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Some uses of knitted fabrics in medical field

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Abstract

This research investigates the many applications of knitted materials in the medical area, emphasizing their distinct features and adaptability. Knitted materials have shown to be useful in a variety of medical settings, providing advantages such as flexibility, breathability, and adaptability. where knitted materials play an important role in improving patient comfort and treatment outcomes. The study also examines developments in material technology, production methods, and design considerations that lead to the increasing integration of knitted textiles in medical applications. This work intends to give insights into the rising significance of knitted textiles as creative solutions in the medical sector by exploring the convergence of textile engineering and healthcare. The research delves into some application of Knitting fabric in Medical Field, including, Medical Dressings, Medical Gauze, Medical Bandages, Heart Patch, Hernia Patch.

Keywords: Knitted Fabrics, Medical Field, Weft knitting, Warp knitting.

Introduction

Knitting, the process of making fabric, has long been related to textile manufacture. Knitting has seen a significant increase in popularity in recent years, particularly in the medical field. Knitting is used in a variety of medical applications, from the manufacture of customized clothes to the development of novel medical gadgets. Knitting opens a world of new and fascinating possibilities in the medical profession. Its potential contributions include improving patient care, developing treatment approaches, and boosting medical research. Knitting appears as a viable technique for improvement in healthcare due to its versatility and adaptability. Medical textiles are classified as non-implantable, implantable, or both[1]

Knitted fabric, woven fabric, braided fabric, and non-woven fabric are the four types of medical textiles. Non-woven medical textiles account for more than 60% of all medical textiles utilized. Ordinary medical fabrics are nearly disposable. Knitted fabric, woven fabric, and braided fabric account for a smaller proportion of total medical fabric. They are, nevertheless, the fundamental structures for high-tech medical textiles such as artificial blood arteries, medicinal patches, and scaffolds for tissue engineering[2-8].

Knitted textiles feature a loose structure, good elasticity, high porosity, and a flexible and variable structural design when compared to woven materials. Knitted fabric constructions can also be changed to fulfill different needs. They are ideal for medical textiles, particularly high-tech medical textiles. Knitted cloth is used in the medical industry to make medical dressings, bandages, and Medical Gauze[9].

Knitting Technology

Knitting is the most frequent way of interlooping and the second most prevalent method of producing textile items, behind only weaving. It is estimated that about 7 million tons of knitted items are manufactured worldwide each year[10].

Knitting is a versatile production technique that makes it straightforward to produce a variety of materials with either complicated or basic structures. Recent advancements in knitting technology could enable the creation of a vast array of high-performing knit-based configurations appropriate for a variety of technical uses[11].

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These fabrics are commonly used in a variety of applications, including clothing, home textiles, industrial products, and medical field. Knitted fabrics' particular qualities, such as elasticity and stretchability, make them perfect for a wide range of medical applications. In the following we give some key properties of knitted fabrics for use in the medical field:

- **Comfort and Flexibility**: Knitted textiles, such as tricot, excel in stretching and moving with the body's motions, providing great comfort to patients, and improving their medical experience.
- **Air Ventilation**: The pattern of knitted fabrics allows for air circulation, which promotes ventilation and reduces the chance of skin problems.
- **Compression Technology**: Compression methods may be incorporated into knitted Fabrics to help treat diseases like varicose veins and improve blood flow.
- **Surgical Garment Suitability**: Knitted textiles are well-suited for the design of surgical garments, providing comfort and assisting healthcare professionals in the performance of their tasks.
- **Antimicrobial Resistance**: Knitted textiles may be treated with antimicrobial chemicals, which reduces bacterial, and germ spread and so aids in infection prevention[9, 10, 12].

Comparison Between Weft Knitting and Warp Knitting

There are two main categories for knitting: warp and weft knitting. The basis for this classification is the direction in which the yarn moves in relation to the direction in which the fabric is formed. Weft knitting is the term for knitting in which the yarns run in the width or cross-wis.se direction relative to the direction of fabric development during the knitting process. The procedure is known as warp knitting if the threads run in the length direction, or the direction in which the fabric forms during knitting[13, 14]. See Table (1) show comparison between weft knitting and warp Knitting[13, 15-17].

