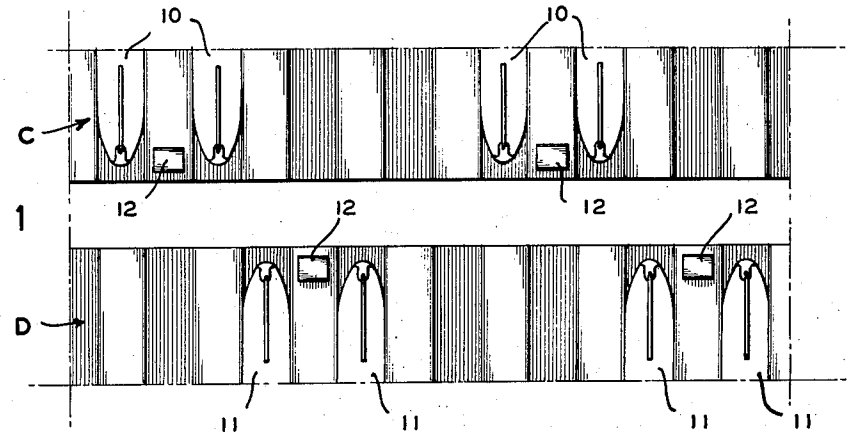
June 24, 1958 J. E. MORGAN 2,839,909

KNITTED FABRIC

Filed May 16, 1957 3 Sheets-Sheet 1

FIG. 1

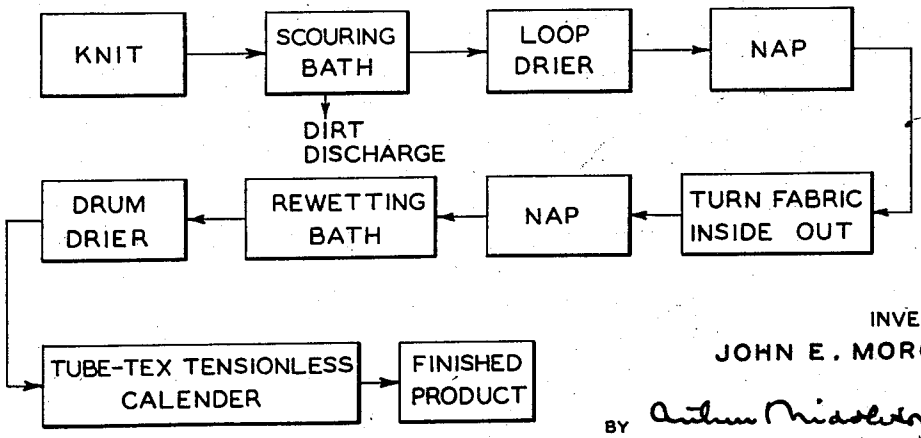


	D	D	C	C	D	D	C	C
1	T	T	K	K	T	T	K	K
2	T	T	K	K	T	T	K	K
3	K	K	K	K	K	K	K	K
4	K	K	T	T	K	K	T	T
5	K	K	T	T	K	K	T	T
6	K	K	T	T	K	K	T	T
7	K	K	K	K	K	K	K	K
8	T	T	K	K	T	T	K	K

