July 15, 1941. H. AULL 2,249,342

KNITTED FABRIC

Filed Sept. 27, 1938

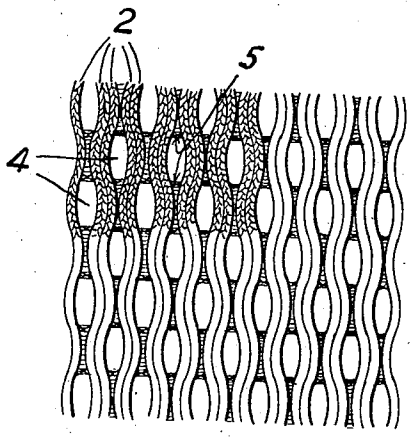

FIG. 1.

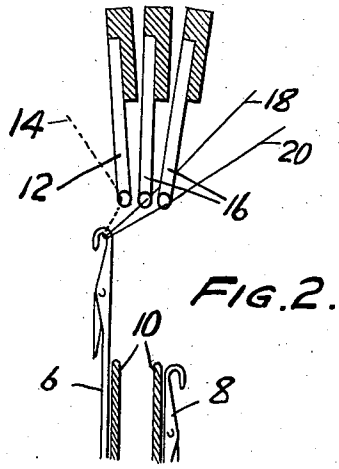

FIG. 2.

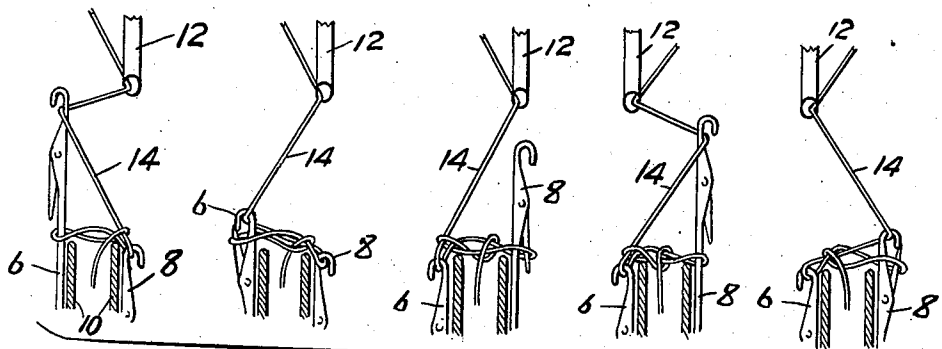

FIG. 3.

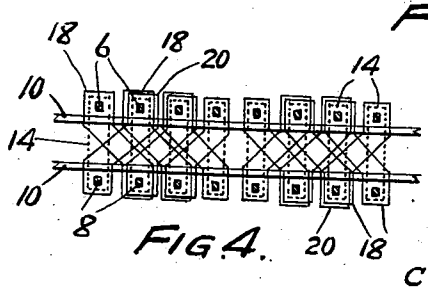

FIG. 4.

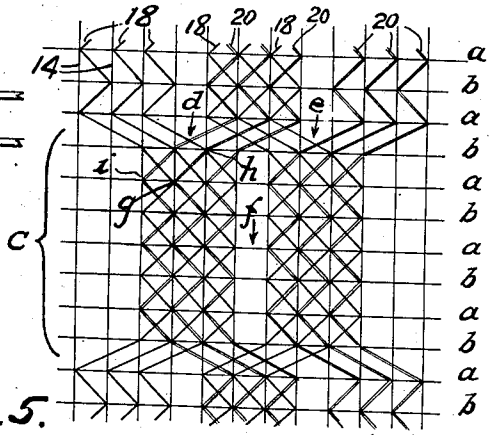

FIG. 5.

WITNESS:

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KNITTED FABRIC

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Application September 27, 1938, Serial No. 231,851

12 Claims. (Cl. 66—195)

This invention relates to a knitted fabric, and specifically to an elastic knitted fabric of openwork type adapted, for example, for the formation of the uppers of women's shoes.

In the formation of women's shoes it is often desired to provide at the toes or other parts of the uppers openwork areas in which appear openings of substantial size. For comfort and close fit, it is also desirable that such regions should be elastic to a sufficient extent to permit such portions of the shoe to conform to the foot. At the same time, the material should be moderately heavy and exhibit stiffness to a substantial extent so as to avoid the formation of wrinkles or the appearance of distortions, which would be undesirable.

