PUBLISHED

JUNE 1, 1943.

BY A. P. C.

E. H. AUBERT
CHANGE SPEED DEVICES BY MEANS OF
A WHEEL OF VARIABLE DIAMETER
Filed Nov. 9, 1942

Serial No.
465,945

4 Sheets-Sheet 1

Fig. 1

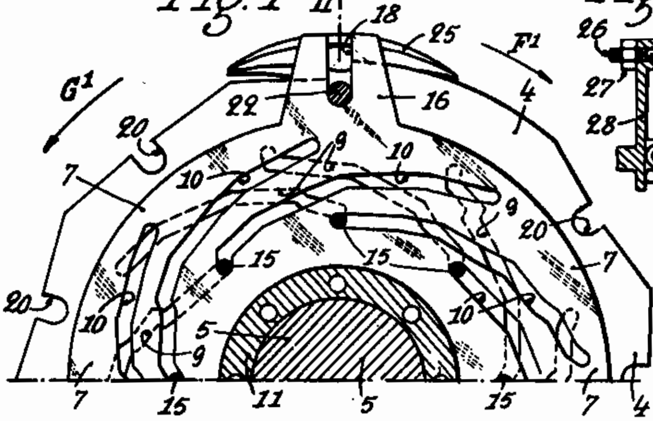


Fig. 2

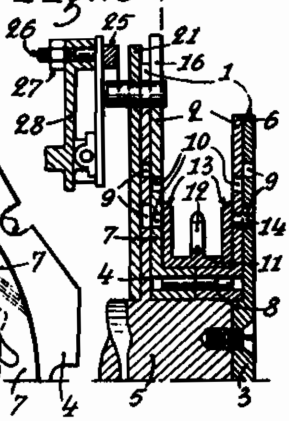


Fig. 3

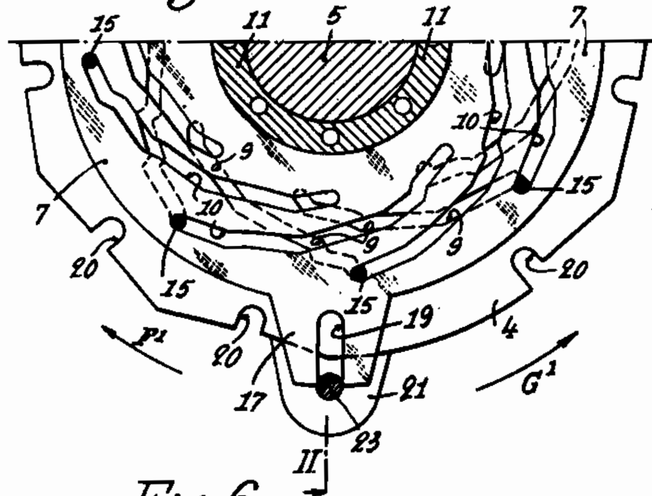


Fig. 4

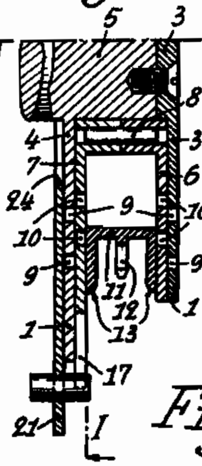


Fig. 5

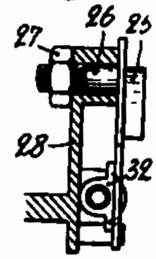
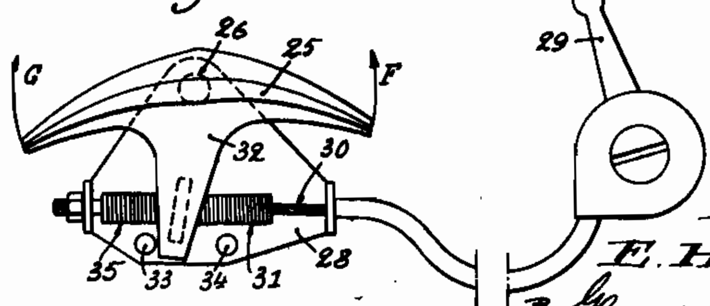


