APPARATUS FOR THE MANUFACTURE OF UNIFORMLY CRIMPED FILTER TOW

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FIG. 7.

FIG. 8.

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APPEARATUS FOR THE MANUFACTURE OF UNIFORMLTY CRIMPED FILTER TOW

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This invention relates to the manufacture of a special tow of cellulose ester continuous filaments. More particularly, this invention concerns apparatus for the manufacture of a tow particularly adapted for use in the production of tobacco smoke filters.

This application is a continuation-in-part of our allowed U.S. application Serial No. 36,881, filed June 17, 1960 (now U.S. Patent 3,120,692). In our U.S. Patent No. 2,794,239 of June 4, 1957, we have described a cellulose acetate tow useful for making cigarette filters. Also, we have described in detail how said tow may be manufactured into the cigarette filters. We have described the functioning of such a filter in taking out nicotine, tar and the like components from tobacco smoke.

We have now discovered how tow of the aforementioned type may be further improved to render the tow more useful in making filters.

This invention has for one object an improved apparatus for manufacturing cellulose ester tow particularly adaptable for use in the production of tobacco smoke filters. Another object is to provide a cellulose acetate tow that is especially uniform both lengthwise and across the tow. Still another object is to provide a tow of the class described from which tobacco smoke filters may be prepared free of soft spots and fuzzy ends. Another object is to provide a tow that is treated with certain filament treating agents which, while lubricating the tow, still permit some static charge to build up on the filaments. Other objects will appear hereinafter.

Crimped tows of textile fibers have been known in the textile industry for a number of years. However, such textile tow is unsatisfactory as such for tobacco smoke filters as filters made therefrom have soft spots and otherwise present disadvantages. In our earlier applications and patents aforementioned we have described a tow comprised of cellulose acetate filaments having an acetyl content of 38-41%, said filaments being of about 3 to 16 denier per filament. The total denier of the aforesaid tow is within a range corresponding to about 80,000 to 160,000. This tow has a crimp of about 4-15 crimps per inch.

We have now found that filters with improved filtering efficiency can be produced using filaments with a wider range of denier as, for example, deniers that are less than 3 and the improved crimping and filter processing techniques of the present invention also permit the use of tows of lower total denier. We have found, for example, that tows of 50,000 total denier will produce firm rods suitable for use on the usual cigarette (24.5-25.5 mm. circumference). Further, 100,000 total denier is in most instances the upper limit for filter tips of the usual commercial length (11-17 mm.). This capability of reduction in tow denier results in a substantial saving in material for the filter manufacturer.

In the broader aspects of the instant invention, in addition to the aspects of improving the finish on the filaments and certain associated features, as described hereinafter, we have found that a much improved tow may be obtained by carefully controlling the uniformity of crimp by use of the novel apparatus construction of the present invention as will now be discussed.

The crimp of the usual textile tow may vary in several ways without seriously affecting the textile end product which is usually a spun thread of short fibers. For example, in the usual textile tow variations in crimp are common. We define crimp as the number of "peak" or "valley" points in a 1-inch length of straight filaments. Thus, an 8-crimp tow would measure 3/4-inch along each straight portion or 3/4-inch for a complete crimp cycle.

In the usual prior art crimped tow for textile use, "skips" are frequently observed. That is, short lengths of less than 4/5 to 3/5 of an inch appear in the tow without any crimp. Also, the crimp may vary at least plus or minus two crimps from the average or nominal value. This prior art variation may occur from length to length or it may be that the crimp will vary across the width of the tow. We have also found that it is quite common to find prior art tow with a higher crimp in the center of the tow band than on one or both edges.

We have found that in the case of tow for cigarette filters uniform crimp is of great importance. We have found that a long skip will cause a soft spot in the finished rod. Furthermore, if in a short length of tow, the crimp is higher than the desired level, the tow is less strong than expected and the tow may break if the tow is bloomed by a process which involves the use of tension. Regardless of which process is used to convert the tow to filter rods, variations in crimp produce variations in the weight, pressure drop and circumference of the rods. Variations in weight and pressure drop are unacceptable to a cigarette manufacturer since the result is non-uniform filter cigarettes. Soft rods and variations in circumference cannot be tolerated as the machine which attaches the filter tip to the tobacco portion may jam and cease functioning when a soft tip is encountered or the tipping material may not form an air-tight joint between the tip and the tobacco portion if the circumference is incorrect.

