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Dossier

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[54] **ONE-WAY DRIVE ROTARY COUPLINGS, ESPECIALLY MECHANISMS OF THE FREE WHEEL TYPE**

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[30] **Foreign Application Priority Data**
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[52] **U.S. Cl.** **192/45.1,** 192/41
[51] **Int. Cl.** **B60l 5/00**
[58] **Field of Search** .... 192/45.1, 41; 64/30 E, 64/30 R; 188/82.8

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[57] **ABSTRACT**

The coupling comprises two coaxial, relatively rotary members. Between the central member and the sleeve member is a shoe, to fix one member rigidly to the other in one rotary direction. The shoe is slidable over a surface of revolution of the sleeve coaxial to the coupling and a rotary skid is inserted between the shoe and the central member and slidable over a flat surface, belonging either to the shoe or to said member, or to a part fast to one of these two elements. The axis of rotation of the skid is suitably displaced with respect to the axial plane normal to said flat surface. A spring cooperates with the central member and the shoe, urging the sliding surfaces to maintain contact. The shoe may be a bar supported at its two ends by two contact zones on the cylindrical sliding surface of the sleeve.

29 Claims, 12 Drawing Figures

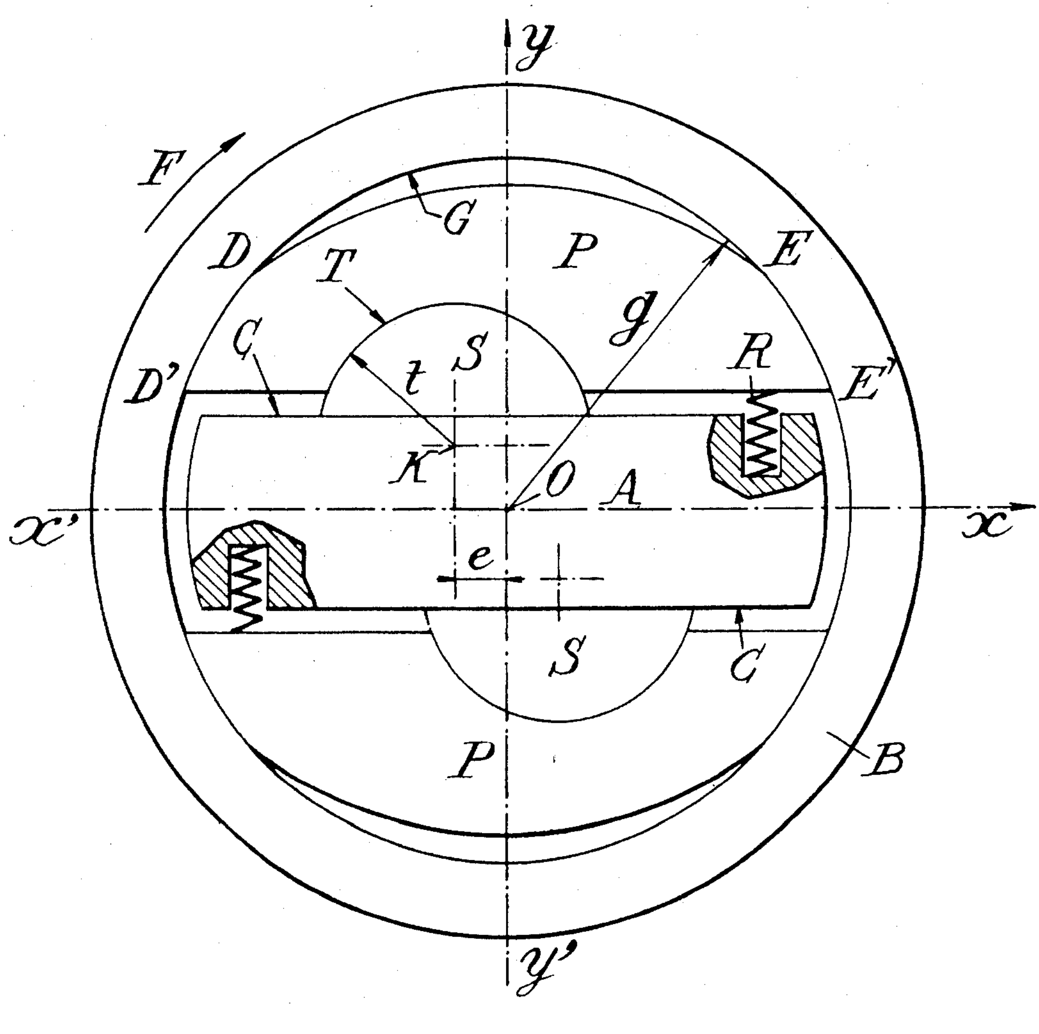

Fig.1.