Fig. 6



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4 Sheets-Sheet 2

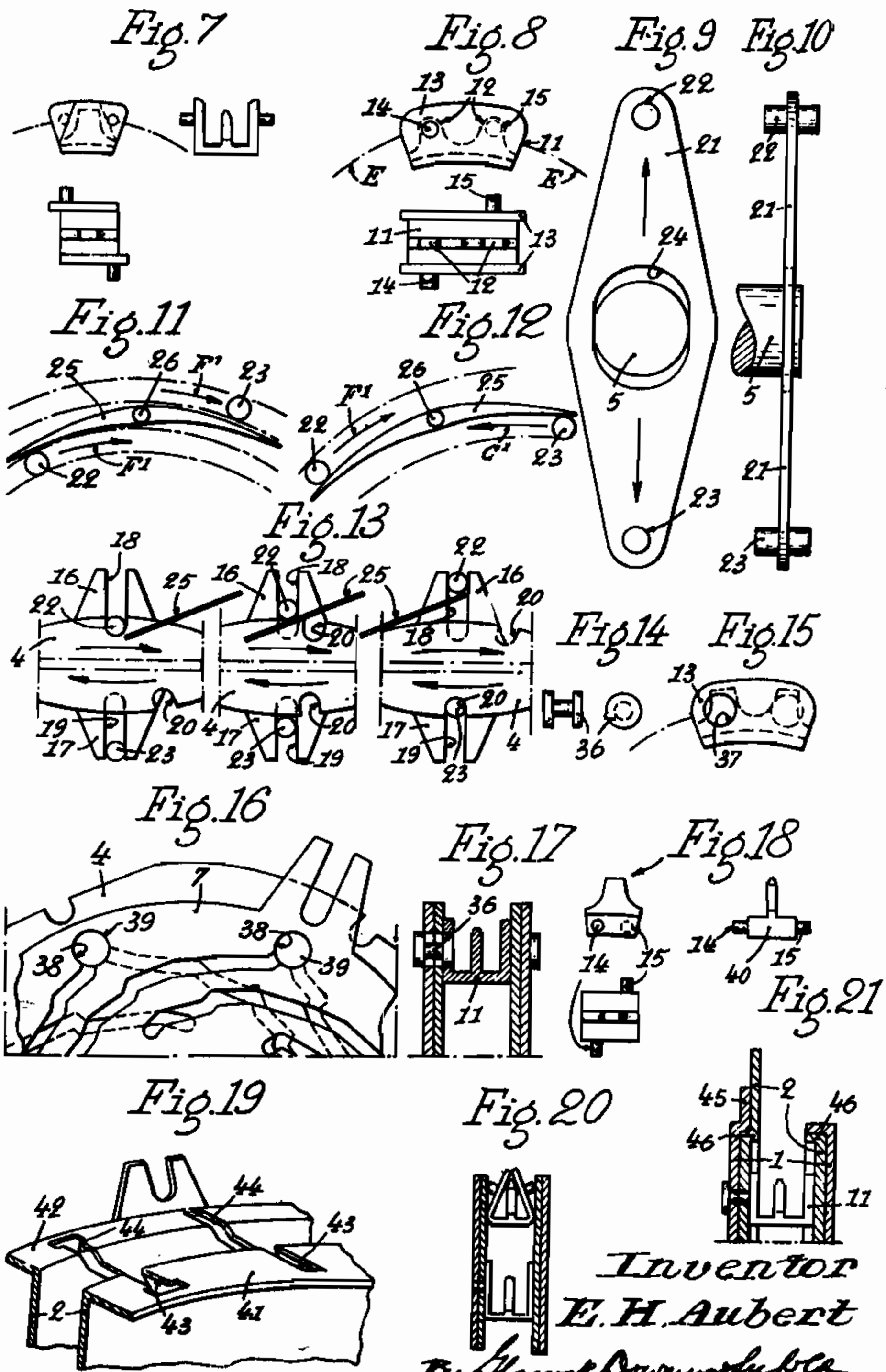

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Fig. 22

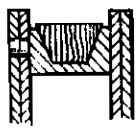

Fig. 23

Fig. 24

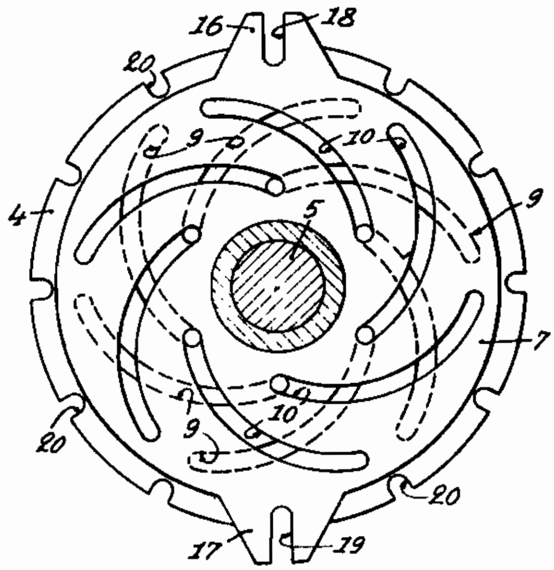

Fig. 25

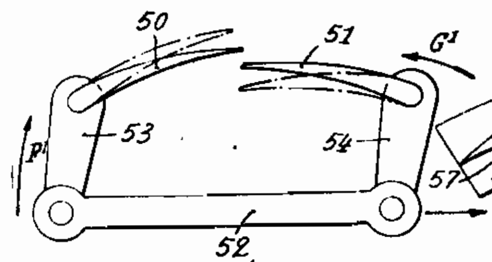

Fig. 26

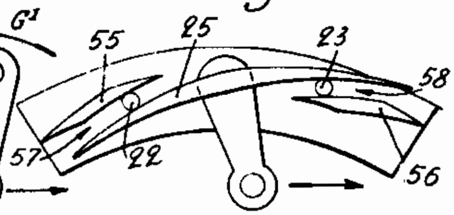

Fig. 29

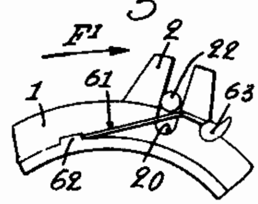

Fig. 27

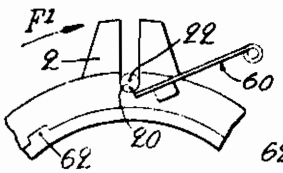

Fig. 28

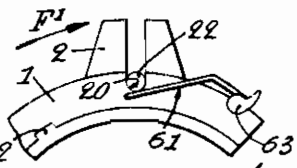

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Fig. 30

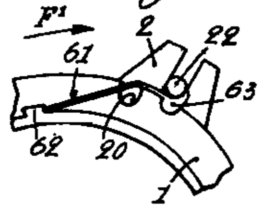


Fig. 31

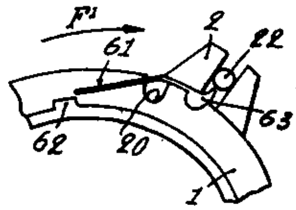


Fig. 32

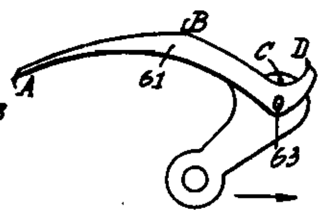


Fig. 33

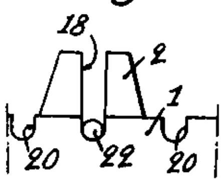


Fig. 34

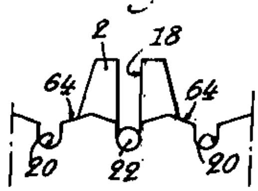


Fig. 35

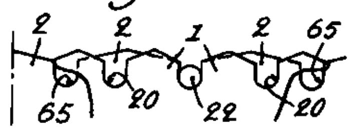


Fig. 36

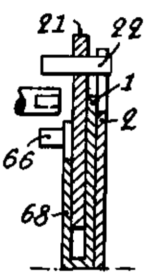


Fig. 37

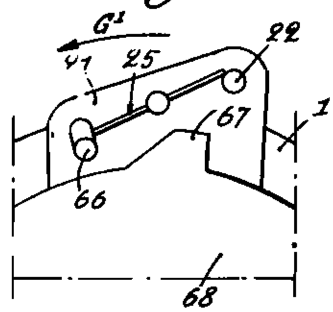


Fig. 38

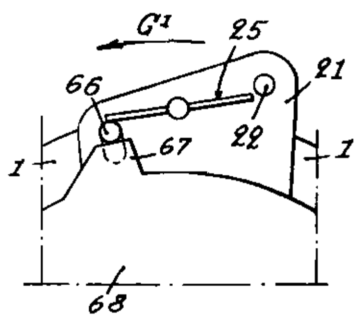
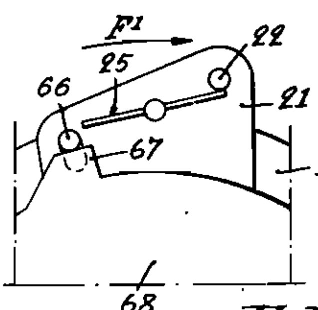


Fig. 39



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Published June 1, 1943 **Serial No. 465,945**

ALIEN PROPERTY CUSTODIAN

CHANGE SPEED DEVICES BY MEANS OF A WHEEL OF VARIABLE DIAMETER

Emile Henri Aubert, Romette, France; vested in the Alien Property Custodian

Application filed November 9, 1942

The present invention has for object a change speed device by means of a wheel or pinion of variable diameter applicable to transmissions of the type of chain, belt or cable transmissions and comprises in particular the following features:

The wheel of variable diameter is composed of movable independent elements capable of assuming successive concentric positions, all these elements being, for each position, on one and the same circle and the passage from one position corresponding to a circle of given diameter to another position corresponding to a circle of greater or smaller diameter being produced by the spacing apart or the approaching of two at least of the movable elements.

