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CAP SPINNING FRAMES

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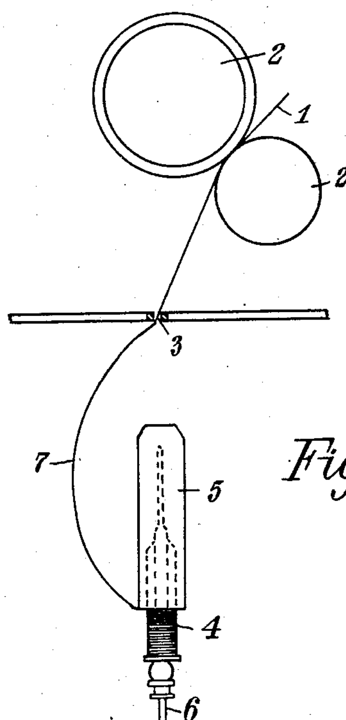

Fig.1.

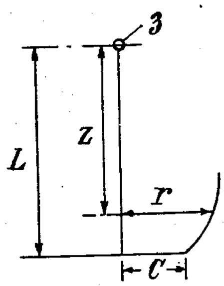

Fig 2.

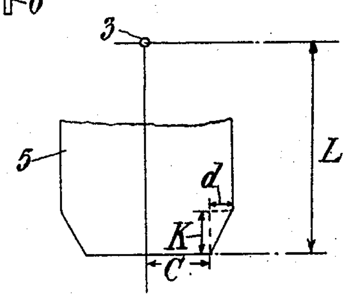

Fig. 3.

Inventor:

Dorothy Margaret Hannah

by Eugene E. Purdy

Attorney

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CAP SPINNING FRAMES

Dorothy M. Hannah, Leeds, England

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This invention relates to cap spinning frames. In conventional cap spinning of continuous filament or of staple fibre yarns, yarn is delivered through rollers to a small guiding hole or pot-eye from which it passes to the spinning bobbin or equivalent element upon which it is wound. A stationary cap rests on the spindle upon which the bobbin or the like rotates and the yarn is guided by the lower edge of the cap to its proper position on the bobbin which latter is given an up and down movement. The hollow caps are usually made of steel and are conventionally of cylindrical, coned, or bell shape. The spinning yarn or thread between the guide hole and the cap edge assumes the shape of the so-called balloon and this thread may fly freely, or a portion thereof may become wrapped round the lower part of the cap.

It is known that the thread tension in the balloon, and at the point of winding on, varies with bobbin diameter and becomes smaller as the diameter of the wound bobbin increases. Also the maximum diameter of the balloon increases with the diameter of the bobbin as the latter is wound. It is usual to provide plates or so-called tins separating adjacent spindles and these plates are struck by the balloon when the diameter of the latter becomes large.

It is an object of the invention to provide an improved cap for spinning frames which enables a more uniform product to be obtained.

The invention comprises shaping the base of the cap to afford a progressive reduction in diameter towards its lower edge over that portion engaged by the yarn or thread during spinning such that the normal fall in yarn or thread tension in the balloon and between the cap edge and the bobbin or the like during the build-up of the bobbin is reduced by progressive variation in the position of the point of contact.

A formula may be obtained from a mathematical analysis giving the theoretical shape for the cap base, in terms of the count spun and the dimensions of the frame and cap and the operating conditions, such shape being a curve with a given characteristic. This shape must however be slightly modified in practice owing to the tendency to adhesion between the yarn and the cap which is not allowed for in the mathematical solution. A coned or bevelled portion at the base of the cap, inclined at an angle to the vertical somewhat larger than that predicted by the mathematics has been found to work satisfactorily. The profile of the balloon and the yarn or thread tension are determined by the size and profile of the cap at the point of contact, and the position of the point of contact depends upon the bobbin size. By appropriate shaping of the lower edge of the cap it results that for all points of contact, and so for all bobbin sizes, the same balloon shape and tension, or approximations thereto, are produced. It is to be understood that by balloon profile is meant the profile as viewed in the vertical plane.