Accordingly, it is believed apparent that tow for use in manufacturing tobacco smoke filters represents a specialized product. Hence, the apparatus of the present invention which provides such a product represents a highly desirable unit.

In accordance with the present invention, in order to prepare an improved tow that is substantially uniform and free of the above discussed types of variations, we proceed as follows. A spinning composition of cellulose acetate having a 38-41% acetyl content is made up in acetone or other suitable solvent. If round or clover-leaf shaped filaments are desired, the spinning solution is spun in accordance with the methods described in H. G. Stone U.S. Patents No. 2,000,047 and 2,000,048 of May 7, 1935. If on the other hand filaments of a special cross section such as a Y cross section are desired, the solution may be spun in accordance with the method described in Raynolds et al. U.S. Patent No. 2,029,057.

The filaments of whatever configuration, produced as aforesaid, after removal of solvent and setting up in a spinning cabinet are conducted out of the cabinet around a godet roll.

Prior to or beyond the godet roll the filaments are treated with one or more of the finishing agents of the present invention. These finishing agents are pharmaceutical or edible grades of the following chemicals:

- Esters of monohydric alcohols and fatty acids such as isobutyl palmitate and butyl oleate.
- Naturally occurring or synthetic esters of polyhydric alcohols or their hydrates with fatty acids, such as glycerol monoesterate, glycerol triacetate peanut oil, coconut oil and glycerol monooleate-diesterate.
- High molecular weight monohydric alcohols such as lauryl alcohol, oleyl alcohol and ethylene oxide condensates comprising monohydric alcohols of 300 to 15,000 molecular weight.
Di- or polyhydric alcohols, such as glycerine and 2-ethylhexanediol. Ethylene oxide-polyhydrid alcohol (or anhydride) ester condensates, such as polyoxymethylene glycerol monolaureate.

Mixtures containing materials from the above groups with or without mineral oil, the mixtures blended in such fashion as to provide emulsifiable compositions suitable for fiber production applications.

We have found that the above agents lubricate the two filaments satisfactorily and while imparting some anti-static effect, do permit a reasonable static charge to develop on the tow during the tow processing in filter manufacturing. Such static charge aids in blooming and separating the filaments during filter manufacturing operations as described in our parent application above-identified.

In addition, the aforementioned agents are nontoxic, free from organoleptic effects and either do not impair the tobacco smoke taste and odor or in some instances may enhance the flavor of the tobacco smoke.

In further detail, the filaments may be prepared and the aforementioned finishes may be applied to the filaments making up the tow by several methods such as the following:

A. Cellosolve acetate is produced by a suitable dry spinning process. Immediately after the yarn from one spinning cabinet is withdrawn therefrom and before it wraps the godet roll, it is passed across the surface of a rotating cylindrical applicator roll. The finish is picked up on the roll by partial immersion in a trough containing the finish. If desired a doctor blade can be used on the applicator roll to control the film thickness of the finish although generally the film thickness is sufficiently uniform to make this unnecessary. The thread of filaments is slightly deflected from a straight line by the roll, preferably no more than 3°. The amount of finish applied can be controlled by carrying this arc of contact or preferably by varying the speed of the roll. The roll may be rotated so that the surface in contact with the thread moves in the same direction as the thread or in the reverse direction. In either case the surface speed of the roll is much less than the linear speed of the thread. The roll speed is generally between 0.1 and 3.0% of the yarn speed. This depends on viscosity and also on the presence of water or other volatile diluent. The roll is generally a ceramic although metals and other suitable materials may be used. Preferably the surface is roughened to insure the adherence of a uniform film of finish. If desired, the threads may be guided to run in a suitable groove cut in the roll, providing better opportunity for all the filaments in the thread to pick up finish.

B. Another method of applying the finish is to pass the thread across a wick which picks up finish from a reservoir by capillary action.

C. Still another method is to meter the required amount of finish to the wick or a surface from which the thread can pick it up.

D. If the finish applied consists of two or more components which are not miscible and which cannot be readily combined by emulsification, two or more lubricant applicators can be used. These may be between the spinning cabinet and the godet roll as described or one or more may be beyond the godet roll but ahead of the crimper.

