

Jan. 5, 1954

R. VERMEULEN

2,665,130

DEVICE FOR DRIVING TAPES

Filed Feb. 12, 1949

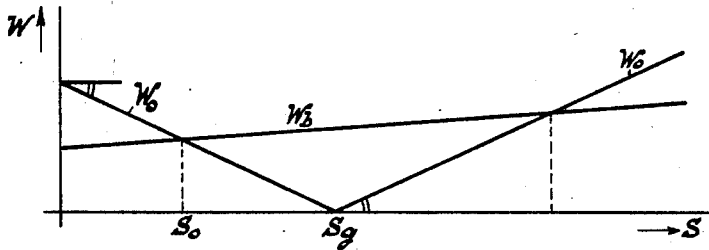


**Fig. 1**

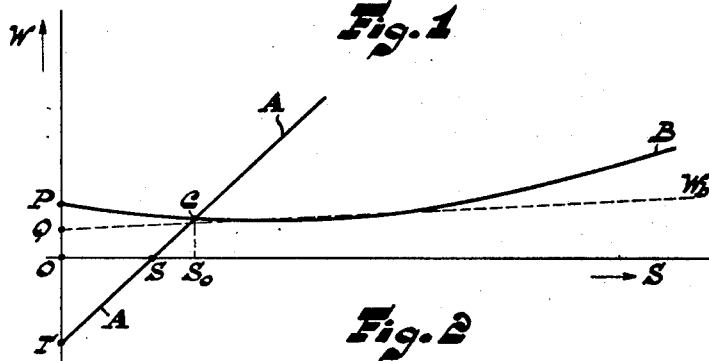


**Fig. 2**

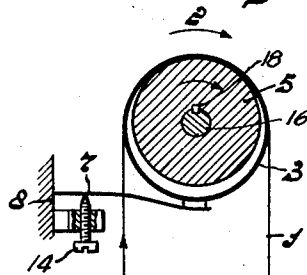


**Fig. 3**

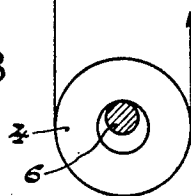
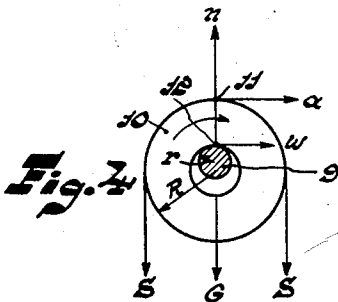


**Fig. 4**

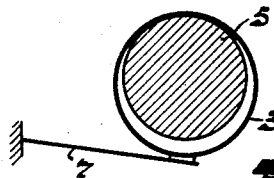


**Fig. 5**

INVENTOR  
ROELOF VERMEULEN  
BY *Heath M. Vogel*  
AGENT

## UNITED STATES PATENT OFFICE

2,665,130

## DEVICE FOR DRIVING TAPES

Roelof Vermeulen, Eindhoven, Netherlands, assignor to Hartford National Bank and Trust Company, Hartford, Conn., as trustee

Application February 12, 1949, Serial No. 76,163

Claims priority, application Netherlands April 20, 1948

3 Claims. (Cl. 271—2.3)

1

This invention relates to a device for moving tapes, more particularly in machines wherein the tape is subjected to treatment in a liquid bath, this device comprising idle rollers on shafts which rollers are arranged in two superposed rows whilst the tape passes alternately over one of the rollers of each row and is drawn at a uniform rate out of the device and supplied to the latter with a substantially constant tension, the shaft(s), on which the upper rollers are provided, rotating in the direction of rotation thereof at a higher speed than the latter. Such a device which has been described in patent application U. S. Ser. No. 726,882, filed February 6, 1947, now abandoned, may, for instance, be used for developing films consisting of regenerated cellulose and comprising images and/or sound records to be developed, or for saponifying films consisting of acetyl cellulose, of which the surface must be saponified to render it suitable for absorbing light-sensitive material, in which images and/or sound records are to be provided.

By a suitable choice of the weight of the lower rollers, the present invention permits such a ratio of the frictional forces between rollers and shafts to be obtained as to ensure a suitable tension of the film.

For reasons which will be explained hereinafter, it has been found, in practice, that it is difficult to adjust this tension in connection with the frictional forces coming in.

The invention provides a new way of adjusting the film tension in a simpler and faster manner, the value of the weight of the lower roller being less critical than in the device according to the aforesaid patent application.

By a suitable choice of the ratio of the outer diameter of the aforesaid rollers and their shafts in the device according to the invention, the increase in driving force exerted, in accordance with the film tension, by the upper rollers on the film portion between the upper roller and the lower roller exceeds for the said purpose the increase in braking force exerted, in accordance with the film tension, by the lower rollers on the said film portion, the upper rollers being braked at the lower side with a constant, adjustable spring pressure.