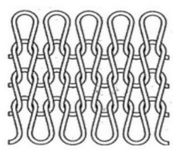
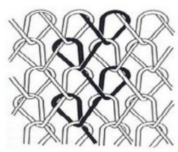
Some Uses of Knitted Fabrics in Medical Field:

Knitted fabrics find various applications in the medical field due to their unique properties such as flexibility, stretchability, breathability, and comfort. Here are some uses of knitted fabrics in the medical field: Bandages, dressings, and gauzes are the most common knitted non-implantable textiles and used in Implantable Knitted Medical Textile such as Hernia patch and Heart Patch. [7]

Non-implantable knitted medical textile

Bandages, dressings, and gauzes are the most common knitted non-implantable textiles. So, it is considered Textile materials and products that have been created to satisfy specific criteria are appropriate for any medical and surgical application that requires a mix of strength, flexibility, and, in certain cases, moisture and air permeability. And from Non implantable Materials Used in knitted Medical Textiles Alginate, chitosan, silk, lyocell in Wound contact layer Cotton, lyocell, elastomeric fiber in Compression bandage Cotton, viscose, chitosan, alginate in Gauze dressing[18, 19]

Table 1: show comparison between weft knitting and warp Knitting

Weft knitting	Warp knitting
The development of loops occurs in a horizontal route. During knitting, yarn travels horizontally or in a straight line.	Loop creation occurs wale upon wale in a vertical direction. During knitting, yarn flows vertically or in a wale direction.
In a knitting cycle, needles knit successively.	Knitting needles knit together in a knitting cycle
Yarn is often given in the shape of cones held in a creel.	Yarn is often supplied in the form of a warp beam (two or more beams).
During the knitting of a fabric, only one or a few yarn(s) (152 maximum) are required.	Many yarns are required to weave a cloth.
Staple yarns are preferred; however, filament yarns are more appropriate.	Filament yarns are the most often utilized, however staple yams are being employed in some circumstances.
Knitting requires fewer pre-processing steps.	Before knitting, further steps are necessary.
A machine can only create a limited number of structures.	A machine may create a vast range of structures.
Elastic in both directions, but more elastic in the breadth (weft) direction.	Elastic in the length direction (warp)
Elasticity higher than warp knit.	Elasticity lower than weft knit.
Higher shrinkage than warp knit.	Weft knit shrinks less than warp knit.
More edge curling than warp knit.	Limited edge curling.
	

Medical Dressings

Medical dressings insulate and protect the wound, adhere medications to the wound, and absorb liquids. It is critical for wound dressing (a wound care material or product) is an important aspect of wound care because it protects the wound from environmental threats and further mechanical injury/abrasion, and it helps to generate circumstances conducive to wound healing. Humans have been using wound dressings for thousands of years. Ancient Egyptians employed grease-soaked gauze bandages as one of the first forms of wound treatments. Leaves, animal fat, and honey were also employed in ancient times. Ancient dressings were prone to severe contamination by germs and might become causes of illness. The need for cleanliness and aseptic practice for medical treatments, particularly wound care, was not recognized until the late nineteenth century (Queen, Orsted, et al., 2004). Knitted medical dressings exhibit improved extensibility, elasticity, fitness, and flexibility. Weft plain stitch and rib stitch are commonly used in medical dressings for two-dimensional constructions due to their easy knitting technology, high flexibility, and low viscidity. Aside from this, several three-dimensional structures, such as weft multiple composites, weft knitted spacer textiles, and warp knitted spacer fabrics, are widely employed in medical dressings. They frequently feature absorbent layers for effective heat and moisture transfer management. Cotton, viscose filament, alginate fiber, jute cell, and chitosan are among the materials used in medical dressings. Yarns and filaments account for most of the short fiber loss throughout the operation[1, 20, 21].

Weft Plain Stitch Applied in Medical Dressings

Medical dressings made using weft simple stitch provide high strength, flexibility, and minimal viscidity. The Alginate is non-toxic and promotes homeostasis throughout the wound healing process . Contact dressings are made of alginate fiber and cotton mixed yarn. After absorbing the effusion, the alginate fiber insides will create a single gel layer, and the gel will be able to separate the wound from the dressings. Cotton fibers are strong enough to keep the form and can be used to cloak the wound. Medical dressings also include viscose. It is frequently coupled with non-woven materials with increased hygroscopicity to segregate the wound from non-woven short fibers[10, 11].see Figure 1 Viscose filament yarn knitted wound dressing fabric.