After the filaments are suitably treated as just described to form a composite tow of 50,000 to 100,000 denier. The spinning capacity of the cabinet and the arrangement of the cabinets will together determine the number which can readily be combined to form the desired tow. Since the linear speed of all cabinet threads should be the same, the godet rolls are driven from a common power source. So that each cabinet will produce its proportionate share of the total denier, each spool or supported spinning solution from its own metering pump and those then driven from a common power unit. The godet rolls and metering pumps may both be driven by the same motor or separate power units may be used in which case they should be interconnected, electrically, hydraulically or mechanically. The threads from the required number of cabinets are drawn together to form the tow which is fed to a stuffing-box type crimper. If desired, additional finish can be applied to the filaments between the godet roll and crimper as discussed above. For example, the finish required on the filaments for good processing into cigarette filters should possess low antistatic properties as disclosed in our earlier U.S. Patent 2,900,988. In the manufacture and packaging of the tow, static is detrimental. Therefore, it is advantageous to apply a temporary antistatic and softening prior to crimping. Water is satisfactory for this purpose.

To secure uniform crimp, it is important that the tow be presented to the crimper as a flat band of uniform width and thickness. Variations cannot be tolerated and it is equally important that the band width as the tow enters the crimper be properly correlated to the width of the rolls. Too narrow a band causes low crimp on the edges. Too wide a band results in what is termed "crimp erharsh." This occurs when a few filaments are trapped between the sides of the rolls and the side plates which form the stuffing box. The filaments are chewed up and pressed into small, flat flakes of the material from which the filaments were spun.

The preferred apparatus for guiding the tow to the crimper and certain details of the crimper configuration are best understood by reference to the attached drawing forming a part of this application. FIGURE 1 is a front elevation view showing the tow band in cross section. FIGURE 2 is a partial side elevation view taken generally on line A—A of FIGURE 1. FIGURE 3 is a sectional plan view taken on line B—B of FIGURE 2 but with the tow omitted. FIGURE 4 is a partial isometric of a critical portion of the stuffing box. The important elements of the groove cut in the roll integral with the main frame or is rigidly attached thereto. Roll 2 is supported by and connected with a shaft which is in integral with the main frame or is rigidly attached thereto. Roll 2 is urged toward roll 1 through action of di-
aperture motor 25 carried on fixed member 24 acting on housing 22 through pin 26. Item 25 represents the diaphragm motor portion of a commercially available diaphragm operated valve. Air or other fluid is introduced on the top of the diaphragm at a pressure sufficient to produce the desired load at the nip of the rolls.

Thus shafts 19 and 21 are horizontal with shaft 21 vertically above and parallel to shaft 19, roll 2 may move toward or away from roll 1, in a generally vertical direction. The horizontal component of the movement can be made negligible by making the distance between shaft 21 and pivot shaft 23 sufficiently long.

Preferably rolls 1 and 2 are both driven. One means of accomplishing this result while still permitting roll 1 and shaft 21 to move is shown in FIGURE 7. This figure represents four gears with 19a, 21a, and 23a on the same centers as shaft 19, 21, and 23 in FIGURES 5 and 6. Shaft 19 is driven by a suitable means (not shown). Shaft 21 is then driven through gears 19a, 27, 23a, and 21a.

Other means to move the movable roll, to load it, and to drive both rolls will be apparent to those skilled in the mechanical arts. Furthermore, although this description of our apparatus indicates that the rolls are mounted on horizontal shafts with one roll above the other, it is not our intention that the invention be limited to this arrangement. The unit may be positioned in any manner desired.

The auffing box is formed by a front plate 5a, a back plate 5b, a bottom doctor blade 4a and a top doctor blade 4b. As indicated in FIGURE 3, the front and back plates 5a and 5b are spaced apart somewhat more than the thickness of rolls 1 and 2. This spacing is accomplished by clamping the bottom doctor blade 4a securely between the front and back plates. The rolls housing three members are bolted securely to the frame of the machine to maintain the indicated relationship with roll 1. The top doctor blade 4b is a slip fit between the front and back plates. It is secured to neither but is supported by the movable portion of the frame which carries roll 2.