In order that the invention may be more clearly understood and readily carried into effect, it will now be explained with reference to the accompanying drawing, given by way of example.

Fig. 1 illustrates the theoretical frictional force  $W_0$  between the lower rollers and their shafts in accordance with the film tension  $S$ , and the frictional force  $W_b$  between the upper

2

rollers and their shafts in accordance with the film tension  $S$ , as described in patent application Ser. No. 726,882, now abandoned.

Fig. 2 illustrates the corresponding forces instrumental in the device according to the invention.

Fig. 3 is a detail view of one embodiment of the device according to the invention.

Fig. 4 represents an arbitrary roller over which a film band passes, the shaft carrying this idle roller being driven in the direction of motion of the film.

Fig. 5 shows an upper roller of the device according to the invention, in the state which occurs on starting the device.

In the aforesaid patent application it is stated that by a correct choice of the weight of the lower rollers the form of the broken line  $W_0$  (Fig. 1), which represents the relation existing between the film tension and the frictional force exerted by the lower rollers on their shafts, may be chosen to be such that of the points of intersection between this line and the straight line  $W_b$  indicating the relation existing between the film tension and the frictional force exerted by the upper rollers on their shafts, the point of intersection having the lowest value of the film tension, yields the desired film tension  $S_0$ .

A definite ratio will exist between the frictional force occurring between the upper roller and its shaft, and between the lower roller and its shaft on the one hand and the force exerted by the upper roller and lower roller on the film part located between the rollers on the other hand. Since the shafts of the upper rollers are driven in the direction of motion of the film in a manner such that their movement is faster than that of the upper rollers, and the lower rollers rotate freely about their shaft, the force exerted on the film by the upper roller may be termed "driving force," and the force exerted on the film by the lower roller may be termed "braking force."

In practice, it has been found that the braking force exerted on the film by the lower roller, which is plotted graphically as a function of the film tension, has no marked zero point ( $S_0$  in Fig. 1) as postulated initially but exhibits the curve form indicated by line B in Fig. 2.

Creation of a marked point of intersection between line B and the straight line  $W_b$  shown in Fig. 1, which line is a broken line in Fig. 2 and shows the relation existing between the driving force exerted on the film by the upper roller and the film tension, is extremely difficult, since the slope of the two lines is small and the

3

forces, at which the film tension is equal to zero (points P and Q), as occurs in slack films, have a low value. This may be explained as follows. Point P represents the frictional force exerted on the shaft by the lower roller if there is no film tension and is determined by the weight of the lower roller, which should have a low value in view of the film tension. The force exerted at the point of intersection Q, which represents the frictional force exerted on the shaft by the upper roller if there is no film tension, should even have a lower value. If the force exerted at Q would exceed that exerted at P, no suitable point of intersection would occur between B and  $W_b$ . With a lower value of the force at Q, conversely, the slope of  $W_b$  cannot be chosen greater, since at the point of intersection between B and  $W_b$  the film tension would have an undue low value.

The steps taken in the device according to the invention permit, independently of the choice of the weight of the lower rollers, a marked point of intersection to be obtained between lines B and  $W_b$  in a manner such as to permit a suitable adjustment of the film tension in a simple and rapid manner.

To this end, as stated above, primarily by a suitable choice of the ratio between the outer diameters of the upper rollers and their shafts, the increase in driving force exerted by the upper rollers on the film part between the upper and lower rollers in accordance with the film tension, exceeds the increase in braking force exerted by the lower rollers on the said film part in accordance with the film tension, in other words the slope of line A corresponding to line  $W_b$  exceeds that of line B.

Secondly, control of the spring pressure with which the upper rollers are braked at their bottom side, permit the line A to be shifted parallel with itself.

The manner in which the slope of A can be influenced will be explained with reference to Figs. 3 and 4.

Fig. 3 shows part of the device according to the invention, in which a film 1 consisting of regenerated cellulose is passed in the direction of the arrow 2 over an upper roller 3 and a lower roller 4, since the film is drawn out of the device at its end. The upper roller 3 is driven in the direction of the arrow by its shaft 5 which moves faster than the roller. Shaft 5 is driven by motor shaft 16 by key 18. The shaft 6 of the lower roller is stationary. A plate spring 7 which is clamped to the device at 8, engages the lower side of the upper roller 3 with a force K. Screw 14 is arranged to control the tension of spring 7.