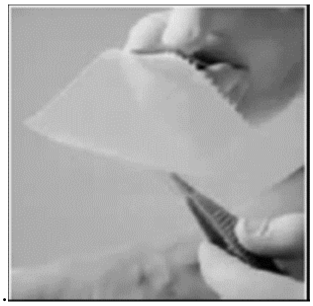


Figure 1: Viscose filament yarn knitted wound dressing fabric

Weft Multiply Composites Applied in Medical Dressings

Weft multiply composites have flexible structures that serve a variety of applications. The inner layer is made up of simple stitching with thick structures. The interlayer is a fleecy stitch that adds thickness to the dressings. The outer layer is tuck stitched with meshes, which boosts the fabric's breathability and attractiveness. Cotton and bamboo fiber are commonly utilized in multiple composites. Dressings for medicinal purposes. See Figure 2 show The structure of the multiply composites.[1]

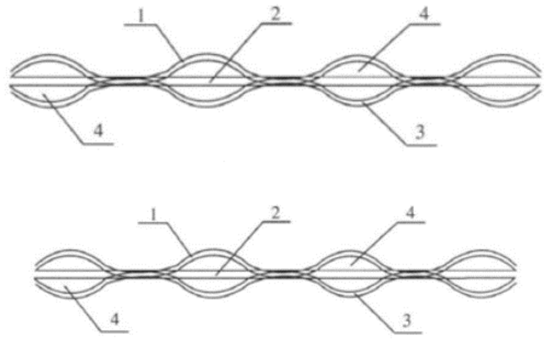


Figure 2: The structure of the multiply composites. 1-surface layer; 2-spacer; 3-inner layer; 4-air layer

Medical Gauze

The use of platinum/rhodium gauze for catalytic applications is widely documented, albeit the rhodium concentration has altered slightly from the initial 10% rhodium. They have been created using weaving techniques since their inception into the nitric acid business. However, it has recently been demonstrated that gauze created using computer-controlled knitting processes offers benefits over conventional materials.

The distinctions between woven and knitted gauzes are shown, as well as a typical surface structure generated on a utilized knitted gauze. They are less brittle after usage than woven equivalents, and they may stretch further before breaking. Because of their bulky three-dimensional structure, they have more surface area, and geometric calculations reveal that the exposed area of a knitted gauze is 93%, but the figure for a woven gauze is 10% less. Wire life is extended over typical gauzes, and mechanical damage that leads to metal loss is minimized. Furthermore, it appears that gas movement through knitted gauzes is improved, resulting in less solid particles trapped on the surface, resulting in less rhodium oxide formation owing to residual iron contamination on the surface. There has lately been another advancement in the production of platinum/rhodium gauze catalysts. Crimping the gauze increases the surface exposed to the process stream by a factor of around 1.4.See Figure 3show Differences in structure between woven and knitted gauzes [22].

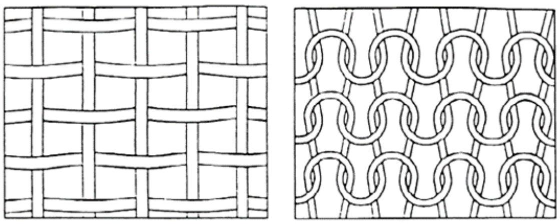


Figure 3: Differences in structure between woven and knitted gauzes.

Medical Gauze in Knitting Technology

Medical Gauze uses materials such as Cotton yarn (ideally one that is soft and absorbent), Structural compositions used by medical gauze Mesh Structure: An open mesh structure is commonly found in medical gauze. This promotes breathability and the interchange of air and moisture.

The mesh structure also aids in fluid absorption, making it appropriate for wound treatment. Plain weave is a basic and widely used knitting method in medical gauze. It entails interlacing the yarn in a basic over-and-under design. The structure of medical gauze is optimized for absorbency, allowing it to absorb fluids such as blood or wound exudate fast.

Gauze Rolls and Pads. Multiple piles of gauze can improve its absorbency and strength. To lessen the risk of infection, several medical gauze products may be treated with antimicrobial compounds [23].

