Oct. 25, 1949. A. CRESSWELL 2,485,957

APPARATUS FOR TREATING STRANDS

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Fig. 1.

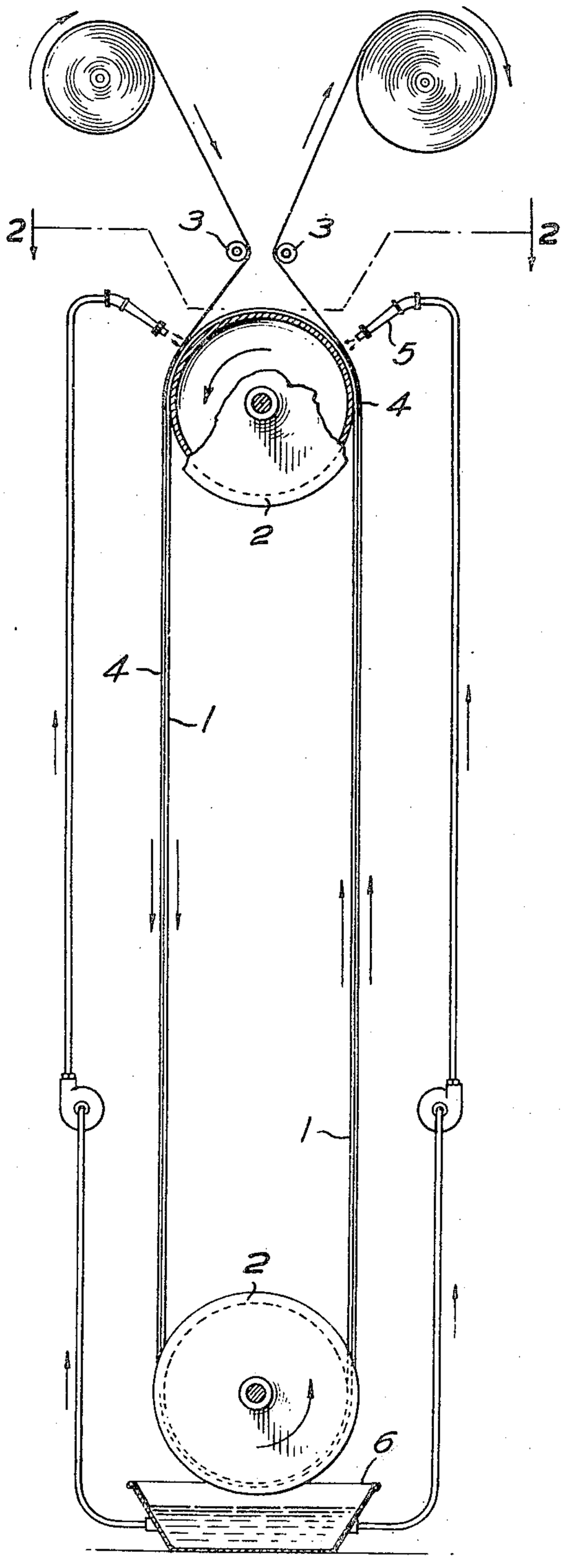
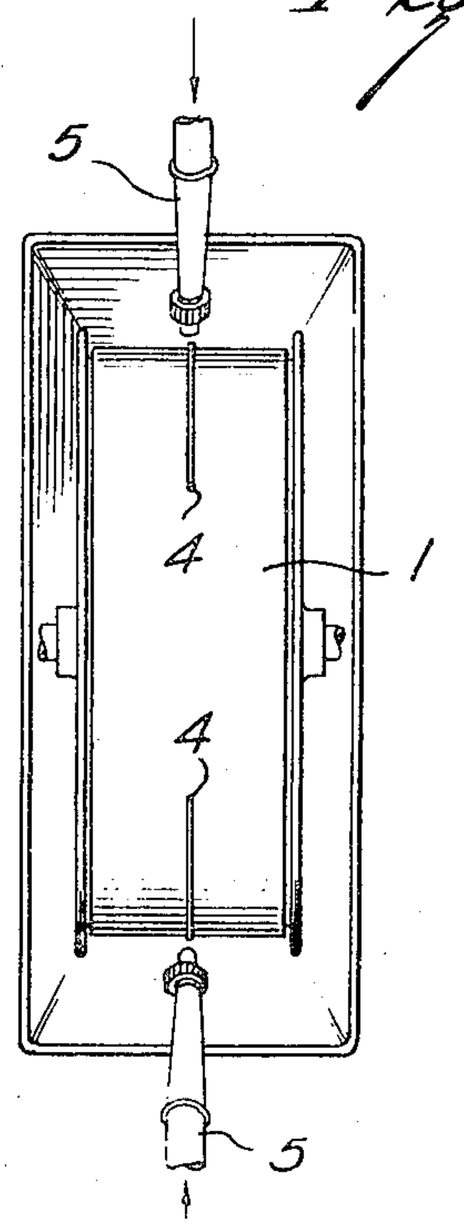


