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(54) **A curtain system with cord drive with external tensioning pulley**

Vorhangsystem mit Kabelantrieb mit externer Spannrolle

Système de rideau avec un cordon de transmission à poulie de tension externe

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Description

Field of the invention

[0001] The invention is concerned with a curtain system comprising a rail, a curtain suspended from and movable along the rail, attached to the curtain a cord which is guided along the rail by means of guiding elements, and a cord drive consisting of at least two drive wheels which are coupled together, at least one drive motor coupled to at least one of the drive wheels, at least one tension pulley at some distance from the drive wheel, which pulley is coupled to tensioning means which apply a bias tension to the axle of the tensioning pulley, and a cord which is fixed to the curtain to be moved.

[0002] The invention belongs to the devices that convert the movement of a rotating drive element into the linear movement of a traction element by means of friction contact, in short to the group of tribotechnical belt drives. The invention is intended to motorize curtains which are equipped with a draw cord system.

[0003] Drives are known, in particular for curtains, which generate traction not by friction but by geometric grip, such as e.g. toothed belts. These are the drives prevailing on the market because it is difficult to achieve in a simple manner the necessary pulling force by frictional contact. The invention solves this problem with ease.

[0004] Besides a sufficiently large wrap angle, a frictional drive requires a bias tension to establish the necessary friction contact. The invention introduces the external tensioning pulley wherewith it achieves by simple means a very effective tribotechnical drive with a large wrap angle and a strongly reduced bias tension.

State of the art

[0005] Electric curtain drives have been marketed for many years. Generally, they consist of arrangements in which the motor unit is mounted on a special rail which of course carries the runners but also a drive belt. In the vast majority of all cases the drive belt is of the geometric grip type: toothed belt, bead chain, perforated belt, and the like. Arrangements like these can be found in such patents as:

Toothed belt:
EP 1316281A1, 2003, Goelst, Device for automatically moving a curtain ...
Bead chain:
EP 0199677B1, 1986, Arquati, A motor-driven curtain operating unit
Perforated belt:
NL0166612, 1981, Bratschi, Trekinrichting...voor gordijnen (Traction device...for curtains)

[0006] Drive solutions using contact friction, however, could be cheaper than those based on geometric grip if they were but available. It proves, however, to be difficult to reach by simple means sufficient pulling power from frictional contact arrangements.

[0007] The marketed drives with toothed belts or the like are, as a result of their higher price level, mainly intended for the higher market segment: for residential homes, office buildings, convention areas, and the like.

[0008] Certain market players as well as serious non-commercially oriented amateurs, for years have been again and again experimenting with ideas of how to find a useful solution to the problem of a simple cord drive for curtains. They start by applying the more or less obvious and well-known arrangements and over and again they discover that the basic problem is, and remains to be, to find a simple way to realize sufficient traction power by increasing the contact arc of the cord on the drive wheel. The great number of patent applications submitted on this subject bears testimony to the fact that it is very troublesome to find a simple, effective, and unproblematic cord drive system. Here is an assorted selection of patents that illustrate the attempts:

The Ω-configuration:
AU 4 5683/85A, Hind, 1986, Motor-driven curtain draw cord arrangement
Multiple winding:
GB418910A, Hall & Hall, 1934, Improvements in ... Curtain-operating Mechanism
Internal tension pulley:
US 3 874 246 A, Woodard, 1975, Cable pulley drive device
Diverse methods:
WO 95/18317, Reynolds, 1965, Cable drive systems

[0009] Figures 3, 4, and 5 show the essential features of the most common methods to achieve a large angle of wrap. Other methods to achieve the desired traction force, such as an anti-slip coating around the drive wheel, cord pinching idlers, V-belts, for various reasons are impractical or uneconomical for curtain moving devices.

[0010] These problems are the cause that only the higher market segment is furnished with motorized curtains, nearly all having drive belts of the geometric grip type. The middle segment of the market is poorly served because of the absence of an acceptable solution for affordable curtain automation. The invention introduces a cord drive with external tension pulley to obliterate this hurdle.

Summary of the invention

[0011] The great majority of commercially available electric curtain drives employ toothed belts, bead chains, or perforated belts to transfer motor traction power to the curtain. These traction elements require a special rail with ducts to guide them, and the driving motors must be attached to the rail itself.

[0012] A cord as traction element is a simpler and cheaper alternative as soon as it becomes possible to rely on friction to transfer enough traction power from a motor to a smooth cord in order to move a curtain.

[0013] The solution lies in realizing a contact arc of the cord as large as possible around the drive wheels. Many attempts have been undertaken to solve this problem and many patents have been issued on this subject. Many of them describe configurations that do solve the problem of a large wrap angle but by doing this create other kinds of problems such as complicated and expensive arrangements with a multitude of guiding pulleys.

[0014] A second problem arising from cord friction drives is that they require a certain bias tension to create sufficient friction. It turns out that all conventional solutions need a bias tension larger than the intended pulling force. This entails the need for relatively sturdy and thus relatively expensive and at times voluminous structures.

[0015] Others try to achieve sufficient pull by using cord pinching idlers or anti-slip coatings on the contact surfaces. Amongst other problems this gives rise to extra wear.

[0016] An aim of the invention is to deliver a cord operated curtain system which avoids the problems mentioned above. The invention is characterized by the following: The cord, arriving from the curtain, encircles one of the drive wheels by in essence 360 deg. or a multiple thereof, continues towards the tensioning pulley which gives it a U-turn, from which it is guided to a second drive wheel, surrounds this wheel by again in essence 360 deg. or a multiple thereof, and from there returns to the curtain. The invention succeeds in realizing a large contact arc in a simple manner, which at the same time requires a bias tension much lower than the requested pull of the arrangement. This is the result of the introduction of the external tensioning pulley.