As shown in FIGURE 2, portions of the top and bottom surfaces of the stuffer chamber are formed by the facing of rolls 1 and 2. To enclose the sides of this portion of the chamber, plates 3a and 3b are supported adjacent to the sides of the rolls. These plates are lightly urged against the sides of the rolls. Plates 3a and 3b are best supported in the desired positions by extended portions of front and back plates 5a and 5b. To minimize wear, generally the plates are made of a hard, ceramic material. Furthermore, a liquid lubricating and cooling medium may be applied to the sides of the rolls to reduce friction and wear. Water applied as a spray is preferred but other liquids or gaseous mediums may be employed. Spray means 58 and 59 are indicated generally in FIGURES 1 and 2. Spray nozzle 28 is typical and includes, in addition to the head, fluid supply pipe 30 and atomizing air supply pipe 31. A minimum of four spray heads is desirable, one for each side of each roll. Application of fluid to the roll face may be accomplished by positioning one or more heads as shown at 29.

Referring now to FIGURE 4, it will be seen that the leading edge 15 of the bottom doctor blade 4a butts against the end 16 of plates 35. Edge 15 is also nearly in contact with the top doctor blade face. An approximate surface 11 of bottom doctor blade 4a is formed on a curve such that the clearance between said surface and the roll increases. The end 16 of plate 3b also bears against the end of back plate 5b. Item 13 depicts the increase in width of the stuffer box at the butting ends of 3b and 5b. Surfaces 11 and 17 of bottom doctor blade 4a do not extend to form a knife edge at 15. Instead a rounded bevel is formed where surface 17 meets the cylindrical surface 16. This is indicated at 12. The beveled edge provides additional strength to "doctor" the crimped tow away from the roll and it prevents the tow from being cut as would be the case with a knife edge. Plates 3a and 5a are similarly positioned. Doctor blade 4b occupies a similar position with respect to roll 2 except that 4b can move between 5a and 5b.

Referring again to FIGURE 2, note that the movement of roll 2 is preferably in a direction parallel to the line joining the centers of rolls 1 and 2. If such is not the case, the ends of the tip of doctor blade 4a will move into or away from plates 3a and 3b. A small amount of lateral movement is permissible especially if the end surface 16 of plate 3b (3a and 3b) is accommodated to this movement.

If desired for ease of operation, one ceramic plate (3a) can be made easily removable. The corresponding side plate (5a) of the stuffer chamber can be formed in two parts, leaving a continuous narrow slot parallel to the common tangent between rolls 1 and 2. This facilitates threading tow into the crimper and is not detrimental to the quality of the product.

Two opposite sides of the crimp chamber (most conveniently doctor blades 4a and 4b) are positioned so that their tow-contacting surfaces are not parallel but diverge slightly. Included in the crimp chamber is a movable gate pivotally mounted to restrict the discharge of the crimped tow bundle from the crimp chamber. The gate may be placed in back plate 5b or in either doctor blade 4a or 4b. If the gate is incorporated in one of the doctor blades, front plate 5a and back plate 5b should diverge slightly. The gate is urged inwardly by a pneumatic bellows, a motor diaphragm, a spring, or a weight operating through levers. FIGURE 8 (which is similar to FIGURE 3) depicts a gate 32 pivotally mounted at 33 in back plate 5b and urged inwardly by bellows 35 whose movable member is connected to the gate by clevis 34. The bellows housing three members is bolted to the back plate. Pneumatic pressure applied to the bellows forces the gate inward, restricting the discharge of the tow from the chamber. Increasing the bellows pressure increases the resistance to the passage of tow through the chamber, increasing the crimp. It is believed that a length of tow emerging from the nip of the rolls is analogous to a column under compressive load. The "column" of tow buckles (crimps) at a length which is inversely related to the load applied. Therefore the amount of crimp in the tow can be controlled by regulation of the pressure applied to the bellows. It has been found that the bellows need not cover the entire working surface of back plate 5b. The gate can be shallower than the chamber height eliminating the possibility of interference between gate 32 and movable top scraper blade 4b.