It is the object of the present invention to provide a knitted fabric which may be used in shoes in the fashion just described, but which is adaptable for other uses. In its preferred form this fabric, while fairly heavy and stiff, has quite substantial elasticity. Additionally, the fabric is so formed that when in use it shows openings of considerable size which are substantially circular in form, thereby hiding to a considerable extent any suggestion of the formation of the fabric by the use of threads running in a particular direction. The elasticity is produced by the incorporation of elastic threads, preferably of covered type, for example, those known as "Lastex," which threads will stand up under the exposure to water and abrasive materials to which shoes may be subjected.

The various objects of the invention, of which specific objects relate to details of construction of the fabric, will become apparent from the following description, read in conjunction with the accompanying drawing, in which:

Figure 1 is a fragmentary plan view showing the appearance of the preferred form of the improved fabric prior to the lateral stretching which will cause the openings therein to be substantially circular;

Figure 2 is a fragmentary sectional view illustrating the elements of a machine used in the formation of the fabric, such illustration being for the purpose of clarifying the fabric diagrams;

Figure 3 is a view somewhat similar to Figure 2, but showing successive steps in the knitting of an elastic thread;

Figure 4 is a horizontal sectional view having incorporated in it a diagram illustrating the fashion in which the various threads are fed to the needles; and

Figure 5 is a diagram illustrating the formation of a typical area of the fabric.

The improved fabric in its preferred form is illustrated in Figure 1. To the eye it exhibits a series of zigzag wale-like chains indicated at 2, which run lengthwise of the fabric in pairs zigzagging oppositely along the fabric and leaving openings 4 across the ends of which there appear floats as indicated at 5. When first formed, the fabric has an appearance substantially that of Figure 1, the openings being of substantially oval form. However, when lateral expansion is imparted to the fabric interior distortion appears to take place, with the result that the openings may be given a substantially circular appearance. At any reasonable viewing distance, the appearance of the lengthwise chains 2 is lost and the fabric appears to have a rather homogeneous construction between the circular openings. It can be recognized, of course, that it is a knitted fabric upon close inspection, when there appear the various structural features, as indicated in Figure 1.

The fabric of Figure 1 is constructed on a conventional type of knitting machine, such as illustrated in Figure 2. The machine comprises two banks of needles, indicated at 6 and 8 and located on opposite sides of a space bounded by plates 10 serving for the reception of the knitted fabric and adapted to cast off the loops. The needles of the two banks are reciprocated as groups alternately by the usual conventional means. In order to feed threads to the needles, there are provided carrying fingers. These carrying fingers are mounted on three bars, the fingers on each bar being of the same number as the needles of one of the groups. One of these bars carries a set of fingers 12 for feeding elastic threads, indicated at 14, to individual pairs of needles. The bar carrying the fingers 12 does not reciprocate lengthwise to carry the elastic threads to different needles of any group, but has imparted to it only the motions necessary to cause each of the elastic threads to feed one needle of one bank and the opposite needle of the other bank, that is, each elastic thread is knit, during the formation of the fabric, on two needles only, i. e., alternately by opposite needles of the two banks. The other two carrying bars have imparted to them by the usual controlling means lengthwise movements as well as movements to cause them to feed the yarns which they carry to needles of both groups. The fashion in which the fabric yarns 18 and 20 are car-

ried by the fingers 16 of these bars will become clear hereafter.

In the production of the fabric there is preferably used as the elastic yarn 14 a yarn of the covered type, though any other type of elastic yarn may be used. The threads 18 and 20 are preferably cotton of a suitable weight to give the desired weight to the final fabric. As indicated above, the fabric is preferably finally of a rather stiff, though elastic, nature, but this may be changed at will by the use of light or heavy cotton threads, according to the desired results.

The nature of the fabric and the mode of its formation will be best appreciated from consideration of Figure 5, which is a diagram comprising horizontal lines which are alternately marked *a* and *b*, which may be taken to represent, so far as formation goes, alternately the banks of needles 7 and 8, which needles might be said to be represented by the intersection of these horizontal lines with the vertical lines of this diagram. The diagram may also be taken to represent the finished fabric with the various intersections of the horizontal and vertical lines representing the concatenations of loops, with the lines *a* and *b* alternately representing the back and front of the fabric, which, as will be evident from Figures 2 and 3, is of a two-ply type, though the front and back plies are very closely interknit. The vertical lines may not only be regarded as representing at their intersections the needles or concatenations as above described, but may also be regarded as representing, as indicated at 14, the lines of the elastic threads 14. 18 and 20, respectively, represent the arrangements of the fabric threads as they are engaged alternately by needles of the front and rear banks. For clarity, the threads 18 are represented by single zigzag lines and the threads 20 by double zigzag lines.