[0017] An internal tension pulley is a pulley that is situated between the drive wheel and the curtain as is shown in fig. 5. An external tensioning pulley is situated at the opposite side of the drive wheel as to be seen in fig. 6.

[0018] A drive for curtains according to the invention can be made at a lower cost because the drive shaft is not stressed by the bias tensioning force, which makes it possible to mount the drive wheel directly on the output shaft of a geared motor. It is no longer necessary to apply extra support bearings as the sleeve bearing of a low priced geared motor is sufficient.

[0019] Due to the cantilever character of the output shaft, the drive wheels and the tensioning pulley can be arranged in such a way that, after the housing has been removed, even a closed-loop cord can be inserted or exchanged without any further disassembly of parts.

[0020] It aught to be mentioned that an external tensioning pulley is known from the US patent A-6280358. However, here the drive is intended for moving a gate and has been chosen because of its compactness. From this document it cannot be deduced that it is known that this drive requires little energy. Therefore, it does not follow from the document that the application of this drive to resolve the problems of curtain drives is obvious.

[0021] To elucidate the achievements of the invention, in the following description the conventional solutions (figs. 3 to 5) will be compared with the innovative solution according to the invention (figs. 6 and 7), partly by means of the pertinent mathematics. See Table 1.

[0022] A drive according to the invention operates with a standard draw cord for Venetian blinds and can be added onto virtually any existing or yet to be installed manually operated draw cord system. The drive unit takes the place of the suspended tensioning device which is usually provided with hand-operated curtains.

[0023] For advantageous embodiments of the curtain system according to the invention, reference is made to the appended claims.

Brief description of the figures

[0024] In the figures 2...7 and 9 the curtains are not depicted. It is to be understood that the strands (1) or (1a) and (1b) continue upwards to a curtain system as indicated in the general view fig. 1.

[0025] The figures 3...5 illustrate the most common methods used to enlarge the arc of contact α of the cord around the drive wheel. The figures 6...9 relate to the invention and are concentrated on drive wheels with only one tension pulley, which is the preferred configuration of the invention. The corresponding contact arcs α are also given in Table 1. The figures show:

Fig. 1 General view of a motorized cord drawn curtain moving system;
Fig. 2 Elementary drive wheel (11) and cord (1a, 1b) to define the essential parameters;
Fig. 3 Drive wheel (11) with cord (1) and diverting idlers (16); $\alpha \approx 300° = 1{,}7\pi$ radians;
Fig. 4 Drive drum (17) with 2½ cord rounds; $\alpha = 5\pi$ radians = 900°;
Fig. 5 Drive drum (17) with 3 internal tensioning pulleys (15); $\alpha = 4\pi$ radians = 720°;
Fig. 6 Twin drive wheel (11a, b) with one external tensioning pulley (15); $\alpha = 4\pi$ rad = 720°;
Fig. 7 View of a possible practical embodiment of the invention;
Fig. 8 Side view of a twin drive wheel with concave cord grooves (29);
Fig. 9 Circuitry of an application with automatic motor stop by means of a cord run detector.

Detailed description of the figures

[0026] Fig. 1 shows a curtain rail (5) with cord drive unit (3), cord (1), a set of cord guide pulleys (7), and a reversing pulley (9). This figure is included here to give a general impression of a motorized curtain system indicating the position therein of a drive unit according to the invention. This configuration, however, is not essential for the invention. The essence of the drive system is that a cord is moved to and fro which in turn moves one or more curtain sheets. Fig. 1 only serves as an idea to support the following explication of the invention.

[0027] Fig. 2 shows an elementary drive wheel (11) with cord (1a and 1b) and the force vectors F_1, F_2, and F_S. The contact arc of the cord around the wheel is 180 deg. = π radians. The bias vector F_S, equaling the sum of F_1 and F_2, exerts its force on the drive shaft (13). This figure serves to ascertain the concepts and definitions which are to be used in the theoretical explanation in the paragraph "Detailed description of the invention". Actually, this configuration is not useful for a curtain drive because of its very poor traction performance.

[0028] Figs. 3 to 5 represent the essence of the configurations that are commonly used. The appertaining values of the contact arc a, the maximum relative traction force $\Delta F/F_1$, and the traction index $\varphi = \Delta F/F_S$ of the configurations depicted, are given in Table 1 in the paragraph "Detailed description of the invention". In the figs. 3...5 the force vectors have been omitted: they essentially correspond with those of fig. 2.

[0029] Fig. 3 shows the Ω-configuration: if the figure is turned upside-down, the cord loop partly resembles the Greek letter Ω. The figure shows: the drive wheel (11), the cord (1), and the cord guiding idlers (16). The contact arc of the cord around the drive wheel (11) amounts to approx. 300 deg. = $1{,}7\pi$ radians.

[0030] **Limited advantage:** Slightly larger than basic contact arc. The guiding idlers (16) take on a part of the bias force and in this way they relieve to some extent the drive shaft (13).

[0031] **Disadvantages:** Moderate traction force ΔF; sharp alternating bends in the cords (1); this results in loss of power and increased cord wear.

[0032] Fig. 4 shows the cord (1) having been wound 2½ times around the drive drum (17). The drive shaft is marked (13); the contact arc is 5π radians = 900 deg.

[0033] **Advantage:** A very high traction force and very favourable traction index $\varphi = \Delta F/F_S$ close to the maximum achievable asymptotic value 1.

[0034] **Disadvantage:** In the working phase, the cord windings exhibit helical wandering. This makes the configuration inapplicable unless the diameter of the drive drum (17) is large and/or the cord travel range is limited. The bias force has full impact on the drive shaft (13).

[0035] Fig. 5 shows a drive drum (17) with four coaxial cord grooves. The three internal tensioning pulleys (15) care for the step-over of the cord from one groove in the drum (17) to the next, thereby enlarging the contact arc step by step. In this illustration the contact arc is about 4π radians.

[0036] **Advantage:** A high traction force and relatively favourable traction efficiency.

