MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1953-A
CONVENTION APPLICATION FOR A PATENT

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LODGED AT SUB-OFFICE
11 JUN 1985
Melbourne

hereby apply for the grant of a Patent for an invention entitled

FULLY FOR A SYNCHRONOUS DRIVE SYSTEM COMPRISING A POLYMERIC MATERIAL TOOTHED-BELT AND RELATIVE TRANSMISSION

which is described in the accompanying complete specification. This application is a Convention application and is based on the application numbered 21346 A/84 for a patent or similar protection made in Italy on 11th June 1984.

Our address for service is Messrs. Edwd. Waters & Sons, Patent Attorneys, 50, Queen Street, Melbourne, Victoria, Australia.

DATED this 7th day of June 1985.

PIRELLI TRASMISSIONI INDUSTRIALI S.p.A.

by

L. J. Dyson
Registered Patent Attorney

To:

THE COMMISSIONER OF PATENTS.
DECLARATION IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT OR PATENT OF ADDITION

In support of the Convention Application made by PIRELLI TRASMISSIONI INDUSTRIALI S.p.A.

(hereinafter referred to as the applicant) for a Patent for an invention entitled: "PULLEY IN SYNCHRONOUS BELT-DRIVE HAVING A TOOTHED-BELT AND THE RELATIVE TRANSMISSION"

I, Alessandro DE GIORGI of Via Erasmo Piaggio, n. 28 - CHIETI SCALO (Chieti), Italy do solemnly and sincerely declare as follows:

1. I am authorised by the applicant for the patent to make this declaration on its behalf.

2. The basic application as defined by Section 141 of the Act was made in ITALY on the 11th day of June 1984, by PIRELLI TRASMISSIONI INDUSTRIALI S.p.A.

3. Mr. Vincenzo MACCHIARULO, residing at Chieti (Italy), Via Madonna della Misericordia, 96 - and Mr. Ezio MARCELLI, residing at Pescara (Italy), Via Raffaello, 94 are the actual inventors of the invention and the facts upon which the applicant is entitled to make the application are as follows:

   The applicant is the assignee of the said invention from the said inventors.

4. The basic application referred to in paragraph 2 of this Declaration was the first application made in a Convention country in respect of the invention the subject of the application.

DECLARED at Milan, Italy this 23rd day of April 1985.

To: THE COMMISSIONER OF PATENTS.

PULLEY FOR A SYNCHRONOUS DRIVE SYSTEM
PULLY FOR A TOOTHED BELT AND SYNCHRONOUS TRANSMISSION

PIRELLI TRANSMISSIONI INDUSTRIALI S.p.A

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VINCENZO MACCHIARULO AND EZIO MARCELLI

Claim

1. Pulley suitable for the transmission of motion with a flexible toothed belt of polymeric material comprising a plurality of grooves alternating with teeth, characterized by the fact that each groove comprises two flanks having a parabolic arc shaped profile and a bottom whose ends coincide with the vertices of the parabolic arc shaped profiles, the length of said bottom being substantially comparable with the length of each parabolic arc shaped profile of the flanks of said groove.

.../2.
8. Synchronous transmission of motion between a toothed belt of polymeric material and at least two pulleys, driving pulley and driven pulley, respectively, said belt comprising teeth alternating to grooves for the engagement with the corresponding grooves and the corresponding teeth in said pulleys, said synchronous transmission being characterized by the fact that in at least one of said pulleys each groove comprises two lateral profiles with variable radii of curvature gradually formed by two parabola shaped arcs whose vertices are disposed on a line forming the bottom of the groove, the length of said bottom being substantially comparable with the length of each of said parabolic arc shaped profiles, the curve of each parabola shaped arc following the formula:

\[ Y = Kx^2. \]
The following statement is a full description of this invention, including the best method of performing it known to us.
The present invention refers to a pulley for a synchronous drive system comprising a toothed belt of polymeric material and to the relative transmission comprising said pulley.

As known, the main problems to be solved in the transmission of motion between toothed-belts and pulleys are two.

The first problem is that to guarantee a correct engagement of the belt tooth both in the step of going into the corresponding groove pulley and in the step of coming out of the corresponding pulley groove, respectively, respectively in and from the corresponding groove of the pulley.

The second problem is that of avoiding the so-called belt tooth skipping phenomenon from the groove of the pulley where the belt tooth is completely engaged for the synchronous transmission of motion.