KNIT COURSES

FIG. 2

FIG. 5



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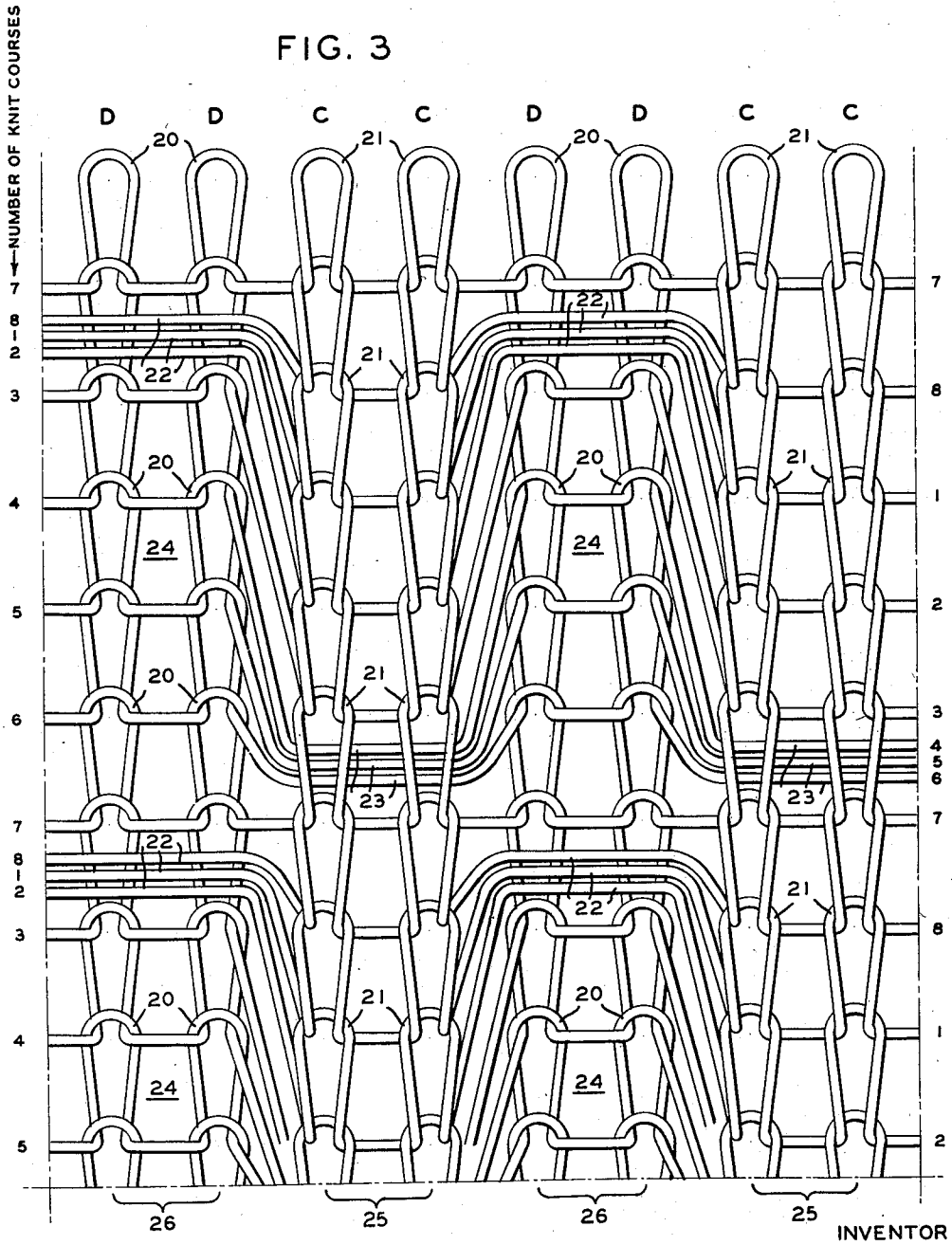
ATTORNEY