In the case of a chain transmission having a definite pitch, the movable elements each carry teeth and they are arranged in such a manner that, when they are in the position corresponding to the circle of minimum diameter, they are all in contact with each other and form a continuous pinion in which the constant space separating the teeth is equal to the pitch of the chain.

According to another feature the movable elements can be held stationary in a certain number of definite positions corresponding to circles the lengths of the circumferences of which are equal to a whole number of pitches, the passage from one circle to the circle immediately larger or smaller being produced by the spacing apart or the approaching of two at least of the movable elements to a distance equal to the difference in length of the two circles, said movable elements then forming a discontinuous pinion, but the space separating two adjacent movable elements being always equal to zero or to a whole number of pitches.

The movable elements are arranged in two groups of side plates which are mounted on the shaft of the device and can have relative angular displacement with respect to each other, said side plates carrying sloped inclines in which are engaged studs rigid with the movable elements, the inclines of one of the groups of side plates having a slope in reverse direction to those of the other group, so that an angular displacement of one of the groups of side plates relatively to the other produces both a radial and angular displacement of each movable element.

Both groups of incline-carrying side plates can be operatively connected as to rotation when the movable elements are in a definitive position corresponding to a whole number of pitches and can have relative angular displacements for the passage of the movable elements from one position to another.

Other features will appear from the following description in the course of which it will be convenient to call working length, a definitive position of the movable elements on a circle of definite diameter, corresponding consequently, to a given speed.

In the accompanying drawing, given by way of example:

Fig. 1 is a half-view with partial section according to line I of Fig. 2 of the device according to the invention when the movable elements have the minimum working length;

Fig. 2 is a section according to line II of Fig. 1;

Fig. 3 is a half-section with partial section according to line I of Fig. 4 of the device when the movable elements have the maximum working length;

Fig. 4 is a section according to line II of Fig. 3;

Figs. 5 to 10 are views showing separately members of the apparatus;

Figs. 11 to 13 are diagrams of the operation of the control device;

Figs. 14 to 26 show constructional modifications of various members of the apparatus;

Figs. 27 to 39 are diagrammatic views showing modifications of operation.

According to the embodiment illustrated in Figs. 1 to 4, the change speed device for a chain transmission according to the invention is composed of two spool-shaped members 1 and 2 fitting into each other, the member 1 comprising two parallel side plates 3 and 4 rigidly mounted on the shaft 5 of the transmission and member 2 comprising two parallel side plates 6 and 7 loosely mounted on the shaft 5, internally adjacent to the side plates 3 and 4 and connected together by pins 8. In the side plates 3 and 4 are cut out slots 9 different from each other but parallel on both side plates, and in the side plates 6 and 7 are also cut out slots 10 which will be hereinafter called inclines, the inclines 10 being sloped in reverse direction to the slots 9. Between the side plates 6 and 7 are arranged movable elements 11 (see also Fig. 8) each comprising two teeth 12 spaced apart to a distance p equal to the pitch of the chain used (not shown). Said elements 11 are so constructed that when two of them are in contact, the distance between one tooth of one and the adjacent tooth of the other is equal to p. Each element 11 comprises two lateral parallel lugs 13 in contact with the inner faces of the side plates 6 and 7 and two studs 14 and 15 secured at the ends of element 11 on each of the lugs 13 at the level of the pitch circle E and penetrating, one into an incline **10** and a slot **9** of the side plates **6** and **3** and the other in the corresponding incline and slot of the side plates **7** and **4**.

In the example illustrated in Figs. 1 and 3 has been chosen the case of a change speed device having a minimum working length of 16, that is to say corresponding to a pinion having 16 teeth formed by eight elements **11** each having two teeth and adjacent to each other (Fig. 1). The number of slots **9** and inclines **10** of each of the side plates **3**, **4**, **6** and **7** is therefore eight. The maximum working length chosen is 24 and corresponds to a discontinuous pinion having eight empty spaces each equal to a pitch *p* and the space separating the adjacent teeth of two elements spaced from each other being then 2*p*. In this case the total number of possible working lengths is nine, each working length differing from the preceding one by a spacing apart equal to *p* and each slot or incline being formed by a broken line comprising eight straight lines end to end, the intersection of two straight lines corresponding to a given working length.