Fig. 2.



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APPARATUS FOR TREATING STRANDS

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The present invention relates to apparatus and methods for the production of collagen filaments, threads and the like and more particularly to apparatus and methods for liquid-treating and stretching such collagen filaments, threads and the like used as sutures.

Such threads, filaments, strands, tapes and the like are hereinafter referred to as "strands" for convenience of discussion and may be single or multi-filament. Such multi-filament strands may result from the conventional processing step of twisting together a number of smaller filaments. Conversely, a substantial unitary strand may result from twisting together a number of smaller filaments when sufficiently wet and untanned to permit a coalescence or cohesive action to occur.

In the manufacture of collagen strands it is desirable to orient the material of which the strand is composed by imparting a stretch to said strand to obtain a product of increased tensile strength. In imparting a stretch to other synthetic strands conventional practice calls for the employment of a godet or a series of godets. Such godets are merely separately geared spools about which the strand to be stretched is wrapped a few times after the manner employed with a capstan and by gearing the respective godets ahead of the preceding spool or godet the desired degree of stretch, or the desired fraction of the total amount of stretch may be imparted. Such godets have been found wanting when applied to stretching the small denier suture strands of regenerated collagen to which the apparatus and process of the present invention are particularly directed. The low wet tensile strength of such strands as occasioned by their small diameter and also perhaps by the fact that they are prepared by the regeneration of a collagen solution having present none of the original fibers upon which prior workers have apparently relied for satisfactory wet tensile strength does not adapt such strands to being stretched with the conventional godet.

The present invention involves apparatus and the use of such in methods for the stretching of a regenerated collagen suture strand and includes the use of a flat endless belt along which the collagen strands are carried while treating liquid is directed along substantially the entire length of

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such strand, the belt being driven at such a linear speed where desired that a stretch may be imparted to the strand. Such liquid treatments include pretanning, softening, washing and the like which are hereinafter more particularly explained.

The aforementioned flat belt may be of any suitable length or width and constructed of any composition suitably resistant to the treating liquid employed. In this connection, rubber is preferred since it provides a suitable degree of traction for stretching the collagen strand in addition to being resistant to the treating liquids generally employed in stretching and/or washing collagen strands. If desired, several belts may be used in series each imparting a given fraction of the total amount of the stretch desired.

Directing means employed in connection with the endless belt may be the usual rods, pulleys and the like which will serve to carry the strand and direct its path along the length of said belt.

The treating liquid is generally applied by suitable jets positioned alongside the endless belt, two jets located on either side and at the top of a vertical belt usually being found sufficient.