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KNITTED FABRIC

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FIG. 3



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FIG. 4

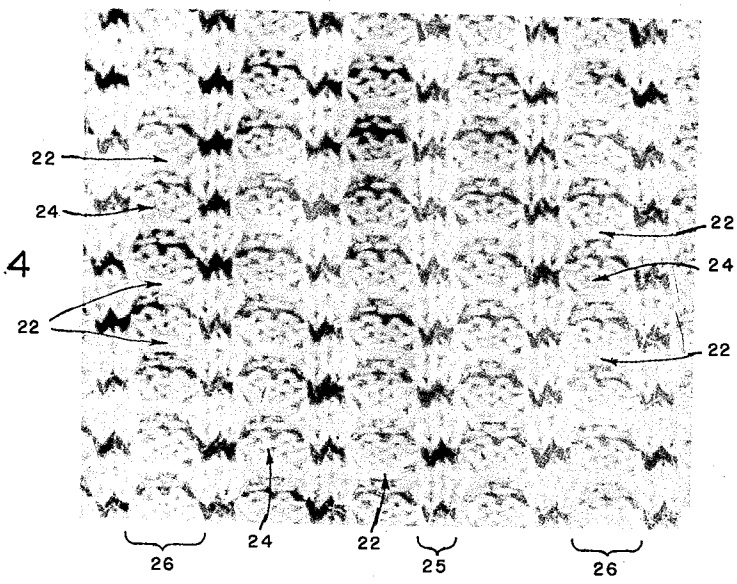
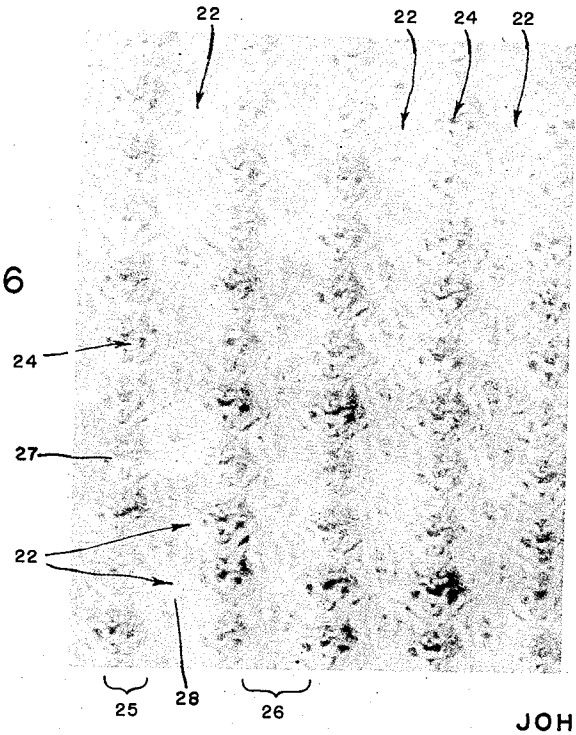


FIG. 6



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United States Patent Office 2,839,909 Patented June 24, 1958

2,839,909

KNITTED FABRIC

John E. Morgan, Tamaqua, Pa.

Application May 16, 1957, Serial No. 659,685

18 Claims. (Cl. 66—198)

The present invention relates to the knitting of air-entrapping fabrics which are suited for use in the production of garments such as underwear and which, because of the cellular configuration or shape of the fabric is particularly adapted to provide warmth. The invention includes the treatment of the knitted product to enhance its hand and softness and also its warmth retaining character. The invention also includes the new heat insulating fabric which is produced by the invention, both before and after treatment thereof to enhance the softness and heat insulating quality thereof.

The invention is particularly directed to the production of light weight knitted fabrics which are not irritating to the skin of the wearer and which have a multitude of air-entrapping cells formed therein, these cells being retained to continue the insulating excellence of the fabric dispite prolonged wear.

In accordance with the present invention, a fabric is knitted upon a rib knitting machine having opposed needle banks. Preferably, the needles are independently mounted on each of the needle banks in groups with the groups of needles on each of the needle banks being positioned between the groups of needles on the opposed needle bank.

The rib knitting machine under consideration is operated by producing tuck stitches on one of the needle banks while the needles of the opposite needle bank are knitting in conventional fashion. After this is done for a plurality of courses, the operation of the machine is reversed and the needles which produced tuck stitches are causesd to knit in conventional fashion while the needles which formerly knitted in conventional fashion are caused to produce tuck stitches. This latter operation is also performed for a plurality of courses. The operation of the machine is thus switched back and forth so that the pattern of knitting is reversed every several courses.

It will be understood that when tuck stitches are produced, that the needles are projected insufficiently to "cast-off" the yarn loops thereon and that the number of yarn loops in the hook of the needle increases with each successive pass of a yarn feed, e. g., with each successive course of knitting. When the needles of one of the needle banks which have been moved through several courses of tuck stitches are finally knitted in conventional fashion, all of the yarn loops carried by the needle at the time are simultaneously "knitted off." Since a rib knitting machine is used so that there are opposed needle banks, and because the operation is periodically reversed, the "knitting off" of a plurality of yarn loops is performed alternately by the needles of each of the opposing needle banks.