In the accompanying drawing,

Figure 1 is a diagram of a conventional arrangement for cap spinning;

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Figure 2 is a diagram showing the theoretical shape of the curve at the base of the cap;

Figure 3 is a diagram of the lower portion of a cap shaped in accordance with the invention.

Referring to Figure 1 which illustrates a conventional arrangement for cap spinning, the yarn **1** is delivered through rollers **2** to a small guiding hole or pot-eye **3** from which it passes to the spinning bobbin **4** upon which it is wound. A stationary cap **5** rests on the spindle **6** upon which the bobbin or the like rotates and the yarn is guided by the lower edge of the cap to its proper position on the bobbin which latter is given an up and down movement. The spinning yarn or thread between the guide hole **3** and the cap edge assumes the shape of the so-called balloon indicated at **7**. This yarn or thread may fly freely, or a portion thereof may become wrapped round the lower part of the cap. In accordance with the invention the base portion of the cap is shaped to afford a progressive reduction towards its lower edge. The theoretical shape for this reduced portion is determined as a particular solution of the general equations of motion of the yarn when it is flying freely; it corresponds to the solution for which the inclination of the yarn to the vertical at the base of the balloon is greatest. Referring to the diagram of Figure 2, let C be the radius of the cap base, L the height of the guide hole or pot-eye **3** above the cap base, and P a quantity depending on the air resistance to the particular count of yarn employed, this quantity being defined by the formula: air resistance per unit length of yarn$=P\times$(linear velocity)^2. Air resistance is here assumed to vary as the square of the linear velocity. Also let m be the mass per unit length of the thread, ω the speed of rotation of the thread round the vertical axis in radians per second, and T_0 the vertical component of the tension. The quantity A is defined as

$$0.2\frac{m}{P}$$

where m is the mass of the yarn per unit length and P is defined as $P\times$(linear velocity)^2=air resistance per unit length of yarn. The quantity β is defined as

$$\left(\frac{m}{T_0}\right)^{1/2}\omega$$

where T_0 is the vertical component of yarn tension which is constant throughout the balloon and ω is the angular velocity of the balloon in radians per second. Then if

$$A=\frac{0.2m}{P} \text{ and } \beta^2=\frac{m\omega^2}{T_0}$$

both A and $1/\beta$ are standard lengths.

The curve of the shaped cap portion is given by the co-ordinates r and z, r being the radius from the vertical axis of rotation of the spindle at a point lying at a distance z from the guiding hole or pot-eye **3**.

The equations involve also the function of θ, an angular displacement round the vertical axis from a fixed plane. This is needed to describe the path of the yarn in space. The equations can be standardized by using

$$r/A=\rho$$
$$\beta z=\zeta$$

and

$$A^2\beta\frac{d\theta}{dz}=\eta$$

The result is given by the solutions ρ (ζ) of the following partial differential equations:

$$\left.\begin{aligned}\frac{\partial 2\rho}{\partial \zeta 2}+\rho-\frac{\eta^2}{\rho^3}=0\\ \frac{\partial\eta}{\partial\zeta}=0.2\rho^3\end{aligned}\right\} \quad (1)$$

for which

$$\rho=0,\ \eta=0$$

$$\frac{\partial\rho}{\partial\zeta}=q$$

$$\zeta=0$$

for all values of the quantity q. It is to be noted that

$$\frac{\partial}{\partial\zeta}$$

denotes partial differentiation with respect to ζ. q is defined by

$$\frac{\partial\rho}{\partial\zeta}=q$$

$\zeta=0$. The value of

$$\zeta\frac{\partial\rho}{\partial\zeta}$$

at

$$\rho=\frac{C}{A}$$

is a maximum for some value of q, say $q=q_0$. Let the corresponding ζ be ζ_0. Then the shape of the lower part of the required cap is obtained by taking the portion of this curve between $\zeta_0-0.4$ and ζ_0, and writing $r=A\rho$,

$$z=\frac{L}{\zeta_0}\zeta$$

It is to be noted that 0.4 here is a representative figure which ensures that the shaped portion of the cap is long enough to compensate for all usual changes in bobbin size. A smaller figure could in some cases be used.