The first problem is relating to the steps carried out before and after the complete engagement between the teeth of the belt and of the pulley; the solution to be sought is therefore limited to a time that can be defined temporary with respect to the real engagement time.

In the cited transient steps, the forces exchanged between the belt and the pulley, are practically sliding forces not useful to the transmission of motion and negative for their nature in connection with both the life of the belt and a correct transmission.

In fact the sliding forces determine in the time the wearing of the belt formed by an elastomeric material with the consequence of submitting the outermost surface of the belt to the action of aggressive substances as dust, polluting substances mixed to oil traces, various unwanted impurities since they give rise to and increase not only
the deterioration of the belt body, but they can also modify the profile chosen for the engagement step originating therefore slacks and noise between the modified profile of the belt tooth and the unchanged profile of the pulley groove.

The second problem to be solved refers to the useful step to the transmission of motion and takes a considerable longer time than that relating to the engagement and disengagement of the belt tooth with the pulley slot; in fact the belt tooth is and remains completely engaged in the pulley groove for the entire period that the belt winds around the pulley.

During the entire engagement step, the tooth-skipping phenomenon could occur for two reasons.

The first reason is connected to the curvature of the pulleys of the transmission around which the belt winds, in particular when rather greater transmission ratios are used; in this case since the belt during its winding around the pulley comprises at its inside a rigid insert could not follow the curvature imposed by the pulley with small diameter.

The second reason is connected to the number of teeth which is lower in one pulley with respect to the other in order to realize a determined transmission ratio.

As understandable, the smaller the number of the teeth in the pulley apt to bear the entire charge to be transmitted and to receive is, the greater risk of a possible tooth-skipping phenomenon will be.

The problem of the tooth-skipping phenomenon is more marked in the present technique where there is the tendency to use more and more a very small number of teeth in one of the two pulleys of the driving system going at the same time toward higher and higher powers to be transmitted.

Therefore it is clear that the present technique requires solutions in which the tooth-skipping phenomenon concentrated causing thus the known fatigue cracks.
is a drawback which must be avoided in the practical uses of the synchronous driving systems.

In fact it is apparent that the drawbacks due to the transient steps, i.e. those relating to the engagement and disengagement between the teeth of the belts and the grooves of the pulleys, could also be tolerated since the wearing of a belt tooth is slow and can be eliminated by substituting the worn belt during one of the possible maintenance periods.

On the contrary to what is now said, the tooth skipping phenomenon is a sudden and an unexpected drawback and can have negative and irreparable consequences in a synchronous drive system.

Therefore the present invention aims at improving the present pulleys and the relative transmissions between the toothed belts and the pulleys so as to overcome at the same time both the problem connected to the engagement and disengagement steps of the belt tooth from the relative grooves of the pulleys and, in particular, the problem connected to the belt tooth-skipping phenomenon from the groove of the pulley, the whole obtained improving as much as possible the noiselessness of the drive system in which the pulley according to the invention is inserted.

Therefore, the object of the present invention is a pulley suitable for the transmission of motion with a flexible toothed belt of polymeric material comprising a plurality of grooves alternating with teeth, characterized by the fact that each groove comprises two flanks having a parabolic arc shaped profile and a bottom whose ends coincide with the vertices of the parabolic arc shaped profiles, the length of said bottom being substantially comparable with the length of each parabolic arc shaped profile of the flanks of said groove.

Preferably, each parabolic arc shaped profile is defined by the curve:

\[ y = Kx^2 \]
being K comprised between 0.09 and 25.83 on varying of the dimensions of the profile.

The present invention will be better understood by the following detailed description made by way of non limiting example with reference to the attached sheets of drawing in which:

- figure 1 is a transversal section of a groove of the pulley according to the invention;
- figure 1a shows one of the flanks of the groove of figure 1;
- figure 2 is a section of the groove of a pulley according to the invention with respect to the pulleys according to the state of the art;
- figure 3 shows the distribution of the stresses between the belt tooth and the corresponding pulley, referred both to the pulley of the invention and to the pulley of the state of the art;
- figure 4 shows in cross section the lightening of the pulley according to the invention with respect to the pulleys of the state of the art with equal geometrical dimensions;
- figure 5 shows the hob of the grooves of a pulley and the relative pulley;
- figure 6 shows the grooves of two pulleys having different diameter, great diameter and small diameter, formed according to the state of the art;
- figure 7 shows a drive system comprising a belt and a small diameter pulley having a groove, formed according to the state of the art;
- figure 8 shows the comparison between the grooves of the small diameter pulleys whose profiles are formed according to the state of the art and according to the present invention, respectively;
- figure 9 shows the comparison between the grooves of two pulleys with determined shape maintaining the rolling pitch line of the hob tangent to the outer
Figure 10 shows the transmission of motion between the belt and the pulley whose grooves have profiles formed according to the present invention.