As will be appreciated, each successive "knitting off" of a plurality of yarn loops is effected in the opposite direction (an inherent characteristic of the use of opposed needle banks as in rib knitting). The yarn loops which are "knitted off" as a result of the tuck stitches extend transversely across the knitted product between

longitudinally extending ribs and overlie longitudinally extending troughs of valleys. The longitudinal ribs form the sides of the air-entrapping cells and the tuck stitches form the bottom and top walls of these cells. When the fabric is turned inside out, the troughs or valleys become the longitudinal ribs for the back side of the fabric and the longitudinal valleys of the front side become the ribs. The tuck stitches from the other needle bank form the bottom and top walls of the cells on the back side of the fabric.

It is to be particularly noted that the opposed needles are arranged in groups and are not constituted, in accordance with preferred practice of the invention, by single needles disposed between adjacent needles of the opposite needle bank. This is of importance because when the tuck stitches are formed by adjacent needles on the same needle bank, only a limited length of yarn is used and when these tuck stitches are "knitted off" the loops so formed are stretched between adjacent longitudinal ribs and function to draw these ribs together at spaced apart points along the length thereof. This serves to accentuate the cellular construction which is produced. At the same time, the tuck strands underlie the ribs and function to brace and maintain the height of these ribs when the fabric is stretched or subjected to prolonged wear.

A feature of the invention is the manner in which the knitted cellular fabrics of the invention are treated, not only to cleanse the fabric, but to nap it in a manner which facilitates the entrapment of air within the cells of the fabric.

As will be seen more fully hereinafter, the knitted fabrics of the invention define cells the walls of which are of varying height. More particularly, there are side walls constituted by longitudinally extending knitted ribs and transverse ridges which constitute the top and bottom walls of each cell. These transverse ridges are constituted by superposed tuck strands which are of lesser height than the longitudinal ribs. In accordance with the invention, the yarns comprise fibrillatable fibers and the knitted fabric is treated to raise a nap the fibrillations of which extend in all directions from the crests of the ribs and from the outer tuck strands to enhance the ability of the cells which are knitted to entrap air. Since the outer tuck strands are lower than the longitudinal ribs, there is provided fibrillations at two different levels.

The treating procedure broadly involves cleaning or scouring the knitted product as by passing the fabric through an aqueous bath containing a detergent or solvent for the grease, size or other foreign substances which may be present, drying the fabric while preferably tumbling the same so that the dried fibers are not all aligned and then napping the surfaces of the drum-dried fabric to fibrillate the yarns or strands at the crests of the longitudinal ridges and at the outer surface of the outer tuck strands.

The invention will now be more fully described in conjunction with the accompanying drawings which are intended to illustrate the invention as applied to a 2 x 2 rib knitting machine.

Fig. 1 is a diagrammatic view illustrating a portion of a circular knitting machine having a pair of opposed needle banks, e. g., a cylinder and a dial, and showing the positioning of the needles for 2 x 2 rib knitting.

Fig. 2 is a chart indicating the operation of the dial and cylinder needles in successive knitting courses, this chart illustrating a particularly preferred knitting sequence in accordance with the invention.

Fig. 3 is a diagrammatic view of the knitted product produced using the opposed needles of Fig. 1 and the knitting sequence of Fig. 2, the view being on a greatly

enlarged scale so that the knitted structure which is produced can be more easily understood.

Fig. 4 is a photograph of the knitted product, the photograph representing an enlargement of 16 times.

Fig. 5 is a schematic view of flow-sheet character illustrating the sequence of treatment to which the knitted product of Fig. 4 is subjected for the purpose of enhancing the softness, hand and insulating quality of the knitted product.

Fig. 6 is a photograph, similar to Fig. 4, and showing the knitted product after treatment as indicated in Fig. 5.

Referring to Fig. 1, it will be seen that there is employed in accordance with the invention a rib knitting machine having a pair of opposed needle banks. Since the invention is particularly adapted for application to circular knitting machines one of the needle banks is identified by the letter C to indicate that it is the cylinder of a circular knitting machine and the other needle bank is identified by the letter D to indicate that it is the dial of a circular knitting machine.

It is desired to immediately make it clear that the invention is not limited to circular or even to continuous knitting so long as there are opposed needle banks. Normally there will be two needle banks in accordance with the invention but this does not exclude the presence of additional needle banks so long as alternate groups of opposed needles are positioned to "knit off" in opposite directions. The invention can even be performed with machines such as links and links machines in which the needles may be operated from either of two aligned needle beds (usually axially spaced apart cylinders) so long as alternate groups of needles are operated to "knit off" in opposite directions.