Fig. 4 represents an upper roller as used in the known device. The shaft 9 exerts a driving force  $w$  on the roller 10, of which the value is determined by the product of the friction coefficient  $\mu$  between roller and shaft, and the normal pressure  $n$ . The force  $a$  exerted on the film by the roller follows from the expression  $\mu \cdot n \cdot r = a \cdot R$ , where  $r$  and  $R$  represent the radius of the shaft and roller respectively, hence

$$a = \frac{r}{R} \mu n$$

The same holds for the lower roller. Consequently, the apparent friction coefficient at a point 11 exceeds in the ratio

$$\frac{r}{R}$$

4

the friction coefficient at 12. Since the ratio

$$\frac{r}{R}$$

of the upper rollers is made large so that the outer diameter of the driving shaft is of the same order of magnitude as the outer diameter of the upper roller, the inner and outer diameter of the roller will only be slightly different from one another, so that the upper rollers are shaped as cylindrical thin-walled bushings, thus satisfying the condition that the weight of these rollers should be as low as possible. Furthermore, the slope of line A can be chosen to exceed that of line B, by the choice of the ratio

$$\frac{r}{R}$$

Since, according to the invention, an upward directed force K from the leaf spring 7 is exerted on roller 3 (Fig. 3), the normal pressure exerted on shaft 5 will be reduced by the spring pressure K and the roller will not only be driven by its shaft but also be braked at the lower side. As a result thereof, the total driving force exerted by the upper roller on the film part between the upper roller and the lower will have a value determined by the expression:

$$W = \mu_b \frac{r_b}{R_b} (2S + G_b - K) - \mu_s K \quad (1)$$

where  $\mu_b$  and  $\mu_s$  represent the friction coefficient between roller and shaft and between roller and spring respectively,  $r$  and  $R$  the radius of the shaft and roller respectively,  $S$  the film tension,  $G$  the weight of the upper roller,  $K$  the spring pressure. The driving force  $W$  as a function of the film tension  $S$  represents, with a definite choice of the friction coefficients, a straight line having a slope which is determined by

$$2\mu \frac{r_b}{R_b}$$

and is represented by line A in Fig. 2. The point of intersection T between this line and the vertical axis yields a value of the driving force  $W_{to}$ .

$$W_{to} = \mu_b \frac{r_b}{R_b} G_b - \left( \mu_b \frac{r_b}{R_b} + \mu_s \right) K \quad (2)$$

The driving force in connection with the film tension may be represented as follows. Initially the film is slack and passes in loops over the rollers of the device. By the leaf-springs 7 the bushing-shaped upper rollers 3 (Fig. 5) are lifted, so that they do not rest on their shaft 5. The device is operated by driving the shafts 5 and drawing the film band 1 out of the device. In this state, the driving force exerted on the film band is negative, in accordance with the choice of  $G_b$  and  $K$  in expression (2). Consequently, a braking force is concerned, since the film band is braked because the bushings 3 are braked at the lower side with a force represented by the line OT which follows from expression (2). The tension in the film band now increases and the film is made taut, the friction at the lower side of the bushings 3 preventing them from being moved. With an increase in film tension the bushings are pulled downwards due to which they engage the upper side of the rotating shafts, so that a driving force is exerted on the film. The difference between the substantially constant braking force of the spring and the driving force of the shaft constitutes the total force exerted on the film, which force will at first be negative (braking) and past point S will be driving (represented by line A).

5

Once the slope of line A is fixed by the choice of  $r$  and  $R$ , this line may be shifted parallel with itself by adjusting  $K$ , as appears from the expression (2). Consequently, the braking force exerted on the film by the bushings 3 and represented by the line OT in Fig. 2, may be controlled in accordance with the value of the spring pressure  $K$ .

The braking force  $B$  exerted by the lower roller on the film part between the upper and the lower roller may, as a function of the film tension, be represented by the curve

$$W = \mu_0 \frac{r_0}{R_0} 2S - G_0 \quad (3)$$

as shown by line B in Fig. 2.

Owing to the absence of lateral and other friction, not taken into account in this expression, the force  $W$  for  $2S=G$  does not disappear completely, but exhibits a flat minimum as shown in Fig. 2. The curve form of this force is no longer of importance, provided that it be such that a well defined point of intersection with line A occurs. Control of spring pressure  $K$  permits this point of intersection C and consequently the desired film tension to be adjusted in a simple manner.

If for some reason, for instance due to random increase of the resistance experienced by the film, the tension increases at a given point of the film, so that it exceeds the adjusted film tension  $S_0$ , the driving force exerted on the said film part by the upper roller nearest to the said point, will more increase than the braking force exerted by the lower roller on the film, as a result of which the film tension tends to decrease again and equilibrium is established at a tension only slightly exceeding  $S_0$ .