[0037] **Disadvantage:** Moderate traction force in view of the effort to be invested in the complexity: every additional tensioning pulley (15) adds no more than 1π radian to the contact arc; very high load on the drive shaft (13) and the tensioning pulley axle (19) in consequence of the well-known hoist effect of a set of pulley blocks.

[0038] The figures 6 and 7 correspond with the most favored configuration according to the invention. Table 1 gives the appertaining performance values.

[0039] Fig. 6 shows the cord circuitry with external tensioning pulley (15) according to the invention. There are two drive wheels (11a) en (11b) on a common shaft (13). The tensioning pulley (15) with its axle (19) is situated at the side of the drive wheels (11) opposite to the side with the traction cords (1). Assume the motor to rotate the wheels (11) counter clockwise, then (1b) is the advancing, pulling, taught, strand and the cord-internal force is F_2. The cord makes a full circle around the wheel (11b), then goes to the tensioning pulley (15) and further to wheel (11a), completes a full circle around wheel (11a) and returns back to the curtain as the retreating, slack strand (1a). When the motor reverses its direction, the cord forces F_1 and F_2 exchange their places.

[0040] Fig. 7 gives a view of a possible realization of a drive unit based on the invention, with cord (1), twin drive wheel (17) on the motor shaft (13), and the tensioning pulley (15), the axle of which (19) is spring loaded (23). The spring (23)

is anchored to the chassis of the drive unit; this is symbolised by (25). Also, the motor (21) is suspended from the chassis in a special manner and this is symbolised by (27). This suspension should leave the motor (21) free - whether spring restrained or otherwise - to move a limited amount in parallel to the traction force vector, at the same time impeding its reactive rotation. This, however, is a refinement which is usually unnecessary. In most cases it is sufficient to fix the motor rigidly to the chassis.

[0041] Fig. 8 is a side view of the preferred rendering of a drive wheel (17) as used in the embodiment fig. 7. It is a drum with twin grooves (29) for the two cord windings, each having a concave cross profile.

[0042] Fig. 9 is a schematic drawing showing a possible arrangement with which to realize an automatic motor stop. When the curtain hits an end of the travel range, the cord (1) stops moving by slipping in the grooves of the drive drum (17), and the tensioning pulley (15) stops revolving. The tensioning pulley carries a code disk (31) which is observed by the detector (33). When the latter detcts a standstill of the pulley, it gives a pulse to the control electronics (35) which then causes the motor switch (37) to shut off the motor power. The switch-off by the stop-and-slip action is also a safeguard against any harmful stalling of the motor in case the curtain becomes blocked.

Detailed description of the invention

[0043] The invention introduces the external tensioning pulley drive to motorize the handling of curtains. As to simplicity and effectiveness, this configuration surpasses the usual drives. It also combines with it a number of special properties favourable for the intended application. Especially, this also applies to the favourable price and ease of installation on site. It is reasonable to expect the invention to be of use for other applications as well as for the drawing of curtains.

The theory of the elementary cord drive (fig. 2)

[0044] A basic knowledge of cord drives is helpful to understand the advantage of the configuration used in the invention (fig. 6) above the common drives (figs. 2...5). The arrangement pictured in fig. 2 is the most elementary cord drive.

[0045] Assume the drive shaft (13) carrying a drive wheel (11) to be rotating counter clockwise as the arrow in fig. 2 shows, (1b) is the advancing, taught, pulling strand coming from the load (the curtain), and (1a) the parting, slack strand returning to the load. F_2 is the force directly moving the load. It stresses the pulling strand (1b), whereas F_1 is the force left over after the cord (1a) has passed around the drive wheel (11). The process is as follows:
The drive motor generates F_2. During the contact of the cord (1a/1b) with the drive wheel (11) the force F_2 is gradually transferred to the wheel, resulting in the left-over force F_1. This process is governed by the Eulerian equation $F_2/F_1 \cdot = e^{\mu\alpha}$. Here μ is the coefficient of friction between cord (1) and wheel (11) and α the arc of their contact (in radians).

[0046] In fig. 2 the arc $\alpha = \pi$ radians; the coefficient of friction is taken to be $\mu = 0{,}2$ from here on throughout the entire discussion. For fig. 2 this results in $F_2/F_1 \cdot = e^{\mu\alpha} = e^{0{,}63} = 1{,}874$ as the force ratio. The force available for moving the load (the curtain) is $\Delta F = F_2 - F_1 = 0{,}874 \cdot F_1$. The tensioning force (the bias force) that operates on the drive shaft (13) is $F_S = F_2 + F_1 \cdot = 2{,}874 \cdot F_1$.

[0047] The effectivity of a cord drive is expressed by the pull to bias ratio $\varphi = \Delta F/F_S$, or pull index for short. For the elementary drive fig. 2 this becomes $\Delta F/F_S = 0{,}874/2{,}874 = 0{,}304$. Thus, if the bias force were e.g. 1 N, the maximum available traction force would be 0,304 N. These figures are to be found in Table 1.

[0048] Assume $\Delta F = 0{,}304$ N to be the maximum available traction force. If the load (the curtain) requires more than that to move, then F_1 becomes zero and the cord on the drive wheel begins to slip. To restore the pulling capacity, the bias F_S needs to be increased. Should the curtain require e.g. 10 N, the bias F_S would need to become (1/0,304). 10N = 32,9 N.

[0049] Both ΔF as well as F_S stress the drive shaft (13) and the designer has to provide a (much) sturdier drive shaft than needed for the actual pulling force ΔF alone. To relieve this situation, the exponent $\mu\alpha$ needs to be increased. The friction coefficient μ is limited by the cord-and-wheel material combination, but to the contact arc α in theory there is no limit. Increasing α will not really help, however, because the pull index $\varphi = \Delta F/F_S = (F_2 - F_1)/(F_2 + F_1) = (e^{\mu\alpha} - 1)/(e^{\mu\alpha} + 1)$ has an asymptotic maximum: $\lim_{\mu\alpha \to \infty} = 1$. With any configuration of the kind as in figs. 2...5 the required bias F_S is larger than the pulling force ΔF.