It will be observed that the needles **10** of the cylinder C are arranged in pairs. In brief, the cylinder C does not have a full complement of needles (or if it does some of the needles must be held inoperative). At the same time, the needles **11** of the dial D are also arranged in pairs. It will be observed that each pair of cylinder needles **10** are disposed between each pair of dial needles **11** and vice versa. This is a 2 x 2 rib knit needle position. Fig. 1 also indicates the presence of combing **12** so that the needles **10** and **11** will have something to draw against when knitting is performed in conventional manner.

The use of pairs of opposed needles is preferred but is not essential to the invention. When each group of opposed needles is constituted by three adjacent needles (a 3 x 3 rib knit needle positioning), then the ribs and valleys will be wider. The opposed groups of needles need not have the same number of needles and a 2 x 3 or a 2 x 4 or a 3 x 4 rib knit needle positioning may be employed. It is even within the scope of the invention to employ a 1 x 1 or 1 x 2 rib knit needle positioning but the cell formation is not nearly as deep and as well defined. It is stressed that the 2 x 2 rib knit needle positioning which is preferred is uniquely superior in providing superior cell formation and consequent air entrapment and this is so with particular emphasis when the 2 x 2 positioning is compared with a 1 x 1 or even a 1 x 2 positioning.

Fig. 2 shows a preferred knitting sequence in accordance with the invention. It will be observed that in general, when the dial needles are knitting conventionally, that the cylinder needles produce tuck stitches and vice versa. It will also be observed that the dial needles knit conventional stitches for a plurality of consecutive courses and then knit tuck stitches for a plurality of consecutive courses.

In the preferred sequence of Fig. 2, the needles knit five conventional stitches and then three tuck stitches. As will be evident, when the first conventional stitch is knitted, four yarn loops will be "knitted off" at the same time. Three of the yarn loops form tuck strands. It will lastly be seen that the last conventional stitch which is knitted by the needles of one of the needle banks is performed at the same time that the needles of the other needle bank are performing their first conventional stitch. This constitutes preferred operation of the invention and leads to the production of a knitted product which is of particularly uniform shape. However, the specific sequence of Fig. 2 is not essential to the invention although it does illustrate the best mode of practicing the invention as it is presently understood.

Referring specifically to Fig. 2, the vertical columns labeled D and C refer to individual needles on the dial and the cylinder respectively. The horizontal columns numbered 1, 2, 3, etc., identify consecutive knitting courses.

The letter K identifies a conventionally knit stitch in which the needle is projected sufficiently to cause the old yarn loop to move rearwardly for a sufficient distance to open the needle latch and to be "cast off" upon the body of the needle to the rear of the opened latch. The needle is then normally partially retracted to move the yarn forwardly to partially close the latch (a tuck position) and fresh yarn is placed in the hook of the needle. The needle is then fully retracted within the needle bed to cause the old yarn loop to be "knitted off" the needle and to draw the new yarn loop to the extent desired.

It will be understood that the foregoing depicts typical conventional knitting and is presented as illustrative of the invention and not as limiting the same. If a plurality of old yarn loops are present on the needle at the beginning of the conventional knitting sequence, as the result of previous tuck stitches, then all of these old yarn loops will be simultaneously "cast off" during needle projection and "knit off" upon needle retraction.

The letter T identifies a tuck stitch in which the needle is projected to an extent sufficient to open the latch so that a fresh yarn will be received within the hook of the needle when the yarn feed passes the needle. However, the needle projection is insufficient to cause the old yarn loop or loops to be "cast off" to the rear of the latch. When the needle is then retracted, no yarn loop is "knit off" and the yarn loops accumulate within the hook portion of the needle. The needle may be fully retracted or preferably only partially retracted to minimize drawing of the fresh yarn. It will be appreciated that any slack is taken up by the drawing action of the opposing needles of the opposite needle bank which knit conventionally while the needles of the other needle bank are producing tuck stitching.

The camming necessary for each of the foregoing operations is a matter of common and general knowledge in the art. The selection and timing of this camming in the needle beds to accomplish the sequence of knitting actions described in Fig. 2 is obvious and will not be described in detail here with the exception of a brief description to be presented hereinafter to show the simplicity of the invention as adapted to circular machine operation with a plurality of yarn feeds.