Feeding the tow to the nip of rolls 1 and 2 is a critical feature of the invention and will be discussed in detail. The strands forming the tow must be arranged to form a flat ribbon of uniform width and thickness as indicated at 7. Formation of such a ribbon is facilitated by directing the strands of the tow across one or more guides 6. It is frequently desirable to use a series of guides, breaking the tow slightly under or over the guides in alternating order. Also one or more pairs of guides 10a and 10b may be placed perpendicular to the edges of the ribbon to define its width. As shown in FIGURE 1, the width of the ribbon as it enters the nip of the rolls should be slightly less than the width of the rolls. If desired, a flat ribbon surface may be added to plates 3a and 3b to define this reduced width. In any event, the width of the tow band should not be unduly reduced by guides close to the rolls as such procedure does not result in uniform band thickness. Preferably the pair of edge guides closest to the nip of the rolls serve to prevent occasional increases in band width rather than to continuously decrease the width.

It is noteworthy that it is not desirable to use a reed to form the tow into a ribbon of uniform width and thickness. The use of a reed results in a cramped tow char-
acterized by a "shoestring" effect; that is the individual strands are discernible in the cramped tow. Likewise it is detrimental to have any twist in the tow or to have groups of filaments wander across the width of the ribbon. The goal is to prevent the ribbon of tow to the crimper as one composite group of parallel filaments. Such precise control of the tow has heretofore not been necessary as previously cramped tow was cut into staple fiber directly or was randomized and broken by a tow-to-top process. The controlled tow feed of the present invention results in a uniform crimping action in the stuffer chamber and this uniform crimper is essential in the production of uniform, high quality cigarette filler tips.

Referring again to the width of the ribbon of tow entering the nip of the rolls, control of this dimension is essential for the production of a tow with a uniform crimp across the width of the tow. In the production of cramped tow for staple it is permissible and frequently the practice not to "fill the crimper." In other words, relatively large spaces are left between the edges of the band and the sides of the crimper. This permits relatively large tolerances and clearances in the design and assembly of the crimper but results in a tow which has a low crimp on the edges. We have found that by precise design and assembly of the crimper as above described it is possible to have the tow band almost as wide as the nip rolls. It is not desirable to have the width of the entering tow band as wide as the rolls as in such case a few filaments might be trapped between the sides of the rolls and plate 3a or 3b. This breaks the filaments or grinds them up to form small, thin flakes of material.

In our crimper it is preferred that the two rolls be of equal thickness and that corresponding sides form a single plane. The working faces of plates 3a, 3b and 5a and 5b are in or parallel to these planes. Likewise it is preferred that the edges of the entering tow band be parallel to these planes.

By adhering to the designs and practices described above, we can produce a cramped tow wherein the crimp is uniform along and across the tow. Such a tow performs in a superior manner when processed on the apparatus disclosed in our U.S. Patent 2,794,340 and results in the production of filter rods having uniform properties.

The drawings and description referred to herein have been based on the premise that the tow band enters the crimper in a horizontal plane and that the nip rolls are positioned one above the other. While this is preferred, other positioning can be utilized.

For further understanding of our invention, reference will be made to the following detailed examples which are set forth primarily for illustrating our preferred embodiment.

**Example I**

In accordance with this example a round or conventional type of filament was produced. This is, a spinning solution of about 28% of cellulose acetate, 0.4% of titanium dioxide, 2% of water, balance acetone solution was made up in a conventional manner. This solution was spun in accordance with usual dry spinning methods through spinnerettes having 250 holes of a 0.07 mm. diameter per spinnerette. The filaments were withdrawn from the spinning cabinet around a godet roll at approximately 10 feet per second.

The withdrawn filaments were then treated with one of the special filament finishes described above, namely, peanut oil. This finish was applied by applicator roll in an amount of 0.5% of the weight of the filament.

A suitable number of filaments thus finished to give a tow of a denier of the crimper as above described, 8.0 crimps per inch with a stuffing box crimper having rolls one inch wide and seven inches in diameter as described above and in the apparatus shown in the attached drawings.

The resultant tow was then formed into cigarette filters in accordance with the method described in detail in our Patent No. 2,794,239. In forming the filters it was observed that static developed on the tow during its passage over the rollers and thereby facilitated the opening and blooming of the tow. Filters made in accordance with this example were tested by procedures as follows:

Hardness was measured by observing the deformation of the rod when subjected to a suddenly applied load, crushing the rod transversely between a stationary base plate and an anvil.