[0050] To summarize: Any configuration like those in the figs. 2...5 in which the drive shaft has to bear not only the traction force ΔF but also the bias force F_S, needs a bias as large or larger than the required traction force, because $(F_2 + F_1) \geq (F_2 - F_1)$. This is the main reason why conventional tribotechnical cord drives are problematic.

The theory of the external tensioning pulley (fig. 6)

[0051] The invention preferably uses two drive wheels (11a) and (11b) on a common drive shaft (13), and a pulley (15), see fig. 6. The cord is wound one full circle around each drive wheel. The total contact arc on the drive wheels is $\alpha = 4\pi$. Halfway the total arc, there where the tensioning pulley is, the stress in the cord is $F_{½} = (F_2 \cdot F_1)^{0{,}5}$ as can be

deduced from the Eulerian equation $F_2/F_1 \cdot = e^{\mu\alpha}$ by splitting α in halves.

[0052] The pulley (15) is kept in place by a force $F_S = 2\times F_{½} = 2\cdot(F_2 \cdot F_1)^{0,5}$. Here the cord is, so to say, lifted off from the set of drive wheels (11a, 11b) by the pulley (15) which functions as a tensioning pulley bearing the tension $F_S = 2\cdot(F_2 \cdot F_1)^{0,5}$. In the nominator of the pull index $\varphi = \Delta F/F_S$ the sum of the two cord stresses $F_S = (F_2+F_1)$ of the conventional configurations is replaced by twice their RMS value $F_S = 2\cdot(F_2 \cdot F_1)^{0,5}$ in the invention configuration.

[0053] While the bias tension $F_S = (F_2+F_1)$ of the conventional configurations always is larger than, or at the most equal to, the traction force (F_2-F_1), with the invention the tension force $F_S = 2\cdot(F_2 \cdot F_1)^{0,5}$ is smaller than $\Delta F = (F_2-F_1)$ for $\mu > 0,14$. In other words, with external tensioning pulley and $\mu > 0,14$ the pull index $(F_2-F_1)/2\cdot(F_2 \cdot F_1)^{0,5}$ is always larger than 1 and that without any asymptotic maximum.

[0054] Table 1 gives a pull index $\Delta F/F_S$ of 1,614 for fig. 6. This is nearly 90% above the value mentioned for fig. 5, while both configurations have the same values for the contact arc ($\alpha = 4\pi$) and the maximum relative pull force ($\Delta F/F_1$).

[0055] It appears that one twin drive wheel plus one tensioning pulley simply delivers enough traction force to make an extension by more drive wheels and external tensioning pulleys in the same drive unit superfluous for most applications. Fig. 7 shows a possible embodiment of a drive unit according to the invention.

Table 1. Parameters and performance values for different configurations with μ=0,2

Figure no.	Description	Contact arc α in radians	Pull force $\Delta F/F1$	Pull index $\Delta F/FS$
2	Elementary situation	π	0,874	0,304
3	Drive wheel in Ω-configuration	$1,7\pi$	1,910	0,488
4	2½ windings on a drum	5π	22,141	0,917
5	Drum & 3 internal tensioning pulleys	4π	11,345	0,850
6	Twin wheel & external tensioning pulley	4π	11,345	**1,614**

[0056] The result in the table, belonging to fig. 6, which represents the invention, means that if the slack (departing) strand during operation is left with a cord stress of e.g. F_1 = 1 N, the taught (pulling) strand will develop F_2 = 12,345 N. The difference is the maximum effective traction force of ΔF = 11,345 N. At that point the cord begins to slip. By enlarging the bias F_S the system can be adjusted to deliver more pull, e.g. for F_1 = 2 N and F_2 = 24,69 N the pull will be ΔF = 22,69 N.

[0057] Increasing the bias F_S in any of the conventional cord drives to receive more pulling power ΔF also means increasing the load on the drive shaft. This does not apply for drives according to the invention because the bias force F_S is not borne by the drive shaft. Please refer to the second-next paragraph. The designer of a drive according to the invention need not regard the bias force F_S when prescribing the amount of bias. Only the pull ΔF needs to be reckoned with when defining the specifications of the drive shaft bearings.

Practical example based on the preferred embodiment:

[0058] The preferred embodiment of a drive unit as in fig. 7 uses a standard curtain draw cord, or a cord for operating Venetian blinds, with a diameter of 2 to 3 mm. In combination with the material of the drive drum (e.g. steel or POM) the coefficient of friction μ reaches values of roughly 0,2.

[0059] The cord (1) is wound a full turn (= 360 deg. = 2π radians) around each twin groove (figs. 6 en 7) and this ensures that the bias force F_S has no effect on the drive shaft. The external tensioning pulley (15) separates the traction force ΔF from the bias force F_S. The drive shaft (13; fig. 7) bears mainly the traction force ΔF while the tension pulley (19) only cares for the bias force $F_S = 2\cdot(F_2 \cdot F_1)^{0,5}$. When the drive has stopped and the cord circuit has relaxed, the tensioning pulley (15) carries the full load F_2+F_1.

[0060] The bias situation changes during the start-up and stop phases. The drive shaft (13) can for a moment become loaded with more than just ΔF. If this radial load becomes a problem for the drive shaft bearings, the motor (21) can be mounted on a support that gives the motor a limited freedom to move up and down while precluding rotation. This is symbolized by (27). But in most cases the motor can be rigidly mounted on the chassis.