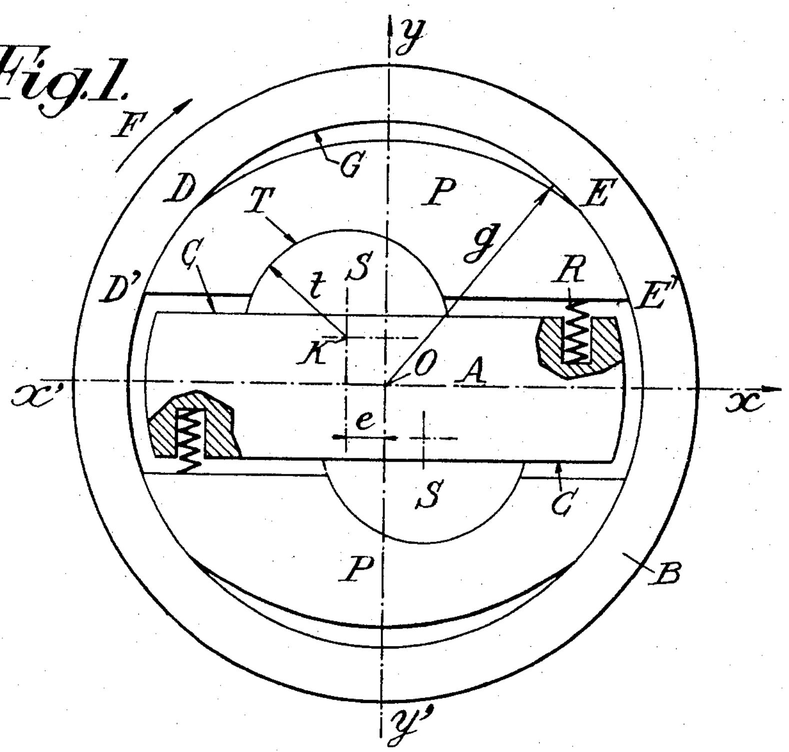
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Fig.2.

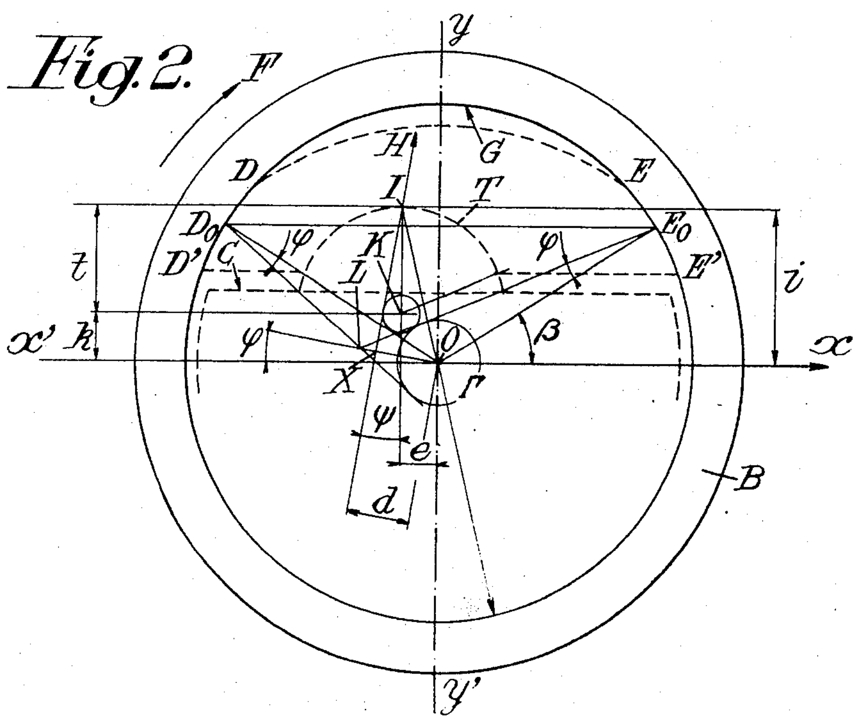
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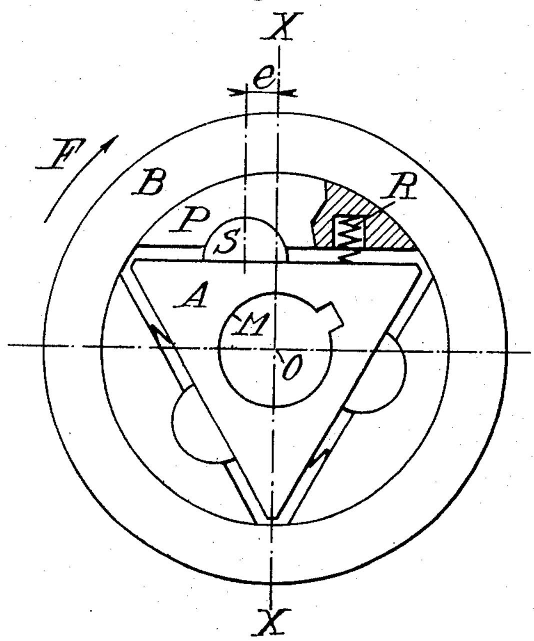
Fig. 3.