Medical Bandages

Depending on the final medical necessity, bandages are intended to serve a wide range of specialized purposes. They can be woven, knitted, or nonwoven, and they can be elastic or not. Bandages are mostly used to keep dressings in place over wounds. Lightweight knitted or basic open weave textiles consisting of cotton or viscose are cut into strips, then scrubbed, bleached, and sterilized. Elasticated yarns are placed into the fabric structure to provide support and conformability. Knitted bandages with varied diameters may be made on either warp or weft knitting machines[24].

Crochet structures, which are comparable to warp knitted structures, embroidery, and braided structures are also utilized in medical devices. Crochet crepe-type bandages have essentially replaced woven crepe bandages in several hospitals in the United Kingdom. Crotchet bandages and dressings, like warp knitted bandages, may be made in a variety of opacities, and the structure does not tear or split. This material, which has a longer breaking strain and higher strength for the knitted structure than a nonwoven structure, may give more comfort to wounded patients. There are now several wound dressings on the market that help the wound heal spontaneously.30,66 Rib structure can experience irreparable deformation over time, however interlock double knit fabric constructed from a range of medical yarns should be investigated further. Because the loops of interlock knitting run in opposing directions and reinforce one another, they are less flexible than rib knit[24].see Figure 4.

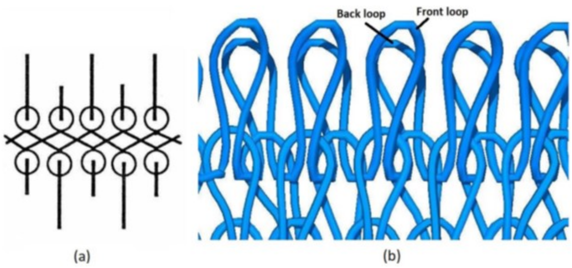


Figure 4: (a) Yarn notation of plain interlock (b) Loop formation of plain interlock

Implantable Knitted Medical Textile

Implantable knitted medical textiles are knitted fabrics composed of biomedical materials that may be implanted into the human body for a variety of medical applications. These textiles are intended to interact with the body to offer healing, support, or therapeutic benefits[25].

Hernia Patch

An implanted textile is knitted hernia patches. They were made utilizing warp knitting construction techniques such as pillars, tricot, and atlas stitches. Jacquard flatbed machine is also utilized for hernia patch creation. These stitches offer more strength and stability. Nonabsorbed (polyester, polypropyl-ene, and others) and absorbed (polyglycolic acid, polylactic acid, polycaprolactone, and others) A patch can be made from a variety of materials. A hernia repair patch was created using an 18-gauge warp knitted tricot machine. This hernia mesh was made using a variety of stitches and has 18-20 courses per centimeter. The yarn used was polypropylene monofilament. Patients reported increased comfort while using mesh with larger holes. Furthermore, the prolonged heat exposure shortened the fabric length. A hernia mesh with varied pull densities has its mechanical characteristics altered. The patch's efficacy was evaluated utilizing a range of pull strengths.

Tensile stress in the vertical direction was first reduced, then rose as pull density increased. It grows initially, then decreases in the horizontal direction. Furthermore, the vertical tearing capabilities of hernia patches were greater than the horizontal tearing capabilities. The bursting strength increased in direct proportion to the pull densities. Shape-changing materials (materials that change shape in response to internal and external stimuli) would relax the patient. When the external environment changes, phase change materials' sizes can alter.

However, no substantial study on phase transition materials as implantable textiles exists. Particular focus should be directed to the development of knitted structures for implantable textiles employing phase change materials. Knitted fabric, due to its lightweight and porous composition, is most used in implanted medical devices.

Knitted medical fabrics have been used to create novel medical devices for hernia and urogynecology. Because these devices are biocompatible and leachable, they were made with biocompatible materials. The implant materials under consideration have an extraordinarily high chemical purity. As a consequence, bigger holes knitted structures with a medium to low surface density gave the highest level of chemical purity. The knitted implants were made from medical-grade polypropylene.