With reference numeral 1, figure 1 shows a portion of a pulley of metallic material or of rigid plastic material equivalent to metal, of the type apt to be used in a synchronous transmission of motion with a toothed belt of polymeric material, in particular of elastomeric material with longitudinal reinforcing inserts.

The pulley comprises a plurality of groove 2, each groove being as that shown in figure 1, alternating with teeth delimited in the upper part of the outermost circumference.

The groove 2 comprises two flanks 5, 6 and a bottom 7. More particularly the groove 2 comprises two flanks having a parabolic arc shaped profile and a bottom whose ends 8, 9 coincide with the vertices of the parabolic arcs traced with reference to a system of cartesian axes x, y.

In the embodiment of figure 1, the bottom 7 is defined by a curvilinear portion with curvature substantially near a rectilinear portion of a length D. In alternative, the bottom 7 can have a path which differs from that of figure 1 for the fact of comprising a convexity toward outside or also an opposite curvature or also according to another embodiment, a rectilinear path alternating to curvilinear portions to originate projections, protuberances and the like and i.e. elements able to cause a contact, if desired, with the crest of a belt tooth.

In all the cited solutions, the bottom 7 comprises the essential characteristic of having a path defined by a length comparable with the length of each parabolic arc shaped profile 5 or 6.

In the present text the meaning of the word
"comparable" is the fact that the distance D between the ends 8, 9, i.e. between the vertices of the two parabolic arcs is equal or also greater to 65% than the length of each parabolic arc measured between the vertices 8, 9 and the radially outermost points of each parabolic arc 10, 11.

The radially outermost points 10, 11 are those determined by the tangent condition of the circumference of radius r defining the teeth 3 of the pulley.

Preferably in all the solutions in which the present invention can be directed, the parabolic arc shaped profile of the flanks 5 or 6 is determined by the formula:

\[ Y = K x^2 \]

where, referring to figure 1a, Y is the axis passing through the center of the pulley and through the point 8 of figure 1; X is the axis orthogonal to Y passing through the same point 8.

The coefficient K is given by formula

\[ K = \frac{\tan^2(90 - \beta)}{4 Y_0} \]

and

\[ Y_0 = H - r (1 - \sin \beta) \]

where with reference to figure 1a:

- \( H \) = total height (mm)
- \( \beta \) = angle formed by the tangent t, common to the parabola and to the contact circle, with the axis Y;
- \( r \) = radius of the contact circle (mm)
- \( Y_0 \) = ordinate relative to the tangent point between the parabola and the contact circle.

The value of the above mentioned geometrical parameters assume a considerable importance in the present solution since the shape of the groove profile and the results achieved with said profile depend on said values.

Particular embodiments of the present invention are obtained imposing the following limits to the above mentioned parameters:

between 8° and 25°.

Pulley as in claim 6 whose ratio between the width
K varies from 0.09 to 25.83 for grooves having a height from 0.7 to 15 mm.

The geometrical characteristics of the lateral profiles 5, 6 and of the bottom 7 are particularly suitable to define grooves belonging to pulleys having a very low number of teeth, up to values of 10 teeth.

Also, preferably, the ratio between the width $L$ and the depth $H$ of the groove is comprised between $1.3$ and $3$ where:

- the width $L$ is measured between the points 12 and 13 in parallel to the bottom of the pulley; the points 12 and 13 are determined by the intersection of the two tangents $t$ with the circumferential line 4.
- the depth $H$ is measured in radial direction between the points 14, 15 at the center of the bottom 7 and on the outermost circumferential line 4 of the pulley, respectively.

The embodiment of figure 1 can correspond to a pulley having a number of teeth $Z = 38$ and ray $R$ that consequently results determined by:

$$R = P \times 38 \div 2\pi$$

where $P$ represents the pitch between two contiguous grooves of the pulley.