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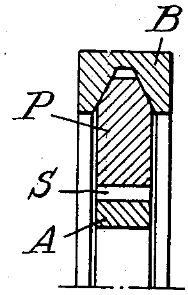
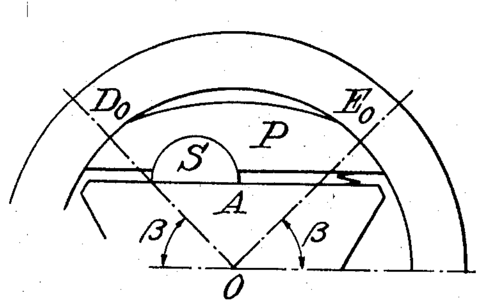


Fig. 5.



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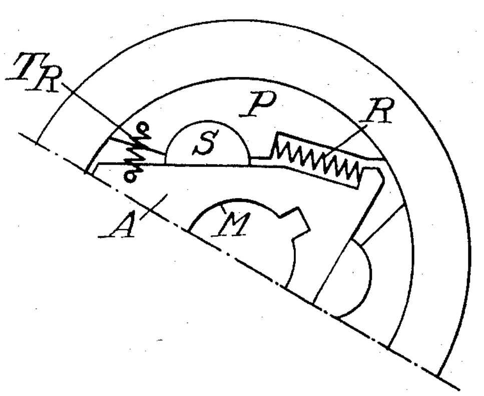


Fig.8.

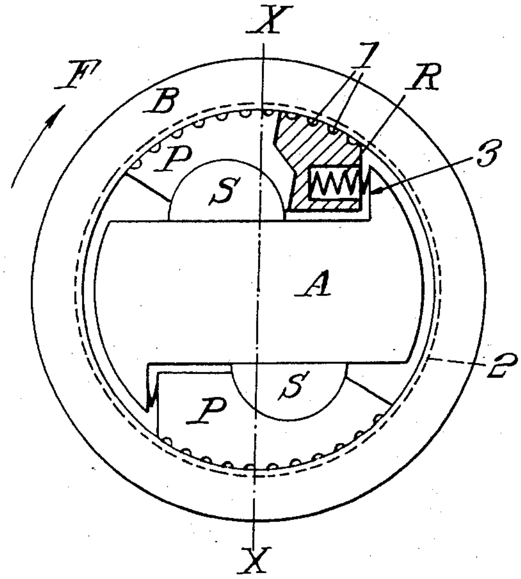


Fig.9.

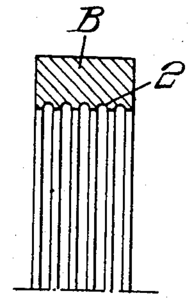


Fig.10.

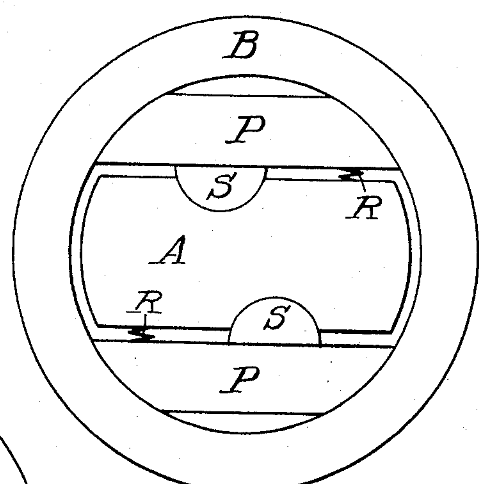
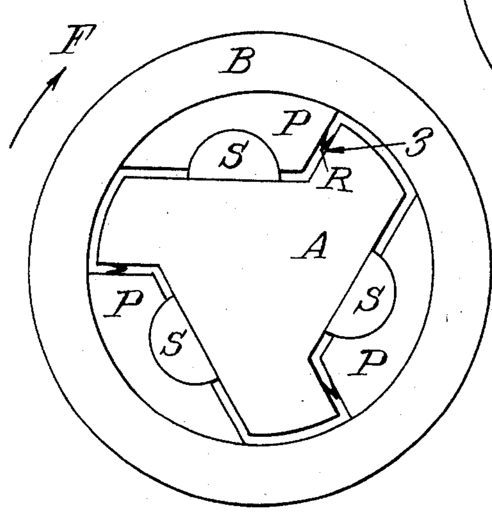


Fig.7.



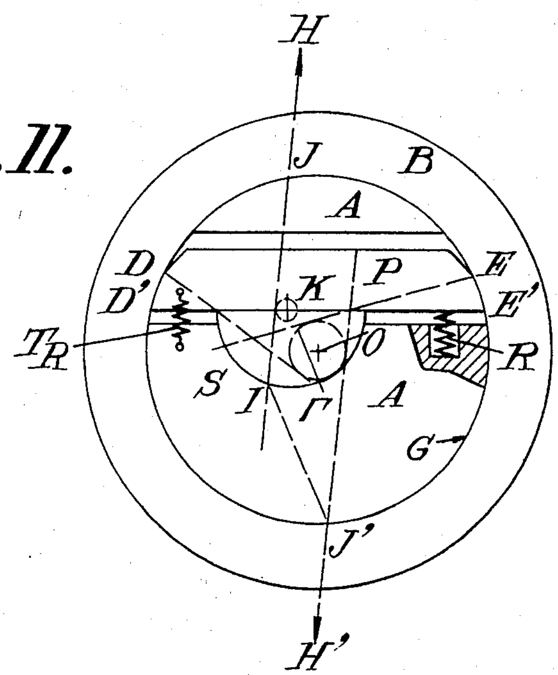


Fig. 11.