The slots **9** and inclines **10** are traced in such a manner that the points where the slots and inclines cross each other for any given position are always all on one and the same circle and so that the passage from a working length r to the working length $r+1$ determines the spacing apart of two adjacent elements **11** to a distance equal to a pitch *p*.

At both ends of one and the same diameter of the incline-carrying side plate **7** are provided two bosses **16** and **17** each comprising a notch **18** and **19**, and on the periphery of the slot-carrying side plate **4** are provided notches **20** equal in number to the number of working lengths provided, that is to say nine in the case chosen.

Against the side plate **4**, and loosely mounted on the transmission shaft **5**, is arranged a cheek **21** (see Fig. 9) carrying at both ends of a diameter two lugs **22** and **23** constantly in engagement with the notches **18** and **19** of the side plate **7** and capable of entering the notches **20** of side plate **4**. The cheek **21** will be called hereinafter: the lug-carrier. The lug-carrier comprises at its centre a slot **24** allowing it to have a radial sliding movement relatively to shaft **5**.

The radial movements of the lug-carrier **21** are obtained by the passage of one or the other of the lugs **22** and **23** on a cam **25** (Figs. 5 and 6). Cam **25** is rockably mounted about a spindle **26** secured by a nut **27** on a small plate **28** rigid with the main frame of the apparatus. The movements of cam **25** are controlled by a hand-lever **29** connected to said cam through the medium of a Bowden cable **30** attached to a spring **31** secured in its turn at its other end on a tongue **32** rigid with cam **25**, the movement of the tongue **32** being limited by means of two abutments **33** and **34**, and a spring **35** constantly tending to restore the tongue against the abutment **33**. The spring **31** acts only when the hand-lever **29** is pushed in the direction of the arrow *f* and it then tends to cause cam **25** to rock about its spindle **26** in the direction of the arrow F and to press the tongue **32** against the abutment **34**. The spring **35** acts, on the contrary, when the hand-lever **29** is released and then tends to cause cam **25** to rock in the direction of the arrow G and to press tongue **32** against the abutment **33**.

The dimensions and shape of cam **25** and its position are such that when tongue **32** is pressed against abutment **33**, the cam is located between the two paths followed by the two lugs **22** and **23**, the lug following the circle of larger diameter passing above the cam **25** without entering in contact therewith (see Fig. 11) and the lug following the circle of smaller diameter passing under cam **25** (dead centre position). When tongue **32** is pressed against abutment **34** (engagement position) cam **25** is on the path of the lug following the circle of smaller diameter when the lug-carrier rotates in the direction of the arrow F^1 (see Fig. 12) and on the path of the lug following the circle of larger diameter when the lug-carrier rotates in the direction of the arrow G thus causing a lifting of the lug-carrier **21** in the first case and a lowering thereof in the second case.

The operation of the device is as follows:

Let us assume that the whole of the transmission operates at the minimum working length, that is to say the working length **16**, illustrated in Fig. 1. In this case all the movable elements **11** are in contact, forming a continuous pinion and the studs **14** and **15** are located at the ends of the inclines **10** and slots **9** nearest to shaft **5**, lug **22** is engaged in the bottom of notch **18** and one of the notches **20**, both members **1** and **2** are rendered rigid together and rotate with shaft **5** in the direction of the arrow F^1, lug **22** following the circle of smaller diameter. If it is then desired to pass to working length **17** immediately higher, the hand-lever **29** is actuated in the direction of arrow *f* and cam **25** rocks in the direction of arrow F (Fig. 6).

If the first lug which passes opposite cam **25** is lug **23** which follows the circle of larger diameter, it passes on the upper half of the cam causing it to rock, spring **31** allowing this movement without having to abandon the hand-lever **29**, and nothing takes place. On the contrary, as soon as lug **22** passes opposite cam **25** (Fig. 13) it abuts against the latter, it is then lifted and disengages from notch **20** of disc **4**, the lug-carrier **21** is lifted in its turn to the same amount and the opposite lug **23** takes a bearing on the periphery of side plate **4**. Lug-carrier **21** is then wedged and stops, which simultaneously causes the stoppage of member **2** constantly connected thereto, member **1** continuing to rotate with shaft **5**. As soon as a notch **20** of disc **4** is opposite lug **23**, the latter which was firmly pressed against the periphery of disc **4**, enters said notch, members **1** and **2** are then again rendered rigid together, lug **22** can continue its movement riding up on cam **25** and pass beyond it, causing it to rock against the action of spring **31** and, if the hand-lever **29** is abandoned, said cam **25** then comes back under the action of spring **35** to its dead centre position.