For practical purposes a modification to the theoretical shapes obtainable by solution of the foregoing Equation 1 may be employed for all counts of yarn and for this purpose the base of the cap 5 is formed with an exterior coned or bevelled portion, the smallest diameter being at the lower edge as illustrated in Figure 3. As here shown, the lower external surface of the cap 5 is of a generally frusto-conical form providing a circumferential surface progressively tapering upwardly for a substantial distance from the lower edge of the cap and forming the sole filament engaging means between the pot-eye and the filament wound on the bobbin. The cap shape above this bevelled portion may be of any conventional or other form desired. Examples will be given of three typical ranges of dimensions of this bevelled portion determined for cap sizes at present in use, the dimensions given being approximate. The numerical results are based on the assumption that drag varies with the square of the velocity which appears to be approximately true for ordinary spinning. The radius at the cap base, i. e. the smallest external radius at the lower edge of the cap, is C, the height of the upper edge of the bevelled surface from the cap base is K, the difference between the maximum radius of the cap and C is d, and the height from the base of the cap from the guiding hole or pot-eye is L. Then for the three examples,

(1) $C=0.5''$ $K=0.12\ L$ $d=0.26''-0.35''$

(2) $C=1''$ $K=0.13\ L$ $d=0.38''-0.53''$

(3) $C=1.5''$ $K=0.14\ L$ $d=0.48''-0.65''$

It will be understood that the above dimensions are approximate and may be varied, and that the actual shapes employed may vary between approximations of the above character and the other modifications of the theoretical shapes as determined from the equation previously given. A further solution of the equations for the three examples cited, where the smallest radius of the frusto-conical surface varies from ½ to 1½ inches, shows that practical dimensions of such guiding caps should have an angle of inclination of the conical surface ranging according to the size of the smallest radius from a minimum of approximately 11° to 18° for a ½ inch radius to a maximum of approximately 21° to 34° for a 1½ inch radius. The value K also can be resolved into inches, as the distance L is substantially fixed for most conventional equipment. A solution of the equations, for the same range of examples, for K, the axial extent of the tapered frusto-conical surface, gives this dimension as between .8 and 1.2 inches. While these dimensions are only illustrative of the solutions of the equations, they serve to provide a guide for a practical development of this invention.

By this invention there is provided an improved cap for spinning which enables a more uniform product to be obtained, since the tension in the yarn or thread can be maintained nearly or approximately constant, or at least with less variation than with conventional caps.

It will be clear from the foregoing that the shaped portion of the cap base may comprise a continuous smooth surface, as in the theoretically correct form, or may be discontinuous and composed of surface portions which approximate to the theoretical shape, as in the cone or bevel approximation described above.

I claim:

1. In a textile cap spinning frame adapted to have a cap for guiding a filament from a pot-eye so as to produce a balloon shape of the filament under suitable conditions of operation, the provision of a cap having its external lower surface of generally frusto-conical form so as to provide a circumferential surface tapering upwardly and outwardly for a distance axially of from .8 to 1.2 inches from the lower edge of the cap, the inclination of said frusto-conical surface to the cap axis being such as to correspond with the maximum angle of inclination to said axis assumed by the lower part of the freely flying filament balloon at the commencement of winding under said operating conditions whereby the filament is prevented from assuming a shape such as to cause a substantial decrease in filament tension during later stages of winding and forming the sole filament engaging means between said pot-eye and the wound filament providing for uniformly guiding and tensioning the filament during its said winding.

2. A hollow cap for guiding a filament during winding upon textile cap spinning frames including a pot-eye, the lower cap surface being of generally frusto-conical form so as to provide a circumferential surface progressively tapering upwardly and outwardly and forming the sole filament engaging means between said pot-eye and the wound filament providing for uniformly guiding and tensioning the filament during its said winding, said surface having a smallest radius of .5 inch, the axial height of said surface being .12 times the distance from the lower cap edge to the pot-eye, and the largest radius of said surface being between .26 and .35 inch greater than its smallest radius.