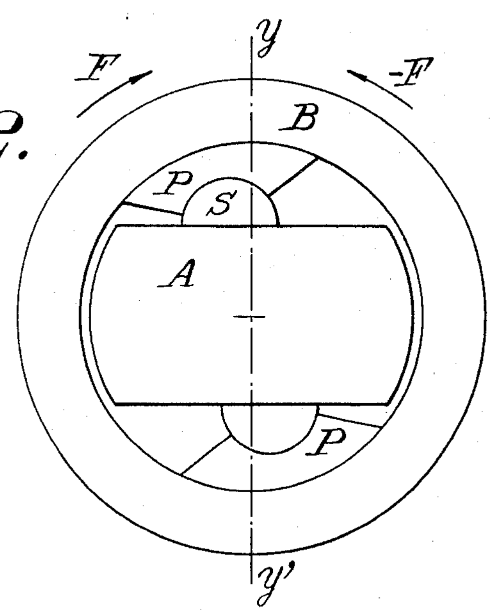


Fig. 12.

ONE-WAY DRIVE ROTARY COUPLINGS, ESPECIALLY MECHANISMS OF THE FREE WHEEL TYPE

The invention relates to a coupling mechanism connecting two solid masses rotatable with respect to one another around an axis, having the function of preventing one of the two possible directions of rotation, without opposing any appreciable resistance in the other direction; irreversible spring catches, unwinders, or free wheels.

In couplings of this type, it is known to provide, between the two solid masses, shoes or wedges capable if necessary of cooperating with skids mounted in orientable manner. However, although this principle is known, the constructions in which it has been used up to the present do not permit good results to be obtained in all cases, since they do not take into account in systematic manner the various factors coming into play, and they involve especially difficult and burdensome machining.

According to the invention, recourse is had to a combination of elements in which, considering two members turning within one another around an axis, for example on one hand, a central member, shaft or hub, and on the other hand, a sleeve, casing or ring surrounding this central member, with the insertion between them of intermediate means of the type of wedges or shoes to ensure driving in a single direction, the latter means are constituted by at least one shoe slidable on a surface of revolution of the sleeve coaxial with the coupling, and a shoe interposed in rotary manner between the shoe and the central member and slidable on a flat surface belonging to the shoe or to the said member, or to a part fast to one of these two elements, the axis of rotation of the skid being suitably displaced with respect to the axial plane normal to said flat surface, each shoe being also connected to the central member by a spring arranged so as to hold all the parts in contact in the blocking configuration, even when there is sliding in the permitted direction.

Thus, for example, the shoe may be constituted of a sort of bar slidable at its two ends on a cylindrical sliding surface of revolution or the like, of the sleeve, whilst the skid, mounted in rotary manner in the shoe and for example in the form of a cylinder truncated along a plane parallel to its generators, can slide on a flat surface of the central member. However, the reverse can also be done, the skid being mounted in rotary manner in the central member and sliding on a flat surface of the shoe.

The latter arrangement is advantageous, since it permits improvement in the wedge effect between the shoe and the cylindrical surface to be driven. In addition, the various parts, skid and bar are easy to produce mechanically. In particular, the obtaining or machining of the bar, of which the cylindrical surfaces in engagement with the corresponding surface of the sleeve are of relatively slight amplitude, necessitates much less accuracy than in the case of a segment intended to come into contact, over the whole of its outer surface, with said sleeve. However it is then convenient to determine, as a function of these data, the displacement which it is convenient to provide between the axis of the skid and the axial plane normal to the flat sliding surface.

This displacement will, generally, be selected sufficiently small to ensure unilateral blocking without sliding nor retardation in the driving direction, and sufficiently great however to avoid any wedging resistance in the reverse direction.

The invention relates particularly to a method of calculation enabling the determination easily of the most favourable value of this displacement as a function of the parameters coming into play, particularly the coefficients of friction between the various surfaces.

The invention comprises, apart from these main features, certain other features which are preferably used at the same time and which will be more explicitly considered below, especially a feature according to which the devices of the type concerned are provided with shoes capable of occupying at will one or other of the two operational positions symmetrical on each side of the axial plane normal to the flat sliding surface, under the effect of a tilting actuation, which thus permits the production of a one-way spring catch mechanism reversable at will.

It relates more particularly to certain types of application, as well as certain embodiments of said features, and it relates more particularly again, and this by way of new industrial products, to mechanisms of the type concerned including the application of these same features, as well as the special elements adapted to their construction and assemblies or motors including such mechanisms.