The implanted devices were placed within the body and were designed to deliver the targeted medicament to a specified region. A patient must have surgery to have these devices implanted. The procedure, on the other hand, proved lifesaving. Recently, researchers reported on the use of chemical vapor deposition and plasma therapy to minimize post-surgical problems in hernia mesh. Researchers have also demonstrated that the final hernia patch might have diverse outcomes owing to procedural factors. As a result, adequate considerations for knitting fabric structure are required. The fabric is made by the author using a Stoll flat knitting machine (530 HP TT med). The M-1 design program was used to produce the design. The yarn was basic medicated polyester with a mesh structure. The objective of the figure is to merely display the structure[16, 26-28].see Figure 5.

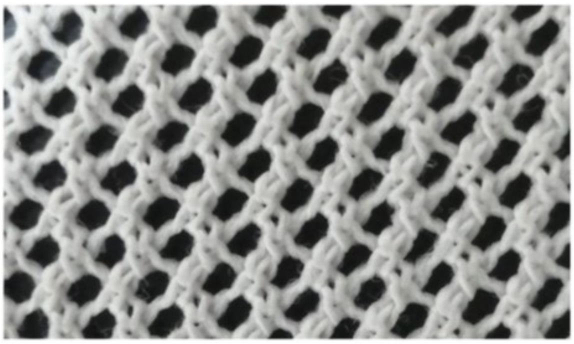


Figure 5: Hernia patch design on flat knitting machine [Developed on Shima Seiki Apex lll software].

Heart Patch

People who have a weak heart or severe cardiac illness may have problems with their heart's capacity to operate properly. Fewer transplants may be feasible due to donor scarcity. The knitting textile method was utilized to make biomimetic heart patches. These patches may improve cardiac function by repairing and renewing naturally anisotropic myocardium and knitting a vascular graft that also acts as a template in an electrospinning approach made possible by the 3D scaffold. The vascular graft was created using multifilament texturized Dacron yarn. To offer mechanical support, a polyester and poly (ethylene terephthalate) mesh was stretched around the dilated heart. As a result, the knitted patches were employed in several cardiovascular research.34,80-83 Because knitted cloth has an inherited property for elongation and flexibility[29, 30].

Soft tissues such as cartilage in the heart can be healed and regrown using scaffolds comprised of silk and fibrin. This scaffold, like a healthy heart, provided mechanical support to the cell seeded PCU. The electrospinning process used three components: poly(lactic-co-glycolic) acid (PLGA) and thermoplastic polycarbonate-urethane . The results revealed that the best cost-effective material for cardiac patching was the elastomeric PCU scaffold, which outperformed other materials.84 Knitting allows you to create structured structures in a range of sizes and forms. Advanced materials, such as phase transition materials, can, on the other hand, build a whole organ. Because organ growth is subject to cyclic stress and may unravel if not maintained by a warp-knitted framework, this sort of structure is used[31].

As seen in Figure 6, commercially available warp knitted elastic meshes can be employed as a cardiac support device. It is available in an open width that may be trimmed and sewn to match the shape of the heart. A multifilament yarn was used to attain the high strength and fatigue resistance properties. It provides immediate wall support to the heart. Diabetic patients' cardiac muscles degenerate with age, leading the muscles to function slowly.86 Support is required to maintain the heart operating properly and to improve blood circulation. Knitted scaffolds were chosen above other types of scaffolds because they provide elongation, elasticity, and strength. They were simple to create, and material management is easier in knitting than in weaving. A waffle knitted structure, on the other hand, may increase the patient's degree of comfort.

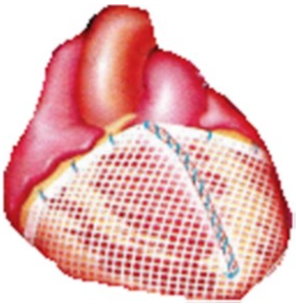


Figure 7: Knitted cardiac patch.

Each heart is unique in size, but sewing ahead of time increases stitch accuracy and reduces time constraints throughout the procedure.

Researchers tested the possibilities of a knitted PTFE patch for cardiovascular surgery in a pig model. The designed knitted PTFE patch demonstrated a lower inflammatory response and gave up to date data[12, 32].

PTFE, on the other hand, is not a biocompatible substance. The knitted pattern below was created on a 20-gauge single jersey machine using knit and miss stitches alternately. The design was identical to the cardiac patch available on the local market. See Figure 8.