The pulley 1 is part of a transmission of motion comprising in its whole at least two pulleys, a driving pulley and a driven pulley, respectively, and a toothed belt formed by a body of polymeric material, more particularly of elastomeric material, reinforced with longitudinal reinforcements in particular of glass fibers and by projecting teeth covered or not with a fabric.

In this drive system, one of the two pulleys can be realized according to what is shown in figure 1.
The second pulley of the drive system could be realized with characteristics different from those of the first pulley; for instance the lateral profiles of one of the two pulleys could have rectilinear portions with grooves substantially shaped according to a trapezium configuration.

In other words the characteristics of the pulley of figure 1 are such as to permit its use in a drive system already provided for working with a determined belt and with a corresponding pulley profile different from that of the invention.

The pulley according to the present invention comprises in particular the characteristic of the profiles formed by the step of rolling the cutting pitch line of the hob on the outer circumference of the pulley as explained in detail hereinafter.

The belt associated to the pulley according to the present invention could be covered with a self-lubricating fabric disposed on the teeth and on the grooves as described in the German patent PS 20 16 830.3. In alternative the belt could be covered with a double fabric as described in the German patent PS 23 63 686.3.

The profile of the belt teeth making part of the drive system could be for instance as that described in the U.S. patent 4 371 363 or also the belt could have teeth with a trapezium shaped profile or according to further solutions the belt could have the tooth provided with a central slot as described in the Italian patent application No. 19 872 A/82.

Moreover the profile of the belt tooth could be conjugated or also not conjugated with that of the corresponding pulley groove.

It has been found that the drive systems for the transmission of motion comprising toothed belts with pitch 9.525 mm, width 15 mm and development from 800 to 1900 mm are particularly suitable to the purposes of the present
invention.

These belts are associated to pulleys (having the grooves as shown in figure 1) with transmission ratio 1:2. In particular the belts and the pulleys are apt to be used for the controls of the distribution of the engines comprising pulleys having a transmission ratio 1:2 and more specifically a first pulley with 21 teeth and a second pulley with 42 teeth.

According to another embodiment the drive system according to the present invention comprises toothed belt having a tooth profile according to the U.S. patent 4,371,363 and two pulleys comprising 16 teeth for the driving pulley and 32 teeth for the driven pulley, respectively.

The present invention attains all the aimed purposes. The absence of at least the appreciable reduction of the risk connected to the tooth-skipping phenomenon in a drive system comprising a pulley according to the present invention appears to be due to the contemporaneous presence of a groove bottom having a length comparable with those of the flanks of the same groove and a parabolic arc configuration of the flanks with the vertices of the parabola at the extremities of the groove bottom.

In particular flanks curved according to the following formula can assume importance in the reduction of the risk connected to the tooth-skipping phenomenon:

\[ Y = Kx^2 \]

where \( K \) is comprised between 0.09 and 25.83.

The characteristics of the pulley according to the present invention are better stressed in figure 2 with regard to the pulleys of the known technique comprising with equal geometrical dimensions of the groove, i.e. depth \( H \) and width \( L \), trapezium-shaped grooves or grooves provided with two arc of a circle shaped flanks 17,18 with centres \( O_1 \) and \( O_2 \) equally spaced with respect to the axis of symmetry \( KK \) and the groove bottom 19 with a short rectilinear portion.
The attained optimal results are better understood from that which is represented in figure 3 where there are shown the stresses originated between a belt tooth and the relative pulley groove when the belt tooth is completely inside the groove and remains during the arc of contact between the belt and the pulley.

In figure 3 the stresses are represented both in connection with the drive system comprising a pulley according to the present invention and in connection with the drive system comprising the known pulley represented in figure 2.

The part relating to the stresses according to the present invention is drawn with a broken line in figure 3.

In respect of the transmission of motion between the belt tooth and the pulley groove, the particular profile of the belt tooth is not drawn; in fact the reasoning explained herein is independent on the fact that the profiles are conjugated or not since in respect of the transmission of motion in the considered step, i.e. during the complete penetration of the belt tooth into the groove, owing to the particular formation of the belt tooth of elastomeric material, one of the tooth flanks presses practically on the entire profile of the corresponding groove flanks.