[0061] In view of the fact that with the external bias pulley (15) the drive drum (17) does not bear the bias force F_S, the drum (17) needs no special bearings. In the preferred version as in fig. 7 the drive drum is directly mounted on the drive shaft of a geared motor. With a conventional device both the bias F_S and the drive forces F_2 and F_1 pull at the drive wheel in the same direction. The bearing or bearings of the drive shaft of a conventional arrangement must in some instances be able to withstand forces up to three times the load of the useful traction force. In the case of fig. 5 the load is even many times greater which is obvious from its configuration resembling a pulley block hoist.

[0062] With an external tensioning pulley one does not have to consider the bias force F_S when choosing one's kind

of drive shaft. That is a great advantage with light driving systems like those of curtains (fig. 7). One can use a low cost geared motor (21) and mount the drive drum (17) onto the bare drive shaft (13). The use of a separate, perhaps sturdier gearbox can be avoided and the whole drive unit will be of a smaller size. The motor itself (21), being simple and low priced, may have modest specifications as to the admissible cross load of the drive shaft. A life time of e.g. 1000 hours and a duty cycle of perhaps 1 minute a day will make it last for about 16 years.

[0063] The preferred type of drive drum (no. 17 on fig. 8) has twin grooves (29) for the cord. Each groove has a concave cross profile bounded by two flanges which are about three cord diameters apart (fig. 8). Having completed a winding of 360 deg. along a groove (29), the cord (1) leaves the drive drum (17) for the tensioning pulley (15) and then goes back to the second groove of the drum (17), where it completes a second winding of 360 deg. to leave the drum (17) as slack strand, and finally to return to the curtain . At the arrival and leaving point in the groove (29) the two strands of the cord (1) touch each other with an infinitely small velocity difference. The strand departing from the groove (29) continuously determines the sideway position of the winding in the groove. The strand arriving at the groove (29) places itself beside the 'existing' departing strand and, while proceeding along the groove, gradually slips to the middle position of the concave groove (29). There it continuously meets the newly arriving strand.

[0064] To apply a single external tensioning pulley according to the invention (figs. 6 en 7) is a simple way to achieve the relatively large $\alpha = 4\pi$ resulting in a large traction force of $\Delta F = 11{,}345 \cdot F_1$. This is difficult to attain with a feasible conventional arrangement. Compare the values given in Table 1 for the figures 5 and 6 with each other. Should the contact arc of 4π nevertheless prove insufficient, one can give the cord a second round on one of the grooves ($\alpha = 6\pi \rightarrow \Delta F = 42{,}38 \cdot F_1$) or even on both grooves ($\alpha = 8\pi \rightarrow \Delta F = 151{,}41 \cdot F_1$). A different albeit complex solution is to add one or two extra drive wheels with associated external tensioning pulleys.

[0065] The tensioning pulley (15) in the figures 6, 7, 9 revolves while the cord is running and stops when the cord stops, irrespectively whether the motor (21) is running or not or whether the drive drum (17) is slipping or not. This fact is being used to realize an automatic switch-off of the motor (21). See the schematic fig. 9. The tensioning pulley (15) carries a code disk (31) which is observed by a code reader (33). When the code stalls, the detector (33) transmits a signal to the control electronics (35) which commands the switch (37) to shut off the motor power.

[0066] Thanks to the slip coupling intrinsic to the drive, the motor (21) suffers no damage when the curtain hits an end stop. Installing a large ΔF (e.g. $\alpha = 6\pi$ or 8π; see two paragraphs back) carries the danger of suppressing the slipping effect and damaging the motor. A correct setting of F_S ensures that the motor stops at either end of the rail. Thus, the drive system needs no end switches irrespective of rail length. An obstacle at any other point along the rail will also cause the motor to be stopped, preventing it from taking damage.

[0067] Besides the automatic switch-off function of course the control electronics has start and stop buttons for manual operation. reliable

[0068] The contact surfaces (29) of the drive drum grooves are polished. This prevents any significant wear of the cord in spite of its natural tangential or axial creep during operation or its frequent slipping action during shut-down. Using the drive keeps the surfaces polished and that ensures a stable, reliable and non-deteriorating tribotechnical process. The same cord can last for years.

[0069] Except for the motor and the tensioning pulley, a drive unit according to the invention has virtually no moving parts. There is little mechanical wear and practically no need for maintenance. Neither does the motor undergo abnormal wear because the cord is wound around the drive drum (17) by full turns ($\alpha = 2 \times 360°$) to eliminate bias force resultants.

[0070] Operable with a standard type of cord means that in principle the drive unit is suitable to be added to any planned or existing manually operated curtain draw system. Its simplicity also makes it easy to install. Threading in and exchanging the cord is simple and can be done without dissembling any other part, even if the cord were welded together to form an endless loop. After instalment, adjusting the bias tension is the only remaining action.

Claims

1. A curtain system comprising a rail (5), a curtain suspended from and moveable along the rail, fixed to the curtain a cord (1) that is guided along the rail by guiding means (7, 9), and a cord drive (3) comprising at least two drive wheels (11a, 11b; 17) which are coupled to each other, at least one drive motor (21) that is coupled to at least one of the drive wheels, at least one tensioning pulley (15) that is present at some distance from the drive wheels and coupled to tensioning means that exercise tensioning force on the rotation axle (19) of the tensioning pulley, **characterized by** the cord (1) which, coming from the curtain is wound around one of the drive wheels (1a; 17) by at any rate close to 360 degrees or a whole multiple thereof, then goes to the tensioning pulley (15) and is guided around to return to the other drive wheel (1b; 17) around which the cord is wound by at any rate close to 360 degrees or a whole multiple thereof and returns to the curtain.

2. A curtain system according to claim 1, wherein the drive wheels (11a, 11b; 17) are coupled to each other in such a

manner that during rotation the circumferential groove velocities of the drive wheels are equal or close to equal.

3. A curtain system according to the claims 1 or 2, wherein the drive wheels (11a, 11b; 17) have a concave groove or concave grooves (29).