It will be appreciated that the foregoing holds not only for devices wherein films are subjected to a liquid treatment but also to devices wherein films are conveyed in the dry state and drawn out of the device at a uniform speed.

Though, for using the device according to the invention, the nature of the film material is, in general, of no importance, the device may be used with advantage for controlling the tension of very thin films several times ten microns thick, which consist of a material, for instance regenerated cellulose, which is liable to stretch or contraction during treatment in the device. In fact the device permits on the one hand the film to move, at different points, at different speeds determined by the degree of stretch or contraction and on the other hand that the tensions in the film are maintained between narrow limits, so that it can be provided that the low tension permissible for these thin films are not surpassed in the device.

If, for treating the film, it is desirable or necessary that during different treatments, for instance treatments in a dry or wet state, to subject it to different tensions determined by these treatments, the device according to the invention furthermore permits this tension to be adjusted separately at different points of the film by controlling the spring pressure exerted at the lower side of the upper rollers. This may, for instance, be the case if the film is to be dried under tension and, in order to compensate the contraction due to the drying operation, the tension should increase in accordance with the degree of dryness of the film.

What I claim is:

1. Apparatus for moving a band-like member

6

between a first given point and a second given point spaced from said first point and at which the said member is driven with a given tensile stress, comprising two shaft members spaced apart one above the other, a roller member loosely mounted on the upper of said shaft members and a roller member loosely mounted on the lower of said shaft members, said band-like member being positioned over the top surface of said upper roller member and over the bottom surface of said lower roller member between said first given point and said second driving point, motor shaft means for driving said upper shaft member, said upper shaft member engaging the surrounding roller member with a given friction force at stresses of said band equal to said given stress and rotating in the direction of movement of the said surrounding roller member and at a higher speed than the speed of said roller member, and a control member engaging the bottom surface of the said upper roller member and exerting thereon an upper force to simultaneously reduce said friction force and brake said roller upon diminution of said given stress in said band like member.

2. Apparatus for moving a band-like member between a first given point and a second given point spaced from said first point and at which the said member is driven with a given tensile stress, comprising two shaft members spaced apart one above the other, a roller member loosely mounted on the upper of said shaft members and a roller member loosely mounted on the lower of said shaft members, said upper shaft member having an outer diameter of the same order of magnitude as the outer diameter of said upper roller member, said band-like member being positioned over the top surface of said upper roller member and over the bottom surface of said lower roller member between said first given point and said second driving point, motor shaft means for driving said upper shaft member, said upper shaft member engaging the surrounding roller member with a given friction force at stresses of said band equal to said given stress and rotating in the direction of movement of the said surrounding roller member and at a higher speed than the speed of said roller member, and a spring member engaging the bottom surface of the said upper roller member and exerting thereon an upper force having a value sufficient to lift said upper roller from contact with said shaft at zero stress values of said band-like member to thereby simultaneously reduce said friction force and brake said roller upon diminution of said given stress in said band-like member.

3. Apparatus for moving a band-like member between a first given point and a second given point spaced from said first point and at which the said member is driven with a given tensile stress, comprising two shaft members spaced apart one above the other, a roller member loosely mounted on the upper of said shaft members and a roller member loosely mounted on the lower of said shaft members, said upper shaft member having an outer diameter of the same order of magnitude as the outer diameter of said upper roller member, said band-like member being positioned over the top surface of said upper roller member and over the bottom surface of said lower roller member between said first given point and said second driving point, motor shaft means for driving said upper shaft member, said upper shaft member engaging the sur-

rounding roller member with a given friction force at stresses of said band equal to said given stress and rotating in the direction of movement of the said surrounding roller member and at a higher speed than the speed of said roller member, and a spring member engaging the bottom surface of the said upper roller member and exerting thereon an upper force having a value sufficient to lift said upper roller from contact with said shaft at zero stress values of said band-like member to thereby simultaneously reduce said friction force and brake said roller upon diminution of said given stress in said band-like member, said spring member having adjusting

means to vary the equilibrium value of said tensile stress.

ROELOF VERMEULEN.

# References Cited in the file of this patent

## UNITED STATES PATENTS

| Number    | Name           | Date          |
|-----------|----------------|---------------|
| 1,544,931 | Patterson      | July 7, 1925  |
| 1,631,476 | De Moos        | June 7, 1927  |
| 1,891,225 | Fear           | Dec. 20, 1932 |
| 2,123,445 | Van Leuven     | July 12, 1938 |
| 2,244,170 | Miketta et al. | June 3, 1941  |
| 2,318,605 | Fess           | May 11, 1943  |
| 2,338,422 | Geyer          | Jan. 4, 1944  |