In the embodiment shown in figure 3 it has been supposed that the thrust $P$ useful to the transmission of motion between the belt and the pulley can be divided for the tooth and the groove of figure into a lot of small thrusts $F_p$ of equal value to which according to the composition of forces shown in the figure vertical thrusts $F_n$ correspond.

The vertical thrusts $F_n$ tend to turn into a sliding tooth-profile and groove-profile; however, as clearly indicated in the figure the vertical components $F_n$ relative to the pulley having the groove delimited by parabolic arc shaped flanks are substantially less than the
vertical thrusts $F_n$ relative to the pulley having the flanks shaped according to an arc of circle.

According to the scheme made by way of example in figure 3, in the pulley according to the invention the vertical thrusts $F_n$ can reach values of about 60% of the vertical thrusts relating to pulley according to the state of the art; this produces both a slower wearing of the toothed belt material and in particular a clear improvement as regards the elimination of the skipping phenomenon between belt tooth and pulley groove.

The removal of the skipping phenomenon is a favourable characteristic for all the pulleys of various maximum pitch diameter according to the present invention, but it is much more substantial when there are used for pulleys with great curvature the same dimensions as the parabolic arc and the distance between the vertices of the parabolic areas when only few teeth are acting and therefore when the risk of the skipping phenomenon is greater.

Then the use of one same groove, i.e. of a groove with dimensions of equal maximum width and maximum depth independently of the pitch diameter of the pulley in one same drive system turns also into a further advantage since not changing the contact between the pulley tooth and the belt tooth in the pulleys with a smaller number of teeth, a wider bearing surface in particular with low specific pressure is determined.

This latter characteristic is useful for the duration and the lifetime of the belts, since the small diameter pulleys in one same drive system having a low specific pressure, produce a slower wearing in the materials forming the toothed belt.

The fact of having moved the vertices of the two parabolic arcs at a considerable distance with respect to the central axis of symmetry KK (figure 1) assumes also importance in respect of the skipping phenomenon.

In fact the cited solution for the present pulley
permits the engagement with a belt tooth of a greater thickness in the outermost pair with regard to the pulley of the state of the art represented in figure 2 with arcs 17, 18.

This consideration is much more apparent in figure 4 in which A at oblique lines indicates the reduction of the metallic area of a pulley with a parabolic arc shaped profile with respect to the pulley with an arc of a circle shaped profile, with equal depth and maximum width of the groove in the upper inlet part.

This fact permits, when the belt tooth is completely inside the groove, a deformation of a greater quantity of elastomeric material in the most flexible part of the belt tooth generating a greater opposition to the thrust which would tend to slide it and therefore to make it skip out with respect to the pulley tooth.

All this, although with the due approximation, is analogous to what could happen for instance in a more deflated tire with respect to a more inflated one and i.e. to a tire that being more deflated and having a wider area of contact with respect to the other one would tend on braking to skid less since in the deformation it involves a greater quantity elastomeric material.

In practice in the present situation, owing to very intense thrusts, the belt tooth tends progressively to press and to involve more layers of elastomeric material of the tooth of the belt before coming out of the pulley groove to originate the so called skipping phenomenon.

The obtained results are also surprising. In fact US patent 3 756 091 teaches to reduce the quantity of elastomeric material present in a belt tooth with respect to a trapezium tooth. At this stage the Applicant moved toward an opposite teaching and instead of reducing and removing the material from the elastomeric part of the conventional belts, has reduced the thickness of the pulley tooth as schematically indicated in figure 4 with oblique
lines, i.e. the Applicant has removed some material from the pulley, the further result of reducing the involved heavy masses is achieved with the consequent reduction in the vibrations and noises.

The achieved advantage is evident looking at figure 4. In fact, from this figure it is apparent that the mass reduction at least for one of the two pulleys is substantial being represented by the following formula:

\[ 2 \times A \times 1 \times n \]

where:
- \( l \) is the dimension perpendicular to the plane of the drawing relating to the width of the pulley;
- \( n \) = number of the grooves.

The result achieved from that which is synthesized in the cited formula is then to be extended to the two pulleys (a driving and a driven one) drive systems, with corresponding reduction in the involved heavy masses constituted generally by metallic pulleys.

Moreover the essential characteristics of the present pulley contribute greatly to improve the transient steps of separation of the belt teeth from the pulley grooves.