The invention will in any case be well understood with the aid of the additional description which follows, as well as of the accompanying drawings, which description and drawings are of course given primarily by way of indication.

FIG. **1** of these drawings, illustrates diagrammatically, in sectional elevation transverse to the axis, a coupling with shoes and self-orientable skids, constructed according to the invention.

FIG. **2** illustrates, in a drawing analogous to that of FIG. **1**, the principles to be respected to determine the geometry and arrangement of the different parts of a coupling according to the invention.

FIGS. **3** and **4** show similarly a coupling according to the invention, with three shoes, respectively in a view analogous to FIG. **1**, and in partial axial section.

FIGS. **5** to **7** illustrate, similarly to FIG. **3**, three modifications of these embodiments.

FIGS. **8** and **9** illustrate respectively and in transverse sectional elevation, and in partial axial section, another embodiment, with groove means to prevent the formation of a film of oil.

FIGS. **10** to **12** illustrate, similarly to FIG. **1**, various other embodiments.

There is shown in FIG. **1**, one of the embodiments using the principles of the invention which can be adopted.

A one-way coupling, according to FIG. **1**, is produced between the shaft A and a ring or sleeve B, rotatable with respect to one another around an axis O, by means of two systems of intermediate parts inserted between the shaft and the ring, each system comprising a shoe such as P, a self-orientable skid, in the form of a cylinder or truncated sphere, such as S, and a spring such as R which tends to hold the parts in contact (it will be seen below, with reference to FIG. **11**, that a single system thus composed could possibly suffice).

The inner surface of the ring B comprises a part G which is a part of revolution around the axis O, forming a continuous sliding path on which the shoe P is supported, which is in the form of a bar in contact at its two ends, through the contact facettes D,D′, E,E′, with said path.

The shaft A comprises two flat surfaces such as C, parallel to the axis O and symmetrical with respect to it.

On each surface C forming a cam on the shaft A, is supported a self-orientable skid such as S which is on the other hand in contact with the corresponding shoe P along a surface T, for example cylindrical and of circular profile, of radius t and of axis K displaced by distance e from the axis O or more accurately from the axial plane $y'y$ (passing through O) normal to the surface C. The surface T being of circular profile, the skid S can turn around its axis K with respect to the shoe.

The spring such as R, or any other device similar to it, holds in contact at the same time the shoe P with the sliding path G, the skid S with the cam C, and the shoe P with the skid S along the surface T.

As will be shown, the assembly, under certain conditions of shapes and portions, produces a one-way coupling between the shaft A and the ring B, the ring being rotatably freely with respect to the shaft A in the direction of the arrow F, without other resistance than the couple created by the contact springs R, any rotation in opposite direction being on the other hand prevented. This direction F is, conversely, the drive direction of the ring B by the shaft A.

To facilitate the explanation, there will first be examined, with reference to FIG. **2**, the jamming conditions of a shoe P supported at intermediate points D_o, E_o between, respectively, D,D′ and E,E′ on the sliding path G. If ϕ is called the limiting angle of friction at the contacts between the shoe P and the sliding path G, it is necessary, in order that there be jamming at D_o or at E_o, that the forces applying the shoe to the sliding path at these points should make, with the radii OD_o and OE_o respectively, angles less than or equal to ϕ. In other words, and as can be demonstrated, it is necessary that these forces cut the circle Γ of centre O and of radius g.sin. ϕ, g being the radius of the sliding path G, which circle can be called the friction circle associated with the circle G.

Now, the geometrical sum of these jamming forces is the force H, resultant of the pressure exerted by the skid S on the shoe P, which merges also with the resultant of the forces that the skid S receives under pressure of the member A.

In order that jamming may exist, it is shown that it suffices that this force H cuts the segment OL at a point X situated between O and L (FIG. **2**), the point L being the intersection of the tangents at the circle Γ emerging from D_o and E_o, and deduced respectively from the radii D_oO and E_oO for an angle of rotation ϕ in the direction of the arrow F.

To ensure that this condition of jamming will be satisfied, it is hence necessary, on one hand, to determine the support line of the force H, and, on the other hand, to verify that it passes in fact between the points O and L.

As regards the support of the force H, its position results from the conditions of equilibrium of the skid S which are at the limit of sliding on the plane C as in its circular housing T. If ψ is called the limiting angle of friction on these two contact surfaces — supposing thereby, for simplification, that it is the same on these two surfaces — it is seen that the support line of H is inclined by an angle ψ in the direction of the arrow F with respect to the normal to the plane C and that it is tangential to the "friction circle" associated with the circle T, friction circle of centre K and the radius t.sin ψ, t being the radius of the circle T. Consequently, this resultant H passes through the top I of the circle T, thereby denoting thus the point of the circle T of which the radius is perpendicular to the plane C, and moreover, it makes an angle ψ with this radius. Consequently, equally, its distance d to the axis O, that is to say its lever arm, has the value:

$$d = e \cdot \cos \psi + i \cdot \sin \psi \qquad (1)$$

in which relationship e and i represent the coordinates of the point I (FIG. **2**), that is to say respectively:

- e: the displacement of the point K, centre of the skid, with respect to the axial plane perpendicular to the plane C,
- i: $k + t$, the height of the top I of the skid with respect to the axial plane parallel to the plane C (k being also algebraically the same as the ordinate of the centre K of the skid).