During this operation, the movement of the movable elements was as follows: As soon as both members **1** and **2** are no longer operatively connected as to rotation and as member **2** is stopped, member **1** continuing to rotate, said members perform a relative angular movement with respect to each other, the points where the slots **9** and inclines **10** cross each other are displaced, which determines a displacement of studs **14** and **15**. The elements **11** have followed said movement by remaining constantly on one circle for each intermediate position and they remain in contact with the exception of two which are spaced from each other, since the circles corresponding to the intermediate positions have increasing diameters and the number and dimension of elements 11 are invariable. Consequently one of the elements 11 has moved according to a radius, the adjacent element, in the reverse direction to the direction of rotation, has been simultaneously subjected to a radial displacement equal to the preceding one and a slight angular displacement in the direction of rotation, the following element to a radial displacement, always constant, and to an angular displacement slightly greater, and so on, up to the last element which has been subjected to the maximum angular displacement. The notches 26 are arranged at the periphery of side plate 4 so that the relative movement of members 1 and 2 determining the passage from the position corresponding to the engagement of lug 22 in one of the notches 20 to the following position corresponding to the engagement of lug 23 in another notch 20 determines an angular displacement of element 11 which has moved away from the adjacent one, such that the total movement which has taken place spacing apart these two elements is equal to a pitch p.

On the other hand, it will be seen that it is sometimes lug 22 which enters in one of the notches 20, sometimes lug 23; both said lugs being diametrally opposed, the notches 20 are distributed on two opposite sectors of circles; the notches corresponding to the odd working lengths 17, 19, 21 and 23, being arranged on one of the sectors and the notches corresponding to the even working lengths 16, 18, 20, 22 and 24 being arranged on the other sector.

On the other hand also, it is important that it should not be the same two elements 11 which are spaced from each other for each working length and, on the contrary, it is desirable that, at maximum working length, each element should be spaced from the adjacent element according to a distance equal to a pitch p; this is easily obtained by tracing the slots 9 and inclines 10 in such a manner that for each change of working length it is a different element which is subjected only to a radial displacement corresponding to a radial element of incline 10 of member 2 and, for balancing the various pinions thus obtained, provisions will be made so that two successive radial elements of inclines 10 corresponding to two successive changes of working length are located on two opposite sectors of circle.

Finally it is to be noted that, in the case of a transmission having teeth and chain, it is indispensable that, at the time the working length is changed, the progressive spacing apart of two movable elements should take place in the part of the pinion which is not in contact with the chain, as the elements in mesh with the chain cannot obviously move away from each other. This result is obtained by suitably disposing relatively to the inclines 10, the diameter on which the two notches 18 and 19 are located, the position of said diameter determining the sector in which the elements 11 will be spaced apart.

If it is desired to effect the operation reverse to the preceding one, that is to say, to pass from working length r to working length $r-l$, the following method will be adopted:

Cam 25 having been actuated by means of the hand-lever 29 and being in the position of engagement of Fig. 12, the transmission shaft 5 will be simultaneously given a movement of rotation in the direction of the arrow G^1, the lug-carrier 21 then rotating in the same direction, the passage of lug 22 following the circle of small diameter opposite cam 25 will produce no change, but as soon as lug 23 following the circle of large diameter will come in position it abuts against the lower face of cam 25 which will tend to cause it to lower and, pushing it downwardly, will press it against the periphery of disc 4 and will cause the opposite lug 22 to come out of the notch 20 in which it was engaged. The lug-carrier 21 and member 2 are then held stationary, member 1 continuing to rotate in the direction of the arrow G^1. Members 1 and 2 then have a relative movement in the reverse direction to that of the preceding case and elements 11 then move in the direction for passing from a circle of a given diameter to the circle of smaller diameter, both elements 11 which were spaced apart to a distance p in the preceding case, returning in contact with each other. As soon as lug 23 can enter another notch 20, the discs will again be rendered rigid together and shaft 5 can re-assume its driving movement in the direction of the arrow F^1.

In the example described, it has been assumed that the elements 11 have two teeth, it is obvious that said elements might comprise a single tooth (Fig. 7) or three or even more.

The case of a change speed device having nine speeds has also been described, but it is to be understood that the number of speeds depends on the successive supplementary intervals created from the initial position.

For instance, a mechanism of 18 teeth constituted by single-tooth movable elements, will correspond to a pinion having 36 teeth when each tooth will have moved one step away from its adjacent teeth, and to a pinion of 72 teeth when each tooth will have moved two steps away from its adjacent teeth.

For equivalent intervals, a mechanism having 18 teeth constituted by movable elements each having two teeth, will successively correspond to 27 and 36 teeth, passing of course, through all the intermediate positions. If this same mechanism of 18 teeth is constructed in groups of three teeth, it will correspond to 24 teeth after each element has moved one step away and to 30 teeth when each element has moved two steps away.

