds per square inch when tested on the Mullen Tensile Tester. This range of bursting strengths ensures adequate freedom from snagging and durability in use.

Stockings made in accordance with this invention may be made full length or partial length and with open or full foot by the usual methods for making such styles on the various machines.

I claim:

1. A fully functional knitted elastic stocking having an average stretched stitch density in the body portion greater than about 750 stitches per square inch formed of yarn comprising an elastic core measuring not more than .007 inch in diameter in the relaxed unwrapped condition and at least one helical winding of relatively inelastic material about said core, said yarn having a

capacity to stretch elastically at least 100% and up to about 170%.

2. A stocking as claimed in claim 1, wherein the body yarns are so weak individually as to break when exposed individually to more than one-half pound of force exerted longitudinally.

3. A stocking of claim 1, having a bursting strength of at least 28 pounds per square inch when measured on the Mullen Tensile Tester.

4. A stocking as claimed in claim 1, capable of stretching circumferentially at least 200%.

5. A stocking as claimed in claim 1, capable of exerting pressure support upon a human leg when worn in the range of 18 to 24 millimeters of mercury.

6. A stocking as claimed in claim 1 wherein the body is wale-fashioned.

7. A stocking as claimed in claim 1 wherein the yarns have a capacity to stretch greater than 150%.

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2,013,396	Adamson	Sept. 3, 1935
2,322,382	Moore	June 22, 1943
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