With the foregoing description in mind, the knitting sequence of Fig. 2 will be self-explanatory.

Referring to Fig. 3, the yarn loops knitted by the dial needles are shown at **20**, the yarn loops knitted by the cylinder needles are shown at **21**, and the tuck strands are identified by the numerals **22** and **23**. The numeral **22** designates the tuck strands produced by the dial needles and the numeral **23** designates the tuck strands produced by the cylinder needles.

The cells **24** which are formed are defined between the longitudinal ribs **25** and the tuck strands **22** which overlie the valleys **26**. The tuck strands **23** underlie the ribs **25** and these, as will be appreciated, form cells with the back surface of the valleys **26**.

Fig. 4, being a photomicrograph, is self-explanatory. Some of the yarn feeds carried black threads to facilitate identification of individual courses. The product pictured in Fig. 4 is a photograph of the same product dia-

grammatically shown in Fig. 3 and the identifying numerals have the same meaning.

Fig. 5 is a flow-sheet of fabric treatment in accordance with the invention and this flow-sheet is self-explanatory. The flow-sheet schematically illustrates the specific treatment utilized in the specific illustration of the invention which will be presented hereinafter.

Fig. 6 is a photomicrograph of the cleaned, dried and napped product produced by the treatment indicated in Fig. 5. The numeral **27** indicates the nap on the ribs **25** and the numeral **28** indicates the nap on the outer tuck strand.

Example

The invention will now be illustrated in its presently preferred form employing a knitting machine of the circular type having a single cylinder and a single dial each of which is provided with 12 needle slots per linear inch. The cylinder needles are 36 gauge and the dial needles are 24 gauge.

The yarn used is a number 12 single yarn consisting of cotton. Reed #1 (the middle dial tuck) has one end of 8 single yarn thereby raising the height of the cell walls, feeds #2 to 7 inclusive use 12 single yarn. Mixtures of cotton with other fibers both natural and synthetic may also be employed with success.

The needle arrangement used is the 2 x 2 needle positioning shown in Fig. 1 and the knitting sequence followed is the specific sequence indicated in Fig. 2.

The circular knitting machine is provided with 8 yarn feeds which are equally spaced around the periphery of the machine. Each yarn feed supplies yarn to both the dial and the cylinder needles. Considering the yarn feeds as being numbered 1–8 consecutively, and with the understanding that the yarn feeds circle the machine with the cams for the dial and cylinder needles while the cylinder and dial are stationary, the cams are constructed as follows:

The dial cams opposite yarn feeds 1, 2, and 8 are configurated to move the needles which they pass through a tuck stitch sequence as previously described in detail. The dial cams opposite yarn feeds 3, 4, 5, and 6 are configurated to move the needles which they pass through a conventional knitting sequence as has also been previously described in detail.

The cylinder cams opposite yarn feeds 1, 2, 3, 7, and 8 are configurated to move the needles which they pass through a conventional knitting sequence and the cylinder cams opposite yarn feeds 4, 5, and 6 are configurated to move the needles which they pass through a tuck stitch sequence.

As will now be appreciated, a conventional circular rib knitting machine has been made to pursue continuously and without change in speed or operation the knitting sequence of Fig. 2 by the simple expedient of selecting and positioning the needle operating cams.

It has been found that the application of a heavy tension on the fabric produced is beneficial in achieving fully satisfactory machine operation.

The fabric produced is then passed through a scouring bath for the purpose of removing all foreign matter such as dirt, oil, paraffin, etc. A suitable scouring bath which may be at the boiling point during scouring has the following composition:

Composition:	Parts by weight
Water	95
C–12 polypropylene benzene sulfonic acid	1
Sodium carbonate	4
	100

In place of the detergent specified above, any of the common detergents anionic, cationic or non-ionic can be used. The detergent may be of the common anionic type such as sodium lauryl sulfate, dioctyl sodium sulfosuccinate, sodium oleate, and sodium or potassium salt of keryl benzene sulfonate (keryl represents a kerosene fraction of from C–12 to C–18 carbon length used in alkylating benzene), the sodium or potassium salt of C–12 to C–18 alkyl naphthalene sulfonate, the alkali metal salt of sulfonated castor oil, etc.