Whatever may be the fractionation chosen for the movable members the choice of which will be determined by the considerations of utilisation, there are many speeds as there are spacing teeth or pitches, plus one. Thus a 18/36 mechanism has 19 successive speeds corresponding to the offsetting of one tooth at each change of working speed.

In Figs. 14 to 17 has been shown a modification of assemblage of the movable elements 11 and members 1 and 2. In this case the assemblage is obtained by means of double-headed studs 36 entering corresponding holes 37 formed in the lugs 13 of element 11 and 38 formed in one of the ends of slots 8 and inclines 10 and to which they are connected by a short slot 39. The assemblage is effected by bringing the studs 36 opposite the various holes and inserting them therein, then by again imparting to both members 1 and 2 a relative movement so as to restore the studs 36 to the normal starting point.

In the case of rustic mechanisms having only slight torques to transmit, the movable elements can be constructed such as they are illustrated in Fig. 18, that is to say by doing away with the lateral lugs and by placing the studs 14 and 15 directly in the heel-piece 49 of the teeth.

In Fig. 19 has been shown a constructional modification of the inner member 2 which is then made in one piece and comprises flanges 41 and 42 in which are provided suitable cut-away parts 43 and 44 allowing the introduction of the movable elements 11 when the latter comprise studs 14 and 15 rigid therewith.

In Fig. 20 has been shown a constructional modification of movable elements of small dimensions in which the lateral studs are formed by sheets of thin resilient steel allowing the elements to be placed in position by pinching them.

In Fig. 21 have been shown members 1 and 2 provided with flanges 45 and 46 intended to increase the rigidity thereof. For further increasing said rigidity and at the same time for protecting the structure from dust, the slots 9 of disc 1 can be simply stamped and need not open to the exterior.

Said slots 9 as well as the inclines 10 can be slightly extended at both their ends for collecting and evacuating the foreign bodies which might be introduced in said slots.

In Figs. 22 and 23, methods of construction of the movable elements have been shown, in the case of a belt or cable transmission. In this case said elements instead of having teeth comprise a smooth groove.

Also in the case of a smooth belt or cable transmission and when the stresses to be transmitted are small, the slots 9 and inclines 10 can be constituted by simple identical arcs of circle (Fig. 24). In this case, the eccentricity of the movable elements is uniform during a change of working length, all the elements moving away or approaching each other to the same amount, which can only apply, as indicated above, to the case of a small load since even the elements under the belt must move relatively to each other. In this case, changes of working length as gradual as desired can be obtained by increasing the number of notches 20.

Owing to the dimensions of cam 25 the location of the points where the movable elements move away from each other, can be somewhat different according as the change of working length takes place in one direction or in the other, that is to say, as the cam 25 is attacked by one of the lugs at one or the other of its ends. This can constitute an inconvenience when the path out of contact with the chain or belt is small (case of an enveloping chain or belt with a returning wheel). In this case it will therefore be advantageous for the cam to be always attacked at the same point, whatever may be the direction of rotation. This result is obtained by means of the device of Fig. 25 in which the cam is replaced by two cams 50 and 51 controlled by a single lever 52 to which they are connected by links 53 and 54, the half-cam 51 being used by lifting in the case in which the change of working length takes place with a rotation in the direction of the arrow F^1 and the half-cam 50 being used by lowering in the case of change of working length with a rotation in the direction of the arrow G^1.

In Fig. 26 has been shown a device allowing of avoiding the change of the direction of movement before cam 25 is passed which might determine the locking of the mechanism. For remedying this inconvenience two fixed cams 55 and 56 are arranged on either side of cam 25 and form with the latter, when it is in position of engagement two channels 57 and 58 in one of which is compulsorily engaged the lug which must determine the operation. These fixed cams have the effect of restoring the lug 22 or 23 to the position it occupied on or under cam 25 before coming in engagement therewith if the direction of the movement is changed before the lug under consideration has completely passed cam 25.

In all the foregoing, it has been assumed that the change speed device according to the invention was mounted as a driving wheel of the transmission. It is obvious that said device might be applied as such, as a driven wheel, the actuation being then produced by the chain itself instead of being produced by the driving shaft 5 and one of the spool-shaped members, for instance the slotted member 1 being connected to the driven shaft by a free wheel device.

In this case, as member 1 is only connected to shaft 5 when the device rotates in the direction of arrow F^1, it will be possible to effect changes of speed in both directions without having to change the direction of rotation; in fact it suffices to hold one or the other of members 1 and 2 stationary for the working length to pass to the higher working length or the lower working length.