Considering on the other hand the triangle E_oOL, it is easy to show that $OL \cdot \sin \beta = OE_o \sin. \phi$, whence

$$l = g \cdot (\sin.\phi/\sin.\beta) \qquad (2)$$

in which relationship l denotes the length OL, g the radius of the circle G and β the angle of EO_o with the direction Ox of plane C (FIG. **2**).

It is also easy to show that the line OL is inclined at an angle ϕ to this direction Ox.

The length l given by the formula (2) above represents the maximum value of the lever arm with which the force H can rotate the ring B, in the limiting case where the support of said force H would be perpendicular at L to the line OL.

The position of the resultant H, and that of the point L being thus specified, it is easy to check if the jamming condition is satisfied, that is to say if the line IH passes between the points O and L. For example, if $\psi = \phi$, which is the case if all the coupling parts shown in FIG. **1** are produced of the same material and with the same surface condition, IH is perpendicular to OL and its distance to the point O is:

$$d' = OX = e \cdot \cos. \phi + \cdot \sin. \phi \qquad (3)$$

and, in this case the jamming condition is written:

$$d' = e \cdot \cos. \phi + i \cdot \sin. \phi < g \cdot \sin.\phi/\sin.\beta \qquad (4)$$

(d' being also here the lever arm along which the force H acts).

The jamming condition being satisfied, it is necessary also, in order that the operation of the coupling be entirely satisfactory, that unblocking, when the movement tends to be produced in the permitted direction, is effected without jamming.

For this, the first condition is that the radius OI should make with the line IK an angle greater than the angle of friction, that is to say:

$$e/i > tg\ \psi \text{ or } e \cdot \cos. \psi > i \cdot \sin. \psi \qquad (5)$$

The second condition is that the shoe P, relieved at I, is unblocked without jamming of its support D_o and E_o, and it suffices for this that

$$\beta > \phi$$

These three conditions, according to formulae 4, 5, 6 above, will enable the man skilled in the art to determine without difficulty the design of a coupling according to the invention, and it will be easy for him here to generalise these formulae in more complicated cases (the case of the biconical surface of FIG. **4**, where $\psi < \phi$, the skid rotating in the member A, etc.).

And to have a margin of safety, two distinct values of β will be considered: $\widehat{EOx}$ instead of $\widehat{E_oOx}$ in the jamming formula (4) and $\widehat{E'Ox}$ instead of $\widehat{E_oOx}$ in the second non-jamming formula (6).

A numerical example, relating to the coupling shown in FIG. **1**, will suffice to demonstrate the compatibility of the three conditions which have just been established:

the radius g of the track G:	50 mm	
the coefficient of friction:	$\tan \phi = \tan \psi = 0.16$	
$\phi = 9°$	sin. $\phi = 0.156$	cos. $\phi = 0.988$
$E_oOx = \beta = 32°$	sin. $\beta = 0.53$	
$e = 8$ mm		
$i = 30$ mm	$(t = 20$ mm,	$k = 10$ mm

The jamming condition (4) is written:

$$OX = d = 8 \times 0.988 + 30 \times 0.156 < 50\ (0.156/0.53)$$

namely:

$$12.7 \qquad 14.7$$

(the lever arm d is hence 12.7 mm).

The first condition of non-jamming (5) is written:

$$8 \times 0.0988 > 30 \times 0.156$$

namely:

$$8 > 4.7$$

and the second is written:

$$32° > 9°$$

which demonstrates, in that practical example, the compatibility of the three conditions formulated above.

All that has just been given is only of course given by way of example. The technician will be enabled, in all cases, as a function of the coefficient of friction, to determine by calculation or by experiment the best values to be adopted, in particular for the values e and i, the coordinates of the point I.

It emerges clearly from the foregoing explanations, that it will be all the easier to respect the conditions of operation of free wheels according to the invention as the coefficient of friction ψ of the skid S on the ramp C and the shoe P is less, on one hand, and as the apparent coefficient of friction ϕ of the shoe on the sliding surface G is greater, on the other hand. It is convenient for example to provide for the ratio ϕ/ψ to be a value at least of the order of 15/10.

To this end, skids will for example be produced of bronze or antifriction alloy, or of plastics material such as those known as TEFLON or DELRIN. The coefficient of friction ψ could also be reduced by linings or suitable surface treatments, such as sulfinization for example. It is understood that the abovesaid skids will also be able to be of steel like the other parts of the free wheel, but preferably sulfinized. If necessary, the shoes could be of cast iron.