The main advantage derived from the process and apparatus of the present invention as regards stretching collagen strands resides in the provision of more suitable gripping means for the strand during stretching. Where a godet is employed the strand is gripped tightly in view of the capstan-like wrapping employed. With the present apparatus the type of gripping provided by a godet is not relied upon, the gripping being the result of the traction between the strand and the belt over a substantial length of the latter. Where there is resistance in the strand to stretching which could result in breakage of the strand such breakage is minimized by the use of such traction gripping as is provided in the apparatus of the present invention. Since the object in any given stretching operation is to impart the maximum stretch while avoiding breaking the strand it should be apparent that the apparatus and process of the present invention more nearly attain this end than does the godet of the prior art where a predetermined elongation is imparted which is at best an estimate of the aforementioned maximum obtainable stretch. In addition, the use of the endless belt provides sup-

porting means for the softened strand which makes it practical to stretch the strand over a greater length. In using a godet a choice must be made between stretching the strand over a short length and avoiding any problem of supporting the same or stretching it over an increased length and having a greater length unsupported. As regards washing or otherwise liquid treating the strand advantage is likewise provided by the process and apparatus of the present invention in that more efficient treatment is afforded, the strand being supported by the belt so that any weakening which may momentarily occur in the strand does not result in breakage before subsequent strengthening treatment, such as stretching, tanning, drying and the like can be applied. Also the strand is somewhat firmly positioned so that a single jet of treating liquid can be conveniently and efficiently applied, thus avoiding cumbersome treating baths and permitting the maintenance of optimum salt concentrations and the like in the liquids, as, for example, 20% ammonium sulfate in the softening liquid employed just prior to imparting the second stretch to the pretanned strand as mentioned hereinafter.

The operation of the device of the present invention is best understood by reference to the attached drawing.

Figure 1 shows a side view illustrating the relationship between the belt, the belt driving means, the strand directing means, and the liquid treating means.

Figure 2 is a section taken along the line 2—2 of Figure 1 and looking in the direction of the arrows for the purpose of showing the position occupied by the treated thread on the belt.

In the drawing, the endless belt 1 is positioned about driving wheels 2, said driving means being driven independently of any spools or the like. The strand is directed along the length of the belt surface by directing means 3, the position occupied by the strand being indicated at 4. The jets employed in directing the treating liquid onto the strand are shown at 5 while the liquid drainage is collected in tank 6 from which it may be recirculated by pumping back to the jets.

A detailed example of the manner in which the apparatus and process of the present invention are employed in the preparation of collagen suture strands follows:

A collagen solution is prepared by treating the cleaned corium of hide or skin material with a solution of organic acid, preferably formic acid, at a pH in the range of 2–4 for about 16–24 hours at 10–30° C. Following the swelling, the material is mechanically subdivided in various types of apparatus ranging from a meat grinder to a colloid mill. Final solution is obtained by adjusting the pH to 2–4 by the addition of organic acid, filtration being employed after these operations to remove any remaining fibers. Such a solution free from fibers or fibrous material may be extruded through small orifices and formed into very fine filaments of exceptional uniformity and purity to render them especially adaptable for use as sutures.

Said collagen solution is of 5–15% collagen content, preferably 9–10%, and is adapted to be extruded through a spinnerette having orifices of from 50 microns to 1 mm. Such orifices are preferably from 75 to 250 microns in diameter when suture material is to be prepared from the said 9–10% solution. The collagen is extruded

into a concentrated solution of ammonium sulfate containing at least 35% of said salt and maintained at a pH of 7.8 and at a temperature of 20–30° C. In working with acidic collagen solutions the addition of a base is required to maintain the desired pH in the spinning bath.

Any suitable coagulant may be employed, although ammonium sulfate is preferred because of its high solubility (about 42%) and low cost. Generally, this coagulant is employed at a concentration of at least 35%. Sodium sulfate and magnesium sulfate can likewise be employed but being considerably less soluble are less effective. Various organic compounds have been suggested, such as ethyl alcohol, acetone, ethylene glycol mono ethyl ether, diacetone alcohol and the like. However, such expensive organic compounds possess no appreciable advantage over the less expensive inorganic salts.