4. A curtain system according to claim 3, wherein the groove surfaces are polished.

5. A curtain system according to the claims 1, 2, 3 or 4, wherein the tensioning arrangement provides a tensioning force by means of a spring (23) or of a device with a characteristic similar to that of a spring.

6. A curtain system according to claim 5, wherein the tensioning force can be varied to allow adjustment of the slippage torque of the cord (1).

7. A curtain system according to any of the preceding claims 1 to 6, wherein the tensioning arrangement comprises detection means (31, 33) to detect the rotation of the tensioning pulley (15), and a control unit (35) that is coupled with the drive motor (21) and the detection means, which control unit switches off the drive motor when the detection means signals that the pulley has stopped revolving.

8. A curtain system according to the preceding claims, wherein the drive wheels (11a, 11b; 17) are directly mounted on the output shaft (13) of a geared motor (21).

Patentansprüche

1. Vorhangsystem, das eine Schiene, einen an der Schiene aufgehängten und entlang der Schiene verschiebbaren Vorhang, eine an dem Vorhang befestigte Schnur, die durch Führungsvorrichtungen entlang der Schiene geführt wird, sowie einen Schnurantrieb umfasst, der aus mindestens zwei Antriebsrädern, die miteinander gekoppelt sind, mindestens einem Antriebsmotor, der mit mindestens einem der Antriebsräder gekoppelt ist, sowie mindestens einer Spannrolle besteht, die im Abstand zu den Antriebsrädern angeordnet und mit Spannvorrichtungen gekoppelt ist, die eine Spannkraft auf die Drehachse der Spannrolle ausüben, **dadurch gekennzeichnet, dass** die Schnur (1), vom Vorhang kommend, genau oder nahezu 360 Grad oder ein ganzes Vielfaches davon um eine der Antriebsrollen (1a; 17) gelegt ist, anschließend zur Spannrolle (15) geführt und umgelenkt und sodann zum anderen Antriebsrad (1b; 17) zurückgeführt wird, wo die Schnur genau oder nahezu 360 Grad oder ein ganzes Vielfaches davon um das Rad gelegt und zum Vorhang zurückgeführt wird.

2. Vorhangsystem nach Anspruch 1, **dadurch gekennzeichnet, dass** die Antriebsräder (11a, 11b; 17) in der Weise miteinander gekoppelt sind, dass die Umfangsgeschwindigkeiten der Schnurlaufflächen der Antriebsräder bei rotierenden Rädern gleich oder nahezu gleich sind.

3. Vorhangsystem nach einem der Ansprüche 1 oder 2, **dadurch gekennzeichnet, dass** die Antriebsräder (11a, 11b; 17) eine oder mehrere konkave Laufflächen (29) aufweisen.

4. Vorhangsystem nach Anspruch 3, **dadurch gekennzeichnet, dass** die Laufflächen poliert sind.

5. Vorhangsystem nach einem der Ansprüche 1, 2, 3 oder 4, **dadurch gekennzeichnet, dass** die Spannkraft von einer Spannvorrichtung mittels einer Feder (23) oder einer Vorrichtung mit vergleichbarer Charakteristik erzeugt wird.

6. Vorhangsystem nach Anspruch 5, **dadurch gekennzeichnet, dass** die Kraft der Spannvorrichtung verstellbar ist, um das Rutschmoment der Schnur (1) justieren zu können.

7. Vorhangsystem nach einem der vorangegangenen Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** die Spannvorrichtung Detektoren (31, 33) für die Erkennung der Drehbewegung der Spannrolle (15) und eine Steuereinheit (35) umfasst, die mit dem Antriebsmotor (21) und den Detektoren gekoppelt ist und für die Abschaltung des Antriebsmotors sorgt, wenn die Detektoren melden, dass die Spannrolle stillsteht.

8. Vorhangsystem nach einem der vorangegangenen Ansprüche, **dadurch gekennzeichnet, dass** die Antriebsräder (11a, 11b; 17) direkt auf der Ausgangswelle (13) eines Getriebemotors montiert sind.

Revendications

1. Système de rideau comprenant un rail, un rideau suspendu au rail et pouvant coulisser le long du rail, un cordon attaché au rideau et étant guidé le long du rail à l'aide de moyens de guidage, et une commande d'actionnement du cordon comprenant au moins deux roues d'actionnement accouplées l'une à l'autre, au moins un moteur d'entrainement accouplé à au moins l'une des roues d'actionnement, au moins un galet de tension se trouvant à distance des roues d'actionnement et étant accouplé à des tendeurs qui exercent une force expansive sur l'axe de rotation du galet de tension, **caractérisé en ce que** le cordon (1) arrivant depuis le rideau est enroulé autour d'une des roues d'actionnement (1a; 17) sur au moins sensiblement 360 degrés ou un multiple entier de 360, puis va vers le galet de tension (15) et est dévié et revient vers l'autre roue d'actionnement (1b; 17), autour de laquelle est enroulé le cordon sur au moins sensiblement 360 degrés ou un multiple entier de 360, et revient vers le rideau.

2. Système de rideau selon la revendication 1, **caractérisé en ce que** les roues d'actionnement (11a, 11b; 17) sont accouplées l'une à l'autre de telle sorte qu'en rotation, les vitesses circonférentielles des bandes de roulement du cordon des roues d'actionnement sont identiques ou presque identiques.

3. Système de rideau selon la revendication 1 ou 2, **caractérisé en ce que** les roues d'actionnement (11a, 11b; 17) ont une ou plusieurs bandes de roulement concaves (29).

4. Système de rideau selon la revendication 3, **caractérisé en ce que** les bandes de roulement sont polies.

5. Système de rideau selon la revendication 1, 2, 3 ou 4, **caractérisé en ce que** le dispositif tendeur fournit la force expansive au moyen d'un ressort (23) ou d'un dispositif ayant une caractéristique comparable.

6. Système de rideau selon la revendication 5, **caractérisé en ce que** la force du dispositif tendeur est ajustable, ceci afin de régler le couple de glissement du cordon (1).