As regards said shoes, their contact surfaces with the sliding track will be linable with materials of high coefficient of friction, like those used in brake linings. There could also be given to these sliding surfaces a bi- or multi-conic profile, as indicated in FIG. **4** which represents in axial section a free wheel with three shoes of which the front view is shown in FIG. **3**, which results in obtaining an apparent coefficient of friction ϕ' greater than the angle of friction ϕ corresponding to the case of cylindrical surfaces (FIGS. **1** and **2**).

When two contact zones are provided between the shoes and the sliding track G, the angle $\widehat{D_oOE_o}$ (FIG. **5**) between said contact zones can also be increased, with however an upper limit, which is that of jamming (condition 6, $\beta > \phi$).

All these features, used together or separately, enable the construction of very robust free wheels, to increase of the space available for the passage of a shaft inside the cam A, such as M (FIG. **3**), for example when there are provided three shoe-skid assemblies, and reduction of the internal stresses by increasing the lever arm such as $d = OX$ (FIG. **2**).

It is good however to note that it is convenient to maintain the parts in contact by elastic means such as a spring R in order that the shoes may always be ready to act. The solution of FIG. **3**, for which the spring R is arranged so as to exert a transverse effect on the shoe P and the part A could, in certain cases, be insufficient.

This drawback can be remedied, by arranging the spring R tangentially, as indicated in FIGS. **6** or **7**. Or again, as in FIG. **6**, there can be provided draw-springs T_R, alone, or in combination with compression springs R.

There can also be provided stop means, as indicated in FIGS. **7** and **8**, at **3**, with a view to limiting the amplitude of recoil by inertia of the shoes P in the case where the hub A is capable of considerable angular acceleration in the permitted direction, opposite the arrow F.

It may also be advantageous, as illustrated in FIG. **8**, completed by FIG. **9**, which shows a partial axial section of ring B, to provide axial grooves **1** on the friction surface of the shoes and of the tangential grooves **2** on the sliding track of the ring B, the crossing of these grooves dividing the contact surface into a grid of contact pavings, this arrangement being provided to prevent the possible formation of a film of oil between the shoe and the ring.

Any other means may be provided for the same purpose.

FIG. **10** shows that the free wheels according to the invention can also be produced with skids S pivoting in the shaft A and shoes sliding on them.

FIG. **11** illustrates the possibility of using the operational principle of FIG. **10**, with a skid pivoting in the shaft A, but with a single shoe-skid assembly.

In this embodiment, the shaft A is for example held and reamed at the end to receive the shoe P and the skid S, a sufficient play being left for movements of the shoe P. The interrupted lines recall the principles of construction illustrated by FIG. **2**, and with the same notations. But here the force H is balanced by an equal and opposite force H', tangential to the circle of friction Γ. The intersection J' of the support of this force H' and of the circle G determines the support point of the hub A on the ring B in drive position. On disengagement, this point J' is the instantaneous centre of rotation of A with respect to B, and it is easy to note that the angle that IJ' and KI form is well in excess of the angle of friction, which enables deblocking without jamming from the point I. The line D'E' does not cut the circle of friction Γ, but the large opening of the angle $\widehat{D'OE'}$ indicates that it is prudent to duplicate the compression spring R by a draw-spring T_R in order to ensure the driving of the shoe when the shaft A tends to rotate, or rotate in the permitted direction with respect to the ring B which surrounds it.

FIG. 12 lastly, illustrates very diagrammatically the principle of a reversable free wheel according to the invention, that is to say that it can at will, be reversed with respect to the direction of blocking.

The shoes P and their associated skids S are capable of occupying, with respect to the shaft A, one or other of two symmetrical positions with respect to the axis y'y passing through O and perpendicular to the sliding surfaces of the hub, and can be held in elastic support in one or other of these positions by a tilting actuating device, not shown in the Figure. The direction of drive F (F or −F) can hence, in this way, be reversed at will.

As a result of which, and whatever the embodiment adopted, one-way drive rotary coupling systems can be constructed of which the operation emerges sufficiently from the foregoing for it to be unnecessary to dwell further on the subject, and which have with numerous advantages, respect to pre-existing systems of the type concerned, for example:

that of only including very simple members, easily machinable, especially as regards the bar-shaped shoe P and of easy assembly,

that of having accurate properties, both as regards absence of sliding in the direction of drive and absence of jamming on unblocking.

It has in fact been shown above that it is always possible to determine the ideal operation by calculation of the various dimensions, in particular of the separations e and i as a function of the coefficients of friction.

As is self-evident, and as emerges already from the foregoing, the invention is in no way limited to those of its types of application and embodiments which have been more especially envisaged; it encompasses, on the contrary, all modifications.

I claim:

1. One-way drive rotary coupling of the free-wheel type comprising a central member and a sleeve member, one member turning relative to the other around the same axis, intermediate means of the wedge or shoe type arranged between said central and said sleeve member, so as to fix one member rigidly to the other in one of the directions of rotation, said intermediate means being constituted by at least one shoe slidable over a surface of revolution of the sleeve member coaxial to the coupling and a skid inserted in rotary manner between the shoe and the central member and having a flat surface slidable over a flat surface carried by one of these two elements, the axis of rotation of the skid being suitably displaced with respect to the axial plane normal to said flat surface, at least one spring being also provided to cooperate with the central member and the shoe, to tend to maintain contact between the sliding surfaces.