Pressure drop was measured by determining the differential pressure necessary to pass 17.5 ml of air per second through the filter.

The weight of the glass rods was measured.

These tests indicated that the filter rods formed from our improved tow were of good, uniform quality. In addition, visual examination indicated that the filaments were uniformly bloomed and the rod ends were cut smoothly and without any fuzziness.

**Example II**

In accordance with this example, the spinning solution used was of a somewhat different composition than that used in Example I and comprised the following: cellulose ester, 27.00%; titanium dioxide, 0.15%; water, 1.55%; acetone, 71.30%. Reasonable tolerances were permitted on the percentage of each component.

This solution was extruded through a spinnerette containing 0.04 mm. openings to obtain a yarn made up of 600 filaments. This yarn was treated with a special finishing agent composed of lauryl alcohol, 5 parts; glycerine 5 parts; water, 90 parts. This solution was applied so that the yarn contained 0.5% of the alcohol-glycerine mixture.

The yarn thus treated was formed into a tow of 90,000 denier, uniformly cramped as in the preceding example and formed into filters. The improvement by the use of this special treating agent was evidenced by the following: the water content of the tow softened the filaments so that the crimping required less stuffing box pressure and the filaments were not weakened appreciably at the points of bending. Subsequently, the tow had more resilience and retained a higher amplitude of crimp after stretching and relaxing.

The filters thus formed were tested and the filters were found to be firmer than those made from a comparable tow lubricated with mineral oil due to the improved crimp retention of the filaments. While in the above examples we have shown the use of a finishing agent in the amount of 0.5%, the finishes of the present invention may be applied in amounts ranging from 0.1% to 3.0%. In regard to holding the crimp uniform in the present invention, we maintain any crimp variation within the range of about a plus or minus one crimp from the nominal and in our preferred operations our product is within closer limits.

It is believed apparent from the foregoing that we have provided a new apparatus which will facilitate the production of tow that has a greater uniformity and may carry certain filament finishes not heretofore used on cramped tow for tobacco smoke filters. As established above the filters made from our improved tow are advantageous in being more firm and otherwise exhibit advantages.

Although the invention has been described in detail with reference to preferred embodiments thereof, it will be understood that variations and modifications can be affected within the spirit and scope of the invention as described hereinabove and as defined by the appended claims.

We claim:

1. A crimping device for uniformly crimping filaments to prepare cramped tow useful for tobacco smoke filter manufacture, said device including in respective order at least one guide rod for controlling the tow whereby the tow may be deflected by passing thereacross.
in the direction of movement of the tow, at least one pair of guide rods placed perpendicular to the edges of said tow and perpendicular to the position of said at least one guide rod, a fixed position roll in combination with a second roll adapted to move apart and against the first roll for providing a nip through which tow filaments may be fed, said at least one guide rod and said at least one pair of guide rods being adapted to present the tow to said nip as a flat band of substantially uniform width and thickness, said width being slightly less than the width of said rolls, stuffing box means positioned opposite the feed rolls adapted to receive said filaments as they pass through said nip, said stuffing box being comprised of a front plate, a back plate, a bottom doctor blade and a top doctor blade and means for retaining the filaments in said stuffing box whereby crimp may be imparted to the filaments.

2. The crimping device according to claim 1 wherein spray means are positioned substantially at the entrance to the nip formed between the rolls whereby a fluid lubricating and cooling medium may be applied to the sides of said rolls to reduce friction and wear.

3. In a stuffing box crimping device comprising a pair of rolls adapted for passage of tow through the nip formed therebetween into a stuffing box means position opposite said rolls, said stuffing box means comprising front plate, back plate, bottom doctor blade and top doctor blade and means for retaining tow in said stuffing box means whereby crimp may be imparted to the filaments of said tow, the improvement which comprises at least one guide rod adapted for deflecting a band of tow by passing thereacross and introducing same to said nip as a flat ribbon of substantially uniform width and thickness and at least one pair of guides placed perpendicular to the edges of the ribbon to define its width to a width slightly less than the width of the rolls as it enters the nip and the rolls.

4. The improvement according to claim 3 wherein the at least one guide rod comprises a series of guides adapted for deflecting the tow slightly by passage under and over said guides in alternating order.

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