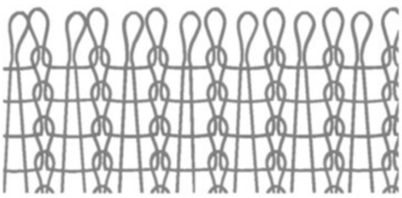


Figure 8: Loop formation of knitted cardiac patch [Developed on Shima Seiki Apex lll and Wise tex software]

Stents. The closure of a heart vein due to blood clotting may end in death. To open the venous channel, a stent is used. Metal, cloth, and polymers are some of the materials used to make stents. Many stents are used to open heart veins. After the stent was put, the occluded vein opened, enabling blood to flow freely. Stents consisting of drug delivery fibers are now accessible in the market.

Knitting is the preferred method for making stents because it has a wide porous surface and may be readily removed by unraveling one loop. The knitted loops' mesh design also helps to prevent further blockage. Stents are tracheal tubes that extend to accommodate the patient's anatomy and relieve significant airway blockages (Figure 9). Ultra-flex stents are now available on the market as knitted mesh with a single strand of nitinol wire. Nitinol has a thermal memory capacity of 55% nickel and 45% titanium. As it enters the human body, it is guided by a flexible guide made of coiled thread. When a thread is pulled, the stent will grow to its maximum diameter. On the market, it comes in a variety of diameters.88 These stents are dangerous since they can cause injury to a patient's body if they move a heavy weight or receive an electric shock. However, similar concerns do not exist with totally fabric-based stents.

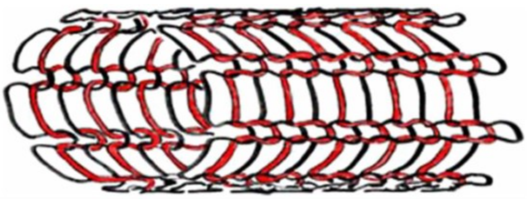


Figure 9: Raw form of knitted stent fabric

The qualities of a knitted polylactic acid airway stent were compared to those of a silicone stent. Stents were implanted in the rabbits utilized in the investigation. Rabbits with silicon airways stents died after three weeks, but rabbits with knitted PLA stents lasted until the 40th week. Knitted airway stents are favored due of their ease of removal. If applied in a place where the PH changes, the form of 59 PLA-based stents will vary. However, using a composite stent (one comprised of two polymers) may help to overcome these difficulties[13].

A nitinol wire and polyparaphenylenebenzo bisoxazole multifilament fiber composite knitted produced stent was created. These stents were also compared to similar knitted metallic stents. Several trials were conducted to evaluate the performance of these newly developed stents. The composite stent compression test exhibited the greatest load values as well as the lowest loop length. The greater the number of vents, the greater the extensibility. Radial compression was minimized in composite stents due to the bending tolerance of composite fibers.62 The aforementioned experiment has limitations because the author did not assess PBO compatibility with the human body. However, in-vivo testing, first on animals and then on people, is suggested before bringing this product to market. Textile-based knitted stents may be easily produced using a jacquard flat knitting machine or a tricot warp knitting machine. The author created a stent-type tubular fabric with a long loop length and a significant space between the loops; it had a mesh construction. Figure 10 depicts the finished cloth knitted pattern and loop construction[33, 34].

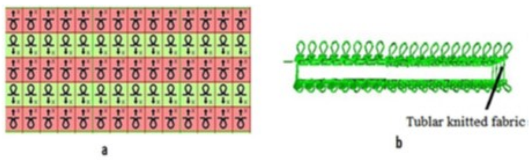


Figure 10: (a) Design and (b) loop formation of design [Developed on Shima Seiki Apex lll and Wise tex software.

Conclusion

The use of knitted fabrics in the medical field offers a wide range of advantages, from comfort and flexibility to customization and innovation. As technology advances and material science progresses, the potential applications of knitted textiles in healthcare are likely to expand further, contributing to enhanced patient care and medical outcomes.

Knitted materials have shown to be adaptable and effective in a variety of medicinal applications. Some major findings from the use of knitted materials in the medical industry include, Comfort and Flexibility, Air Ventilation, Compression Technology, Surgical Garment Suitability, Antimicrobial Resistance.

Conflict of Interest

There is no conflict of interest in the publication of this article.

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