With the above explanations, the nature of the concatenations will be readily understood. Each of the elastic threads 14 is alternately knitted by a needle of one bank and the opposite needle of the other bank. As a result, these elastic threads extend lengthwise of the fabric and are formed into loops of which alternately formed loops are concatenated at the two sides of the fabric while there is no concatenation of the loops of any elastic thread with the loops of another. The elastic threads are fed to the needles by a substantially rectangular motion of the carriers 12, as indicated by the dotted lines 14 in Figure 4.

Each of the fabric threads 18 is knitted through a substantial length of the fabric first by a needle of one bank and then by a needle of the other bank, which is next to that needle opposite the first mentioned one. In other words, the successive loops formed from the fabric thread 18 are not only alternately at the front and back of the fabric, but are zigzagged transversely of the fabric. This will be evident by following the course of any of these threads 18 indicated in Figure 5. After such knitting has proceeded for an extended length of the fabric, a shift occurs, as indicated at *e*, and the zigzag knitting is resumed, but with a displacement of the region of knitting by, say, three needles.

The fabric thread 20 is similarly knit, but the zigzagging takes place in an opposite direction to that of the thread 18. Lateral displacement occurs as indicated at *d* when displacement in the opposite direction of the threads 18 occurs at *e*. As a result of this each of the fabric threads of both of the sets may be said to be formed into loops concatenated with loops of the elastic threads and with successive loops of the fabric threads concatenated with loops of different elastic threads and with successive loops of each of the fabric threads of one set concatenated with loops of different fabric threads of the other set where they are concatenated with any loops of threads of the other set. This occurs, for example, at *g* and *h*, though it will be noted that at points such as *i* a fabric thread is concatenated only with an elastic thread. As a result of this it may be said that the fabric threads have zigzag arrangements lengthwise of the fabric compared with the elastic threads which, at least at the time of formation, may be said to be extending almost straight, though distortion occurs thereafter, as indicated below and in Figure 1.

At the same time, due to the lateral shifting at *d* and *e*, open spaces are provided as indicated at *f*, so that the resulting fabric may be said to comprise transverse zones such as *c* in which the threads are interknitted within groups but without any interknitting of threads of different groups, so as to leave the openings *f* (or 4 of the finished fabric) between the groups. By reason of the displacement of the threads at *d* and *e*, the openings in successive transverse zones only are staggered relative to each other, as will be evident from Figures 1 and 5. It may be here noted that the floats which appear in the finished fabric at 5 are due to the substantial lateral displacement, such as indicated at *d* and *e*.

While for clarity only the central portion of Figure 5 is completed, it will be understood that the right and left hand portions are interknitted in the same fashion as the central portions with the result that the arrangement of the central portion of that figure is repeated throughout the fabric. Thus the staggered arrays of openings 4 are provided.

By reason of the lateral strains set up by the zigzag knitting and the presence of the elastic threads which are knitted under some tension, the fabric as it comes off the knitting machine does not have the elastic threads running in generally straight lines, but the grouped chains of loops formed by the elastic and fabric threads are distored as indicated in Figure 1, giving the chains smooth wave-like appearances leaving oval openings of characteristic type. Heretofore in the production of openwork fabric such openings have generally been rectangular and are incapable of distortion into satisfactory circular openings. In the present case, however, lateral stretching of the fabric will produce permanent enlargement of these openings laterally with some accompanying lengthwise shortening, with the result that in the final fabric in its preferred form circular openings are provided as indicated above.

The use of an elastic thread is not absolutely necessary, though desirable if a maximum elasticity is required. The elasticity of the fabric in a lengthwise direction is due to the fact that the straighter wales formed by the elastic threads are extensible by reason of the elasticity, whereas the fabric is extensible despite the relatively inelastic cotton threads by reason of the fact that these threads are in a zigzag array and hence can be more or less straightened out. On the other hand, if an inelastic thread is knit in place of the elastic thread 14, a substantial loss of lengthwise elasticity occurs, though the lateral distortion necessary to produce circular openings is still possible.