The strands are removed from the coagulating solution or spinning bath and directed along the length of the endless belt, or a series of such endless belts, and thereafter wound on a spool. Such endless belt is preferably run at a linear speed sufficient to remove the strands from the spinning bath as rapidly as they are formed without applying undue tension to the newly formed strands which just after formation are in an especially weakened condition. The linear speed of the spool which is used as a take-up spool for the strands as they come off the endless belt is appreciably greater than that of said belt in order that a stretch may be imparted. In working with the fine suture strands such as result from using the presently detailed conditions the linear velocity of the take-up spool is about twice that of the belt so that substantially a 100% stretch is imparted. The same effect may be obtained if desired by interposing a take-up spool before the endless belt for the purpose of removing the strands from the spinning bath, in which case the belt would be operated at a linear speed in excess of that of the interposed spool and the take-up spool on which the strands are wound from the belt would be operated at a linear speed substantially equal to that of the belt. The spooled stretched strands are thereafter preferably left in contact with coagulating solution, usually the same as used in the spinning bath, for a suitable period of time to set the strands in their stretched condition and minimize any tendency of retraction upon the removal of tension. After the first stretch has been set the strands are preferably treated with a dilute solution of a tanning agent, those commonly termed "mineral" tanning agents and formaldehyde being greatly preferred. Such mineral tanning agents are aluminum, ferric, and chromic salts and the like. This step may be described as a pretanning operation and is best carried out with chromic salts, basic chromic sulfate being preferred at a concentration equivalent to 0.01–0.50% Cr_2O_3, 0.05% being preferred. It is also preferred that such pretanning solution be substantially saturated with a coagulant, the aforementioned ammonium sulfate being highly suitable. After such pretanning the strands are then softened by treatment with water or aqueous solution so that a stretch may be imparted. The preferred treating liquid is one containing an appreciable percentage of a coagulant, 20% ammonium sulfate having been found to be highly satisfactory. The softened strands are thereafter stretched, a stretch of 15–40% being advisable

in the case of the small suture strands prepared by using the process conditions being detailed, although a stretch of 20–25% is usually found preferable. Such softening and stretching operations are best carried out by passing the strands over the endless belt of the present invention while impinging a jet of the aforementioned treating liquid on the strands as they are first carried by the belt and running the belt at a linear speed 15–40% greater than the linear speed with which such strands are unwound. If desired, the linear speed with which the strands are conveyed to the endless belt can be identical with that of the belt, the stretch being imparted by running the take-up spool at a speed in excess of that of the belt. It is in this second stretching operation that the advantages of the apparatus of the present invention are particularly apparent in that the softening and stretching of the strands occur while the strands are carried by the belt so that suitable support and the aforementioned preferred gripping means are provided.

After the second stretch has been imparted to the strand, the strand is usually subjected to a final tanning action with a more concentrated solution of a tanning agent. Preferably chromic sulfate is used here also, a basic chromic sulfate solution equivalent to 1.0–10% Cr_2O_3 being employed, a solution equivalent to 2.5% Cr_2O_3 and containing 10% Na_2SO_4 being preferred. The finally tanned strand may thereafter be washed free from all contaminating salts and dried and it is then ready for use as a suture or may be used in the preparation of twisted multi-filament suture or braided suture. The latter washing operation is very conveniently and efficiently carried out using the apparatus of the present invention, passing the strands over the belt with no differential linear speed between the belt, and the unwinding and winding spools. In washing the strand particular advantage is afforded by the countercurrent washing provided as the strand passes upward in the second half of the belt travel. Also, with respect to the recirculation of the treating liquid, the water used in washing is not recirculated by the pumps shown in the drawing but rather fresh water is continuously supplied for reasons of efficiency.

While the present invention has been described reference being made to a particular embodiment, it is nevertheless to be construed broadly and limited solely by the scope of the appended claims.

What is claimed is:

1. Apparatus for treating a collagen strand comprising in combination an independently driven vertical endless belt, means for directing a collagen strand along substantially the length of said belt and duplicate means positioned near either side at the top of said belt for applying treating liquid to said strand as it is carried by said belt, said liquid exerting a cohesive force between the said belt and the said strand.

2. Apparatus for stretching a collagen strand comprising in combination an independently driven vertical endless rubber belt, means for directing a collagen strand along substantially the length of said belt and duplicate means positioned on either side and near the top of said belt for applying treating liquid to said strand as it is carried by said belt and means for leading the strand from the belt at a linear velocity greater than that at which it is fed to the belt.

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