This result is obtained by making recourse to drive systems comprising at least a pulley according to the invention and belts having the tooth profile of different shapes, for instance of trapezium shape, or arc of a circle shape or with teeth characterized by parabolic arc shaped flanks provided or not with a groove at the crest of the tooth.

In fact, in the cited drive systems, the characteristic configuration of the parabolic arc shaped flanks of the present pulley and the distance between the vertices of the two parabolas permit favourably a progressive and gradual engagement step between the tooth and the belt and corresponding pulley groove.

The situation of favourable engagement is
determined by the particular configuration of the pulley flank, configuration characterized by first infinitesimal nearly rectilinear portions, i.e. portions having a less curvature, and by subsequent portions having a curvature which increases more and more up to the extreme point of the groove bottom according to a specific curve determined by the value of the parameter $K$.

Consequently, just owing to the graduality of the curvature of the groove flank, the belt tooth is guided and obliged in the engagement step to a contact which is gradual, with a desired and pre-determining deformation of the elastomeric part of tooth.

In other words by means of the characteristics according to the present invention the engaging step is guided whatever the profile of the belt tooth is, with deformations of the belt tooth imposed by the shape of the flank of the pulley groove, the whole so as to obtain a continuous control of the engagement step, anyhow, always maintaining the deformations and the consequent unavoidable slidings and the relative wearing to very reduced values owing to the cited gradual curvature of the groove flank.

A further advantageous aspect of the present invention is a groove having parabolic shaped flanks, as previously described, formed by a hob 20 (figure 5) whose cutting pitch 21 is tangent to the outer circumference 22 of the pulley.

In order to clear up this particular aspect of the present invention, reference will be made to the diagrammatic view of figure 5 where the hob 20, according to the state of the art, originates the profile of the pulley groove in a way completely different from what previously said, i.e. its pitch line 23 is tangent to the pitch line of the pulley with a circumference of diameter $D/4$ and rolls on this latter pitch line.

As it is observed in this view the pitch line of the hob has a distance "a" on the line which delimits the
root of the hob teeth and also a distance "a" from the outer circumference of the pulley of a diameter \( \Phi_1 \) of which it generates the grooves.

After calling the hob pitch \( P \) and the number of the grooves and teeth to be generated on the pulley \( z \), the situation is defined by the formula:

\[
P = \frac{(\Phi_1 + 2a) \pi}{z}
\]

Following the known technique it has been noted that the profiles of the grooves of the pulley differ according to the rolling diameter.

This circumstance determines negative aspects when profiles of the grooves are to be created on smaller and smaller diameter pulleys, for instance pulleys provided with ten teeth, pitch of 3 mm or 20 mm and therefore with diameters of 9.55 mm and 64 mm.

This is apparent from the quite edge shaped configurations and from the variation of the inclination of the flanks of the grooves in the passage from a great pulley 25 to a small one 26 as schematically shown in figure 6.

It is evident that in the pulleys having a small diameter the presence of accentuated edges on the contact zone 27 and the inclination of the flanks lead to the removal from the flanks of the belt tooth creating both an excessive concentration of the stresses at the root of the belt tooth as indicated in figure 7 by the arrows \( F_1 \) and a reduction in the area of contact between the belt and the pulley.

These two effects constitute the main cause of the short lifetime and the poor resistance to the skipping phenomenon in a drive system comprising small diameter pulleys.

In fact, the edge produces a quick wearing of the belt surface during the engagement and also when the belt is engaged, the stress at the root of the tooth is too
concentrated causing thus the known fatigue cracks.

Moreover it is evident from the figure 7 that owing to the scarce surface of contact between the belts and the pulley it is possible to have the cited skipping phenomenon.

By contrast to what is stated by the known technique, the Applicant has now found that it is possible to eliminate the previously cited drawbacks by using the profiles of the pulley grooves generated by the rolling without the sliding of the hob cutting pitch line 21 on the outer circumference 22 of the pulley (figure 5), i.e. nullifying the distance "a".

A possible explanation of the advantages achieved by means of the profiles generated as said, derives from the fact that placing the hob rolling pitch line tangent to the outer circumference of the pulley it is possible to obtain for all the points of the profiles generated during the rolling, an approaching of said points to the centers of instantaneous rotation.