It will be obvious that various changes may be made in the specific embodiment of the invention without departing from its scope as defined in the following claims. For example, minor changes in the concatenation of the loops may be provided with the attainment of substantially the same desirable result.

What I claim and desire to protect by Letters Patent is:

1. An openwork knitted fabric comprising a set of elastic threads and two sets of fabric threads, each of said elastic threads being formed into loops of which alternately formed loops are concatenated at the two sides of the fabric without concatenation of loops of any elastic thread with loops of another, each of the fabric threads of both sets being formed into loops concatenated with loops of said elastic threads with successive loops of the fabric threads concatenated with loops of different elastic threads and with successive loops of each of the fabric threads of one set concatenated with loops of different fabric threads of the other set where such concatenation of threads of the two sets takes place, with no concatenation of loops of threads of the same set, said fabric threads thereby having zigzag arrangements lengthwise of the fabric compared with the elastic threads, said threads being interknitted within groups in transverse zones of the fabric without interknitting of threads of different groups leaving openings of substantial lengthwise extent in said fabric between the groups, the openings in successive transverse zones being staggered relative to each other, said groups of threads being laterally spaced to produce substantial widths of the openings between the groups, the knitting in each of said groups being compacted laterally of the fabric.

2. An openwork knitted fabric comprising three sets of threads, each of the threads of the first set being formed into loops of which alternately formed loops are concatenated at the two sides of the fabric without concatenation of loops of any thread of the first set with loops of another, each of the threads of the second and third sets being formed into loops concatenated with loops of the first set, with successive loops of the threads of the second and third sets concatenated with loops of different threads of the first set, and with successive loops of each of the threads of the second and third sets concatenated with loops of different threads of the other of said second and third sets where such concatenation of threads of one of the second or third sets with threads of the other occurs, with no concatenation of loops of threads of the second and third sets with loops of the same set, the threads of the second and third sets thereby having zigzag arrangements lengthwise of the fabric compared with the threads of the first set, said threads being interknitted within groups in transverse zones of the fabric without interknitting of threads of different groups leaving openings of substantial lengthwise extent in said fabric between the groups, the openings in successive transverse zones being staggered relative to each other, and said groups of threads being laterally spaced to produce substantial widths of the openings between the groups, the knitting in each of said groups being compacted laterally of the fabric.

3. An openwork knitted fabric comprising a plurality of sets of threads, each of the threads of at least one set being formed into loops of which alternately formed loops are concatenated at the two sides of the fabric, and each of the threads of a plurality of the other sets being formed into loops concatenated with loops of the first set, the threads of these latter sets having zigzag arrangements lengthwise of the fabric compared with the threads of the first set, said threads being interknitted within groups in transverse zones of the fabric without interknitting of threads of different groups leaving openings of substantial lengthwise extent in said fabric between the groups, the openings in successive transverse zones being staggered relative to each other, and said groups of threads being laterally spaced to produce substantial widths of the openings between the groups, the knitting in each of said groups being compacted laterally of the fabric.

4. An openwork knitted fabric comprising a plurality of sets of threads, each of the threads of at least one set being elastic and formed into loops of which alternately formed loops are concatenated at the two sides of the fabric, and each of the threads of a plurality of the other sets being formed into loops concatenated with loops of the first set, the threads of these latter sets having zigzag arrangements lengthwise of the fabric compared with the threads of the first set, said threads being interknitted within groups in transverse zones of the fabric without interknitting of threads of different groups leaving openings of substantial lengthwise extent in said fabric between the groups, the openings in successive transverse zones being staggered relative to each other, and said groups of threads being laterally spaced to produce substantial widths of the openings between the groups, the knitting in each of said groups being compacted laterally of the fabric.

5. An openwork knitted fabric comprising a plurality of sets of threads of which the threads of at least one set are formed into loops of which alternately formed loops are concatenated at the two sides of the fabric, a plurality of the other sets of threads being concatenated with loops of the first set and extending in zigzag formation lengthwise of the fabric, said threads being interknitted within groups in transverse zones of the fabric without interknitting of threads of different groups leaving openings of substantial lengthwise extent in said fabric between the groups, the openings in successive transverse zones being staggered relative to each other, and said groups of threads being laterally spaced to produce substantial widths of the openings between the groups, the knitting of each of said groups being compacted laterally of the fabric.