Suitable cationic detergents are amine and quaternary ammonium salts containing hydrocarbon chains of 12 or more carbons, such as Triton X–400. Cetyldimethylammonium acetate is also suitable.

The amine salt is preferably one which is wholly aliphatic in nature and secondary as well as tertiary amine salts are particularly effective. Such specific salts as sauryl dimethyl amine hydrochloride, oleyl dimethyl amine sulfate and stearyl methyl amine sulfate are all suitable.

Non-ionic detergents can also be employed, such materials including glyceryl monolaurate, a sorbitol monooleate, sorbitol monostearate, and ethylene oxide condensation products of each of these aforementioned hydroxy esters in which from one to all the hydroxy groups are condensed with one mole of ethyl hydroxy in the presence of an alkaline catalyst.

The scoured fabric is then mangled to extract liquid from the same and dried on a conventional loop dryer.

The dried fabric is then napped or fleeced lightly first on one side and then on the other side (the circular knitted fabric is turned inside out).

Rewet with water and then dry again in a fabric tumbling drum dryer. The dried fabric was then finished by calendering on a "Tube-Tex Tensionless Calender" which is described in "Textile Industries," April 1952.

The napping operation was performed on a "Universal Napper Grinder" which is described in booket N–69 published by the Davis & Furber Machine Company of North Andover, Mass. Another napping machine which can be used effectively is the 20 Roll Geared Double Action Napper described in Davis & Furber Bulletin N–66A.

If desired, the finished product may be run through mechanical shrinkage equipment after washing at any desired temperature.

The heat insulating cellular knitted fabrics of the invention are of outstanding utility where extreme warmth coupled with light weight are desired. These fabrics are, therefore, particularly adapted for underwear intended for arctic use. However, the utility of the knitted fabrics of the invention is not limited in this regard and these fabrics can also serve as the basis for sweaters, dresses and other articles of knitted outerwear.

The invention has been described to illustrate the continuous production of what might be considered to constitute yard goods. The invention is not limited in this regard since many variations can be made without departing from the invention as it has been described. Thus, for example, the invention can be performed in such manner as to provide rib knitted cuff portions. If these cuff portions are desired, it is only necessary to remove the tuck forming cams from the cylinder and the dial and replace these with cams which will cause the needles to move through the conventional knitting pattern. When this is done, the knitted product will be a conventional 2 x 2 rib. The rib knitting machine can be provided with conventional automatic equipment for producing a selvedge and, in this manner, a cellularly configurated body with a rib bottom having a self-edge can be continuously produced. Also, the color and/or weight of the yarn supplied may be altered intermittently to produce various designs. Many similar modifications of the invention lie within the skill of the art and are intended to be encompassed by the claims which follow.

I claim:

1. A heat insulating knitted fabric comprising a rib knitted fabric having longitudinally extending alternate ribs and valleys on both sides thereof and longitudinally

spaced apart laterally extending groups of adjacent tuck strands overlying the valleys and underlying the ribs of said fabric, said ribs forming the side walls of air-entrapping cells the top and bottom walls of which are constituted by said tuck strands.

2. A heat insulating knitted fabric as recited in claim 1 in which said tuck strands rise to a height which is less than the height of the crests of the adjacent ribs and in which said tuck strands extend across at least two conventionally knitted yarn loops.

3. A heat insulating knitted fabric as recited in claim 1 in which said knitted fabric comprises fibrillatible yarn and said fabric is napped to provide fibrillations extending from the surface of said ribs and said tuck strands.

4. A heat insulating knitted fabric as recited in claim 1 in which the tuck strands on opposite sides of said fabric are staggered along the length of said fabric.

5. A method of forming a heat insulating knitted fabric having air-entrapping cells on both sides thereof comprising knitting on a rib knitting machine having opposed needle banks a first plurality of courses with the needles of one of the needle banks being operated to produce conventional knit stitches and with the needles of the opposed needle bank being operated to produce tuck stitches and then reversing the sequence to knit a plurality of courses with the needles of said first named needle bank being operated to produce tuck stitches while the needles of said opposed needle bank are operated to produce conventional knit stitches.