7. Système de rideau selon une des revendications 1 à 6 précédentes, **caractérisé en ce que** le dispositif tendeur comprend des moyens de détection (31, 33) pour détecter la rotation du galet de tension (15), et une unité de contrôle (35) qui est accouplée au moteur d'entrainement (21) et aux moyens de détection et qui déconnecte le moteur d'entrainement lorsque les moyens de détection détectent un arrêt du galet de tension.

8. Système de rideau selon les revendications précédentes, **caractérisé en ce que** les roues d'actionnement (11a, 11b; 17) sont montées directement sur l'axe de sortie (13) d'un moteur de réduction.

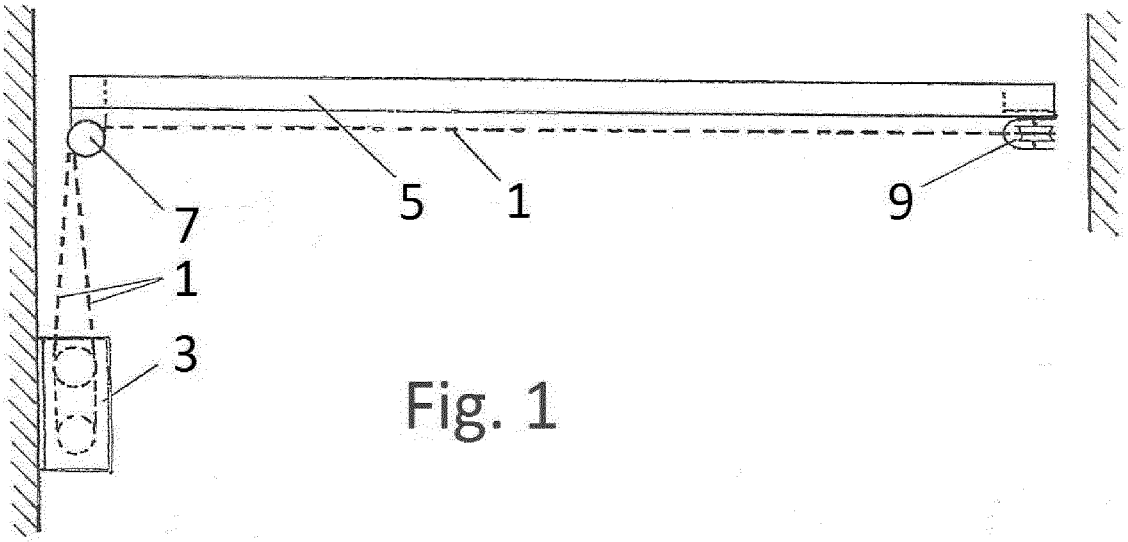


Fig. 1

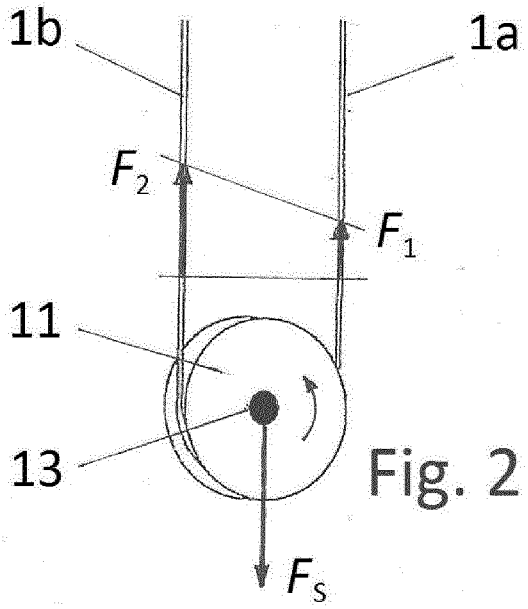


Fig. 2

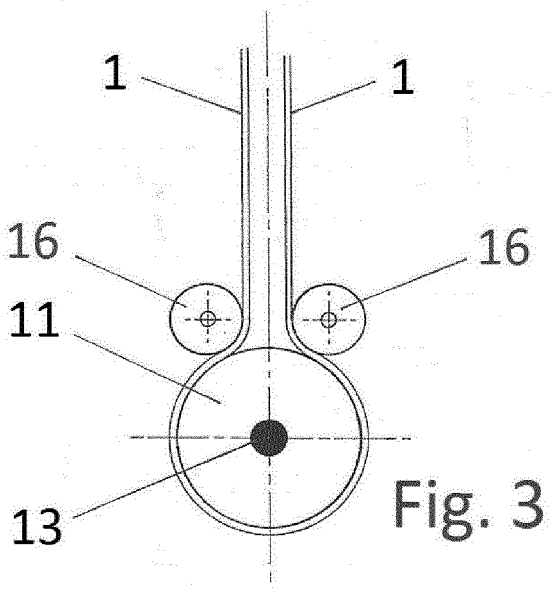


Fig. 3

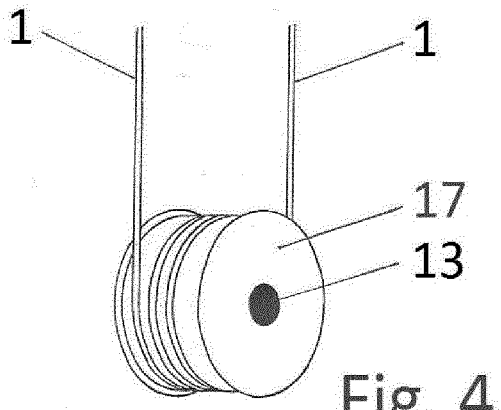


Fig. 4

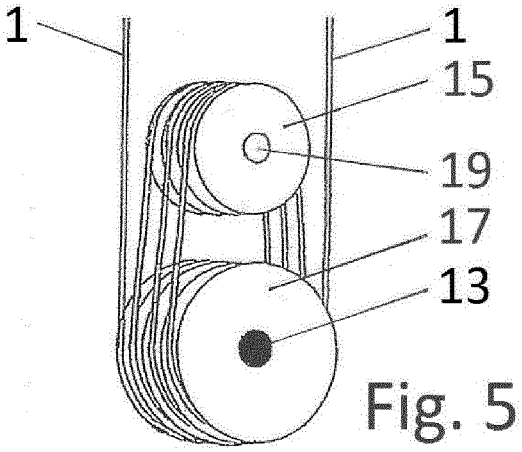


Fig. 5

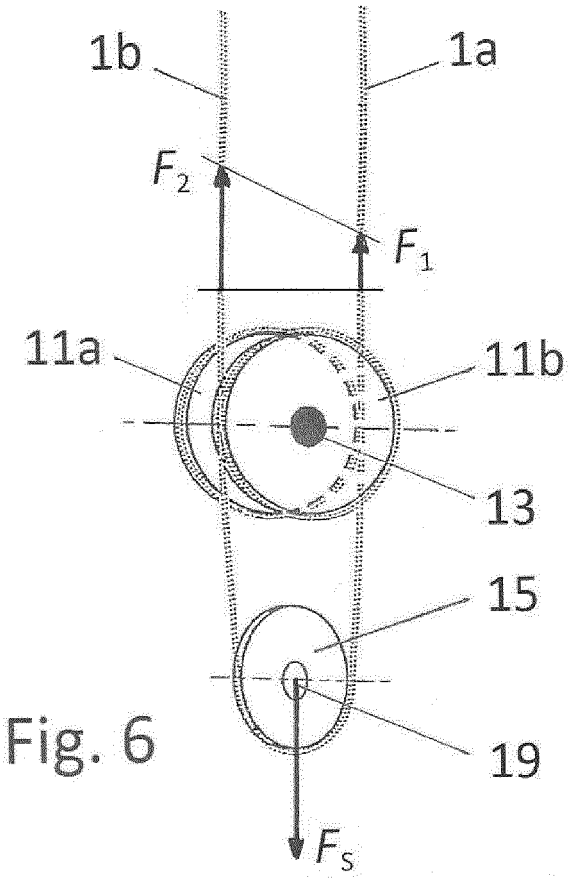


Fig. 6

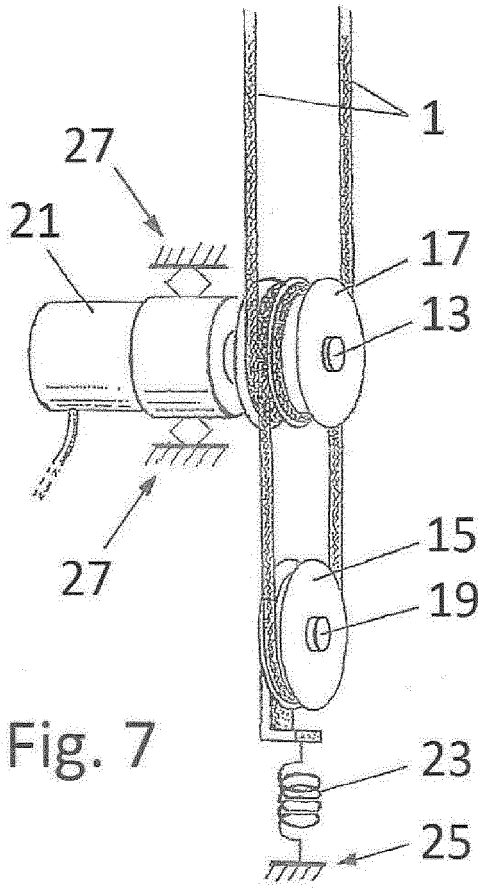


Fig. 7

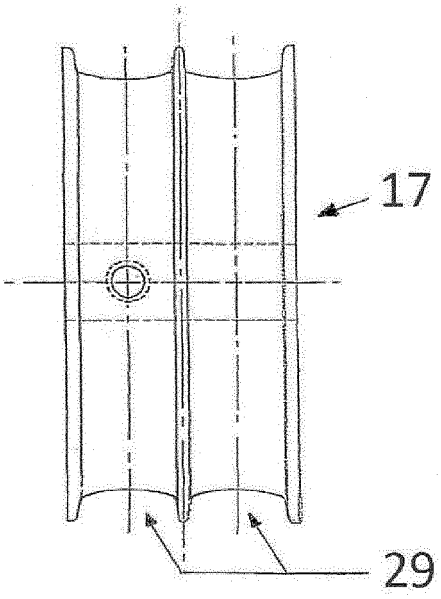


Fig. 8

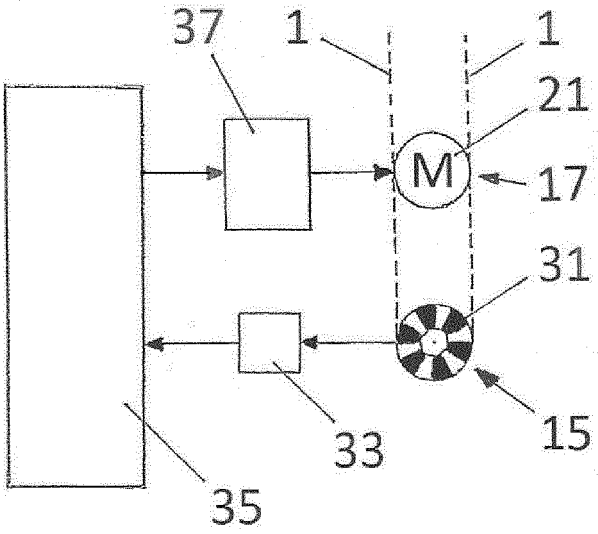


Fig. 9

REFERENCES CITED IN THE DESCRIPTION

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