6. An openwork knitted fabric comprising a plurality of sets of threads of which the threads of at least one set are elastic and formed into loops of which alternately formed loops are concatenated at the two sides of the fabric, a plurality of the other sets of threads being concatenated with loops of the first set and extending in zigzag formation lengthwise of the fabric, said threads being interknitted within groups in transverse zones of the fabric without interknitting of threads of different groups leaving openings of substantial lengthwise extent in said fabric between the groups, the openings in successive transverse zones being staggered relative to each other, and said groups of threads being laterally spaced to produce substantial widths of the openings between the groups, the knitting of

each of said groups being compacted laterally of the fabric.

7. An openwork knitted fabric comprising a plurality of sets of threads of which the threads of at least one set are formed into loops of which alternately formed loops are concatenated at the two sides of the fabric, a plurality of the other sets of threads being concatenated with loops of the first set and extending in zigzag formation lengthwise of the fabric, said threads being interknitted within groups in transverse zones of the fabric without interknitting of threads of different groups leaving openings of substantial lengthwise extent in said fabric between the groups, and said groups being laterally spaced to produce substantial widths of the openings between the groups, the knitting of each of said groups being compacted laterally of the fabric.

8. An openwork knitted fabric comprising a plurality of sets of threads of which the threads of at least one set are elastic and formed into loops of which alternately formed loops are concatenated at the two sides of the fabric, a plurality of the other sets of threads being concatenated with loops of the first set and extending in zigzag formation lengthwise of the fabric, said threads being interknitted within groups in transverse zones of the fabric without interknitting of threads of different groups leaving openings of substantial lengthwise extent in said fabric between the groups, and said groups of threads being laterally spaced to produce substantial widths of the openings between the groups, the knitting of each of said groups being compacted laterally of the fabric.

9. An openwork knitted fabric comprising a plurality of sets of threads at least one of which comprises elastic threads, said threads being concatenated to form chains running lengthwise of the fabric, said threads being interknitted within groups, each of which groups comprises a plurality of threads of every set, in transverse zones of the fabric without interknitting of threads of different groups leaving openings of substantial lengthwise extent in said fabric between the groups, the various threads of each set being knit into different wales in the same course in each of said groups, the openings in successive transverse zones being staggered relative to each other, and said groups of threads being laterally spaced to produce substantial widths of the openings between the groups, the knitting in each of said groups being compacted laterally of the fabric, and forming wavy ribs of substantial width running lengthwise of the fabric and forming curved boundaries for said openings.

10. An openwork knitted fabric comprising a plurality of sets of threads, said threads being concatenated to form chains running lengthwise of the fabric, said threads being interknitted within groups, each of which groups comprises a plurality of threads of every set, in transverse zones of the fabric without interknitting of threads of different groups leaving openings of substantial lengthwise extent in said fabric between the groups, the various threads of each set being knit into different wales in the same course in each of said groups, the openings in successive transverse zones being staggered relative to each other, and said groups of threads being laterally spaced to produce substantial widths of the openings between the groups, the knitting in each of said groups being compacted laterally of the fabric, and forming wavy ribs of substantial width running lengthwise of the fabric and forming curved boundaries for said openings.

11. An openwork knitted fabric comprising a plurality of sets of threads at least one of which comprises elastic threads, said threads being concatenated to form chains running lengthwise of the fabric, said threads being interknitted within groups, each of which groups comprises a plurality of threads of every set, in transverse zones of the fabric without interknitting of threads of different groups leaving openings of substantial lengthwise extent in said fabric between the groups, the various threads of each set being knit into different wales in the same course in each of said groups, and said groups of threads being laterally spaced to produce substantial widths of the openings between the groups, the knitting in each of said groups being compacted laterally of the fabric, and forming wavy ribs of substantial width running lengthwise of the fabric and forming curved boundaries for said openings.

12. An openwork knitted fabric comprising a plurality of sets of threads, said threads being concatenated to form chains running lengthwise of the fabric, said threads being interknitted within groups, each of which groups comprises a plurality of threads of every set, in transverse zones of the fabric without interknitting of threads of different groups leaving openings of substantial lengthwise extent in said fabric between the groups, the various threads of each set being knit into different wales in the same course in each of said groups, and said groups of threads being laterally spaced to produce substantial widths of the openings between the groups, the knitting in each of said groups being compacted laterally of the fabric, and forming wavy ribs of substantial width running lengthwise of the fabric and forming curved boundaries for said openings.

HARRY AULL.