2. Coupling according to claim **1**, wherein the shoe is arranged in the form of a bar supported at its two ends by two contact zones on the cylindrical sliding surface of the ring.

3. Coupling according to claim **2**, wherein the two contact zones of the shoe if viewed from the central angle of the coupling at an angle ($\pi-2\beta$), the angle β is greater than the angle of friction ϕ between the shoe and the surface of revolution.

4. Coupling according to claim **2**, with at least one shoe with two contact zones seen from the angle $\pi-2\beta$, cooperating with a cylindrical skid of radius t, of which the centre K has coordinates e and k with respect to axial planes normal and parallel to the flat sliding surface, with equal coefficients of friction, ϕ and ψ, of the shoe on the cylindrical surface and of the skid on the flat surface, these different values being connected to one another by the jamming relationship $e\cdot\cos.\phi + i\cdot\sin.\phi < g(\sin.\phi/\sin.\beta)$, where i is the algebraic sum $k + t$.

5. Coupling according to claim **2**, wherein two shoes with their skids are provided on each side of the central member.

6. Coupling according to claim **2**, wherein the angle $\pi-2\beta$ under which the two contact zones are viewed from the central axis of the coupling, is of the order of 90° to 160°.

7. Coupling according to claim **6**, wherein the angle $\pi-2\beta$ is from 110° to 140°.

8. Coupling according to claim **2**, wherein the skid is constituted by a cylinder truncated by a plane parallel to its generators, thus forming a flat face slidable on said first mentioned flat surface, the axis K of this cylinder having coordinates e and k such, with respect to axial planes normal and parallel to the sliding surface, that the condition of unilateral drive is realised, the radius t of said cylinder being itself of the order of 20 to 60 percent of the radius g of the cylindrical sliding surface of the ring.

9. Coupling according to claim **8**, wherein considering a skid of radius t whose axis has coordinates e and k with respect to axial planes normal and parallel to the flat surface of the skid, these values are connected with the coefficient of friction ψ of the shoe by the formula $e\cdot\cos.\psi > \cdot\sin.\psi$ where i is the algebraic sum $k + t$.

10. Coupling according to claim **8**, wherein the radius t is from 30 to 50 percent of the radius g.

11. Coupling according to claim **2**, wherein the skid pivots in the central body and slides on a flat surface of the shoe.

12. Coupling according to claim **11**, wherein a single shoe is mounted inside a channel formed in the shaft, which channel is of sufficient width to house said shoe therein.

13. Coupling according to claim **12**, wherein said shoe serves as a flat sliding surface for the skid rotating in a housing adjacent to one of the two edges of the channel.

14. Coupling according to claim **2**, wherein the skids are of material having a surface with a low coefficient of friction ψ.

15. Coupling according to claim **14**, wherein said material surface with a low coefficient of friction is selected from the group consisting of bronze, Teflon, Delrin or a sulfinized surface.

16. Coupling according to claim **2**, wherein the sleeve, the shoe and the skid are selected of materials such that the angle of friction ψ of the shoe on the sleeve is higher than the angle of friction of the skid on the shoe and on the flat surface.

17. Coupling according to claim **16,** wherein $\phi/\psi = 15/10$.

18. Coupling according to claim **1,** wherein the coaxial surface of revolution is cylindrical.

19. Coupling according to claim **1,** wherein the coaxial surface of revolution is biconic or multiconic so as to increase the limiting angle of friction ϕ.

20. Coupling according to claim **1,** wherein the skid is constituted by a segment of a sphere.

21. Coupling according to claim **1,** wherein three shoes and three skids are provided, in combination with a central member of triangular shape.

22. Coupling according to claim **1,** wherein means are provided to constitute a stop with respect to the shoes and to limit the amplitude of their possible recoil by inertia, for example in the case of a considerable angular acceleration of the central member in the opposite direction to the direction of drive.

23. Coupling according to claim **1,** wherein the spring exerts an action tending to separate the shoe transversely from the central member, at one end of the shoe.

24. Coupling according to claim **1,** wherein the spring tends to exert an action in the direction parallel to the sliding surface of the skid.

25. Coupling according to claim **1,** wherein the spring is a draw-spring.

26. Coupling according to claim **1,** wherein the surface of revolution of the ring is provided with grooves adapted to prevent the formation of a film of oil between the sleeve and the shoe.

27. Coupling according to claim **1,** wherein the surface of the shoe is itself provided with a group of grooves.

28. Coupling according to claim **1,** wherein circumferential grooves are provided in the surface of revolution of the sleeve and axial grooves are provided in the surface of the shoe which hence cross said circumferential grooves.

29. Coupling according to claim **1,** wherein the shoes as of a shape so that they can occupy, with the associated skids, two symmetrical positions and be brought and held elastically in one or other of these positions by a tilting actuation connected to the coupling, to thus produce a reversable free wheel.

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