In other words, according to the present solution, the points of the profiles of the grooves have smaller radii with respect to those according to known solutions reaching thus a more gradual and accentuated curvature in the curvilinear portions of the grooves, the whole with the result of eliminating or also of attenuating the edges 27 of the grooves represented in figure 6.

Consequently it can be stated that the pulleys of the invention not only have groove parabolic arc shaped profiles suitable for the transient engagement and disengagement steps with the teeth of any profile of a belt, but also that said profiles formed with a distance "a" substantially equal to zero, are maintained for small diameter pulleys in particular in the contact zones.

This situation is furthermore schematized in figure 8 for a better description of two small diameter pulleys, respectively 28, 29, the first pulley with grooves
generated with a distance "a" equal to zero and the second pulley with a distance "a" greater than zero. Moreover figure 9 stresses the absence of edges in the upper contact zone of a groove in the embodiment of a profile shaped according to a parabolic arc when the distance "a" is zero and from a greater diameter pulley 30 it is passed to a smaller diameter pulley 31.

The optimal situation achieved by means of the invention, in particular as regards the wide zone of contact between the belt and the pulley is furthermore schematized with reference numeral 32 in figure 10.

Although some preferred embodiments according to the present invention have been described and illustrated, it is understood that the present invention includes in its scope any other alternative embodiment accessible to a technician of the field.
zero and the second zero. Moreover, the upper contact profile shaped reference "a" is zero passed to a means of the outer zone of furthermore figure 10. Metrics according to and illustrated, which includes in its possible to a
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Pulley suitable for the transmission of motion with a flexible toothed belt of polymeric material comprising a plurality of grooves alternating with teeth, characterized by the fact that each groove comprises two flanks having a parabolic arc shaped profile and a bottom whose ends coincide with the vertices of the parabolic arc shaped profiles, the length of said bottom being substantially comparable with the length of each parabolic arc shaped profile of the flanks of said groove.

2. Pulley as in claim 1, characterized by the fact that each of said parabolic arc shaped profile is defined by the curve:

\[ Y = K R^2 \]

being \( K \) comprised between 0.09 and 25.83 on varying of the dimensions of the profile.

3. Pulley as in claim 1, characterized by the fact that the bottom of said groove is substantially flat.

4. Pulley as in claim 1, characterized by the fact that the profile of the groove is determined by the rolling pitch line of the hob tangent to the outer circumference of the pulley.

5. Pulley as in claim 1 characterized by the fact that the ratio between the length of the bottom and the length of each parabolic arc shaped profile in the groove is equal or at the most greater than 0.65.

6. Pulley as in claim 1, characterized by the fact that the tangents of the two radially outermost points of the parabolic arc shaped profiles form with the radii of the pulley passing through the two points of contact of the parabola with the bottom of the groove an edge comprised
7. Pulley as in claim 6 whose ratio between the width and the depth of the groove is comprised between 1.3 and 3.

8. Synchronous transmission of motion between a toothed belt of polymeric material and at least two pulleys, driving pulley and driven pulley, respectively, said belt comprising teeth alternating to grooves for the engagement with the corresponding grooves and the corresponding teeth in said pulleys, said synchronous transmission being characterized by the fact that in at least one of said pulleys each groove comprises two lateral profiles with variable radii of curvature gradually formed by two parabola shaped arcs whose vertices are disposed on a line forming the bottom of the groove, the length of said bottom being substantially comparable with the length of each of said parabolic arc shaped profiles, the curve of each parabola shaped arc following the formula:

\[ Y = kx^2. \]

9. Transmission of motion between a toothed belt of polymeric material and at least two pulleys as in claim 8, characterized by the fact that the grooves of each pulley are delimited by said parabolic arc shaped profiles and by said bottom whose extremities are the vertices of the two parabola shaped arcs.

10. Transmission of motion as in claim 8 or 9, characterized by the fact that the grooves of the two pulleys of the drive system have equal shape and dimension.

11. Transmission as in claim 8, characterized by the fact that the depth of the pulley groove is greater than the height of the corresponding belt tooth.
12. Transmission as in claim 8, characterized by the fact that the profiles of the grooves of the two pulleys are generated by a hob whose cutting pitch line rolls without sliding on the outer circumference of said pulleys.

DATED this 21st day of May, 1985
PIRELLI TRANSMISSIONI INDUSTRIALI S.p.A.

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DRAWINGS
of the pulley with oblique

The situation of favourable engagement is