3. A hollow cap for guiding a filament during winding upon textile cap spinning frames including a pot-eye, the lower cap surface being of generally frusto-conical form so as to provide a circumferential surface progressively tapering upwardly and outwardly and forming the sole filament engaging means between said pot-eye and the wound filament providing for uniformly guiding and tensioning the filament during its said winding, said surface having a smallest radius of one inch, the axial height of said surface being .13 times the distance from the lower cap edge to the pot-eye, and the largest radius of said surface being between .38 and .53 inch greater than its smallest radius.

4. A hollow cap for guiding a filament during winding upon textile cap spinning frames including a pot-eye, the lower cap surface being of generally frusto-conical form so as to provide a circumferential surface progressively tapering upwardly and outwardly and forming the sole filament engaging means between said pot-eye and the

wound filament providing for uniformly guiding and tensioning the filament during its said winding, said surface having a smallest radius of 1.5 inches, the axial height of said surface being .14 times the distance from the lower cap edge and the pot-eye, and the largest radius of said surface being between .48 and .65 inch greater than the smallest radius.

5. A hollow cap for guiding a filament during winding upon textile cap spinning frames from a pot-eye spaced from said cap, said cap having its external lower surface of generally frusto-conical form so as to provide a circumferential surface progressively tapering upwardly for a substantial distance from the lower edge of the cap forming the sole filament engaging means between said pot-eye and the wound filament providing for uniformly guiding and tensioning the filament during its said winding, the inclination of said frusto-conical surface to the cap axis being such as to correspond with the maximum angle to said axis assumed by the lower part of a freely flying filament balloon at the commencement of winding under given operating conditions whereby the ballooing filament is prevented from assuming a shape such as to cause a decrease in filament tension, said frusto-conical surface having a smallest radius from ½ to 1½ inches, and said angle of inclination ranging according to the size of the smallest radius of said frusto-conical surface from a minimum of approximately 11° to 18° for a ½ inch radius to a maximum of approximately 21° to 34° for a 1½ inch radius and with an axial extent ranging from approximately .12 to .14 of the disance from said pot-eye to said lower edge of said cap.

6. A hollow cap for guiding a filament during winding upon textile cap spinning frames from a pot-eye spaced from said cap, said cap having its external lower surface of generally frusto-conical form so as to provide a circumferential surface progressively tapering upwardly for a substantial distance from the lower edge of the cap forming the sole filament engaging means between said pot-eye and the wound filament providing for uniformly guiding and tensioning the filament during its said winding, the inclination of said frusto-conical surface to the cap axis being such as to correspond with the maximum angle to said axis assumed by the lower part of a freely flying filament balloon at the commencement of winding under given operating conditions whereby the balloning filament is prevented from assuming a shape such as to cause a decrease in filament tension, said frusto-conical surface having a smallest radius from ½ to 1½ inches, and said angle to inclination ranging according to the size of the smallest radius of said frusto-conical surface from a minimum of approximately 11° to 18° for a ½ inch radius to a maximum of approximately 21° to 34° for a 1½ inch radius and with an axial extent ranging from approximately .8 to 1.2 inches from said lower edge of said cap.

7. A hollow cap for guiding a filament during winding upon textile cap spinning frames from a pot-eye spaced from said cap, said cap having an externally generally cylindrical surface and having an external lower surface of generally frusto-conical form so as to provide a balloon controlling circumferential surface of substantial axial extent progressively and uniformly tapering upwardly and outwardly from the lower edge of the cap and to the generally cylindrical surface of the cap forming the sole filament engaging means between said pot-eye and the wound filament providing for uniformly guiding and tensioning the filament during its said winding, said frusto-conical surface having a smallest radius ranging from ½ to 1½ inches and a largest radius ranging according to the size of said smallest radius and being equal to said smallest radius plus an increase ranging according to the size of said smallest radius from a minimum of approximately ¼ to ½ inch for a ½ inch smallest radius to a maximum of approximately ⅓ to ⅔ inch for a 1½ inch smallest radius and with said axial extent of the frusto-conical surface ranging according to the size of the smallest radius from approximately .12 to .14 of the distance from said pot-eye to said lower edge of said cap.