This result is obtained as diagrammatically illustrated in Figs. 27 to 32 by providing the device with two half-cams 60 and 61 controlled as cam 25, the half-cams 60 playing the same part as cam 25 for passing from working length r to working length $r+1$ by braking member 2 and the half-cam 61 cooperating with a projection carried by member 1. The surface of cam 61 which can rock about the spindle 63 is divided into three parts: an incline AB, a circular part BC having as axis, the general axis of rotation when cam 61 is in position of engagement and a nose CD. Let us assume that the device constantly rotates in the direction of arrow F^1, the changes of working length in the direction for passing from working length r to working length $r+1$ take place by stopping member 2 by means of cam 60, as indicated above for cam 25. If it is desired to return from working length $r+1$ to working length r, cam 61 is placed in engagement (Fig. 28). As soon as lug 22 which, for instance, is that which is then engaged in one of the notches 20, comes in position, it rides up the incline AB, and causes cam 61 to rock about the spindle 63 and as soon as the projection 62 comes in position in its turn, it abuts against the end of cam 61 at the moment lug 22 has reached B and is disengaged from the notch 20 in which it was housed (Fig. 29). Member 1 is then stopped and member 2 continues to rotate while lug 22 follows the circular path BC. During this time, another notch 20 has come in front of the opposite lug 23 which has engaged therein and lug 22 can then ride up on the incline CD and pass over cam 61 by causing it to rock in the reverse direction to the preceding one and thus releasing the projection 62 which allows members 1 and 2 operatively connected together by lug 23, to resume their common movement.

In Figs. 33 to 35 have been shown various modifications of the profiles of members 1 and 2 allowing to increase the progressivity and the smoothness of the change of speed.

In Fig. 33 is diagrammatically shown the most simple profile. The incline-carrying member 2 has two diametrally opposed slots 18 and the slotted disc 1 a series of notches 20. The lug 22 passes from one notch 20 to the other completely immobilising member 2 at the moment the working length is changed.

In Fig. 34, the general arrangement is the same but the notches of the slotted member are joined, not by a circular portion as in Fig. 33, but by bosses **64**. Lug **22**, instead of completely stopping the incline-carrying member **2** at a definite point, will have a slight displacement on the cam due to the height of the boss **64** and instead of the member **2** being completely held stationary during the change of speed it will be simply braked relatively to the slotted member. This method allows a smoother change of speed.

In Fig. 35 is shown a device allowing a more important movement of both members **1** and **2** during the change of working length and therefore a gearing-down allowing greater smoothness. Instead of the incline-carrying member **2** being provided with only two diametral slots, it can also be divided by notches **65**. The distance between the notches **65** of member **2** less the distance between the notches **20** of member **1** represents the relative movement necessary for the changes of working length.

When a transmission having wheels of variable diameter is at its minimum working length or at its maximum working length, the engagement of the cam will have for consequence a prejudicial shock to the mechanism. A device illustrated in Figs. 36 to 39 prevents the cam from coming in engagement even when the control thereof is actuated.

The lug-carrier **21** is provided with a stud **66** which, in its normal position, at all the intermediate speeds, is not located in the zone of the cam. In Fig. 37 will be seen the mechanism at an intermediate working length. The operation is normal, lug **22** and with it the lug-carrier, is about to be lowered by cam **25** and the change of length will take place.

In Fig. 38, the mechanism is illustrated at one of the two extreme working lengths and rotating in the direction of the arrow G^1. The stud **66** has been lifted by a boss **67** carried by a flange **66** rigid with the slotted member **1**. In this new position, stud **66** causes cam **25** to rock (which cam is connected to its control by a spring allowing said movement even when the control lever is maintained in position) at the moment lug **22** comes in position and the latter goes beyond the cam by passing over it.

If the movement takes place in reverse direction (Fig. 39) then it is lug **22** which causes the cam to rock just before the passage of stud **66**, in other words, stud and lug mutually cancel the cam.

For the other extreme working length, it is the other diametral end of the lug-carrier which carries a cancelling stud placed in position at said latter working length by another boss carried by the flange.

The boss **67** can be replaced by a slot provided in the same flange and putting in engagement, at the required moment, one or the other of the cancelling studs for the extreme working lengths.

The change speed device according to the invention can be applied to all transmissions of the chain, belt or cable type and in particular on bicycles, and it is mounted in combination with a chain or belt-tightener of any known type.

The device can also be mounted both on the driving wheel and on the driven wheel which can allow the chain-tightener to be done away with when the diameters of both wheels vary simultaneously and in reverse direction.

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