6. A method of forming a heat insulating knitted fabric having air-entrapping cells on both sides thereof on a rib knitting machine having opposed needle banks comprising, providing said needle banks with spaced apart groups of needles, said groups of needles on each of said needle banks being positioned between groups of needles on the other of said needle banks, knitting a first plurality of courses with the needles of one of the needle banks being operated to produce conventional knit stitches and with the needles of the opposed needle bank being operated to produce tuck stitches and then knitting a second plurality of courses with the needles of said first named needle bank being operated to produce tuck stitches while the needles of said opposed needle bank are operated to produce conventional knit stitches and alternately repeating said first plurality of courses and said second plurality of courses.

7. A method of forming a heat insulating knitted fabric as recited in claim 6 in which all of the needles are operated to produce conventional knit stitches for at least a single course after said first plurality of courses and after said second plurality of courses.

8. A method of forming a heat insulating knitted fabric as recited in claim 6 in which the needles of said needle banks are positioned to assume a 2 x 2 rib knit position.

9. A method forming a heat insulating knitted fabric as recited in claim 7 in which the needles of said needle banks are positioned to assume a 2 x 2 rib knit position.

10. A method of continuously forming a heat insulating fabric having air-entrapping cells on both sides thereof on a circular rib knitting machine having a dial and a cylinder provided with independently mounted groups of knitting needles, said groups of needles on said dial and said cylinder being positioned between one another, knitting a first plurality of courses with the needles of said dial being operated to produce conventional knit stitches and with the needles of said cylinder being operated to produce tuck stitches and then knitting a second plurality of courses with the needles of said dial being operated to produce tuck stitches while the needles of said cylinder are operated to produce conventional knit stitches and alternately repeating said first plurality of courses and said second plurality of courses.

11. A method of continuously forming a heat insulating knitted fabric as recited in claim 10 in which all of the needles are operated to produce conventional knit stitches for at least a single course after said first plurality of courses and after said second plurality of courses.

12. A method of continuously forming a heat insulating knitted fabric as recited in claim 11 in which said first and said second plurality of courses are each constituted by three consecutive courses and a single course in which all of the needles are operated to produce conventional knit stitches after each of said plurality of courses.

13. A method of forming a heat insulating knitted fabric having air-entrapping cells on both sides thereof on a rib knitting machine having opposed needle banks comprising, providing said opposed needle banks with independently mounted knitting needles positioned in 2 x 2 rib knitting position, knitting three courses with the needles of one of the needle banks being operated to produce conventional knit stitches and with the needles of the opposed needle bank being operated to produce tuck stitches, then knitting a single course of conventional knit stitches with the needles of both of said needle banks, then knitting three courses with the needles of said first named needle bank being operated to produce tuck stitches while the needles of said opposed needle bank are operated to produce conventional knit stitches, then knitting a single course of conventional knit stitches with the needles of both of said needle banks and then repeating the above set forth series of operations.

14. A method of forming a heat insulating knitted fabric having air-entrapping cells on both sides thereof comprising knitting with fibrillatible yarn a rib knitted fabrc having longiudinally extending alternate ribs and valleys on both sides thereof and longitudinally spaced apart laterally extending groups of adjacent tuck strands overlying the valleys and underlying the ribs of said fabric, said ribs forming the side walls of air-entrapping cells the top and bottom walls of which are constituted said tuck strands, scouring the knitted fabric, drying the scoured fabric and then napping said dried fabric.

15. A method of forming a heat insulating knitted fabric as recited in claim 14 in which said scouring is performed by passing the knitted fabric through an aqueous bath containing a detergent to remove dirt, grease and similar foreign material.

16. A method of forming a heat insulating knitted fabric as recited in claim 14 in which said tuck strands rise to a height which is less than the height of the crests of the adjacent ribs and said napping operation produces fibrillations at two different levels and in which said tuck strands extend across at least two conventionally knitted yarn loops.

17. A method of forming a heat insulating knitted fabric as recited in claim 14 in which both faces of said dried fabric are napped.

18. A method forming a heat insulating knitted fabric as recited in claim 14 in which said scoured knitted fabric is dried while said fabric is tumbled.

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