8. A hollow cap for guiding a filament during winding upon textile cap spinning frames from a pot-eye spaced from said cap, said cap having an externally generally cylindrical surface and having an external lower surface of generally frusto-conical form so as to provide a balloon controlling circumferential surface of substantial axial extent progressively and uniformly tapering upwardly and outwardly from the lower edge of the cap and to the generally cylindrical surface of the cap forming the sole filament engaging means between said pot-eye and the wound filament providing for uniformly guiding and tensioning the filament during its said winding, said frusto-conical surface having a smallest radius ranging from ½ to 1½ inches and a largest radius ranging according to the size of said smallest radius and being equal to said smallest radius plus an increase ranging from a minimum according to the size of said smallest radius of approximately ¼ to ½ inch for a ½ inch smallest radius to a maximum of approximately ⅓ to ⅔ inch for a 1½ inch smallest radius and with said axial extent thereof ranging from approximately .8 to 1.2 inch.

9. A hollow cap for guiding a filament during winding upon textile cap spinning frames from a pot-eye spaced from said cap, the lower cap surface being of generally frusto-conical form so as to provide a circumferential surface progressively tapering upwardly for a substantial distance from the lower edge of the cap forming the sole filament engaging means between said pot-eye and the wound filament providing for uniformly guiding and tensioning the filament during its said winding, said distance being at least a substantial proportion of the external cap diameter, and said frusto-conical surface being inclined to the cap axis at an angle which corresponds with the angle assumed by the lower part of a freely flying filament balloon at the commencement of winding, said frusto-conical surface having a smallest radius from ½ to 1½ inches, and said angle of inclination ranging according to the size of the smallest radius of said frusto-conical surface from a minimum of approximately 11° to 18° for a ½ inch smallest radius to a maximum of approximately 21° to 34° for a 1½ inch smallest radius.

10. A hollow cap for guiding a filament during winding upon textile cap spinning frames, the lower cap surface being of generally frusto-conical form so as to provide a circumferential surface progressively tapering upwardly for a substantial distance from the lower edge of the cap forming the sole filament engaging means between said pot-eye and the wound filament providing for uniformly guiding and tensioning the filament during its said winding, said distance being at least a substantial proportion of the external cap diameter and having an axial extent between .8 and 1.2 inches, and said frusto-conical surface being inclined to the cap axis at an angle which corresponds with the angle assumed by the lower part of a freely flying filament balloon at the commencement of winding, said frusto-conical surface having a smallest radius from ½ to 1½ inches, and said angle of inclination ranging according to the size of the smallest radius of said frusto-conical surface from a minimum of approximately 11° to 18° for a ½ inch smallest radius to a maximum of approximately 21° to 34° for a 1½ inch smallest radius.

11. In a textile cap spinning frame adapted to have a cap for guiding a filament so as to produce a balloon shape of the filament under suitable conditions of operation, the provision of a cap having its external lower surface of generally frusto-conical form so as to provide a circumferential surface tapering upwardly and outwardly for a distance of .8 to 1.2 inches axially from the lower edge of the cap forming the sole filament engaging means between said pot-eye and the wound filament pro-

viding for uniformly guiding and tensioning the filament during its said winding, the inclination of said frusto-conical surface to the cap axis being such as to correspond with the maximum angle of inclination to said axis assumed by the lower part of the freely flying filament balloon at the commencement of winding under said operating conditions whereby the filament is prevented from assuming a shape such as to cause a substantial decrease in filament tension during later stages of winding, said frusto-conical surface having a smallest radius from ½ to 1½ inches, and said angle of inclination ranging according to the size of said smallest radius from a minimum of approximately 11° to 18° according to the proportionate smallest radius of said frusto-conical surface to a maximum of approximately 21° to 34°.

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