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P. GARNIER
CHANGE SPEED MECHANISM
Filed July 16, 1942

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2 Sheets-Sheet 1

Fig. 1

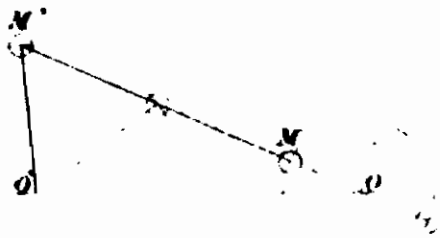

Fig. 5

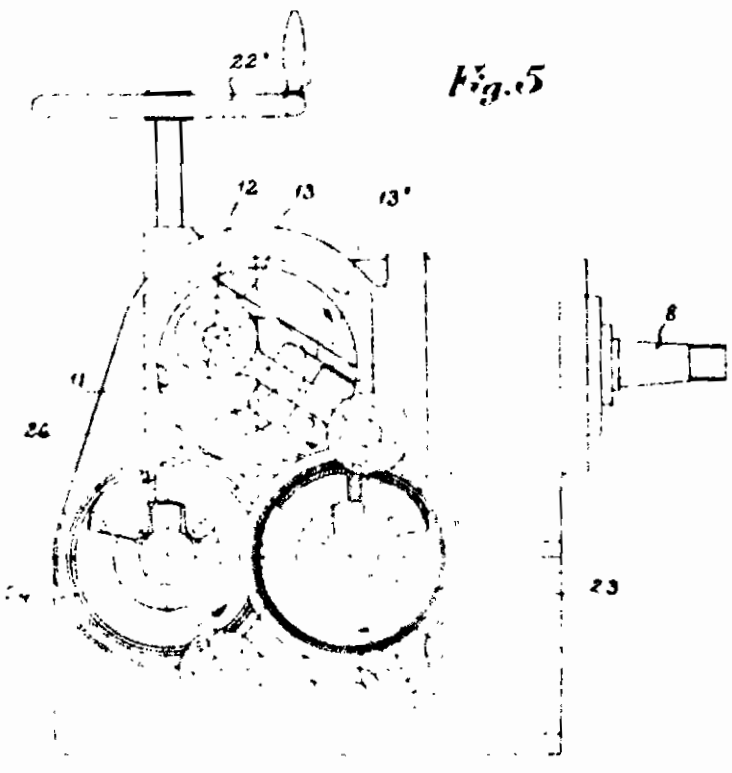

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Fig. 4

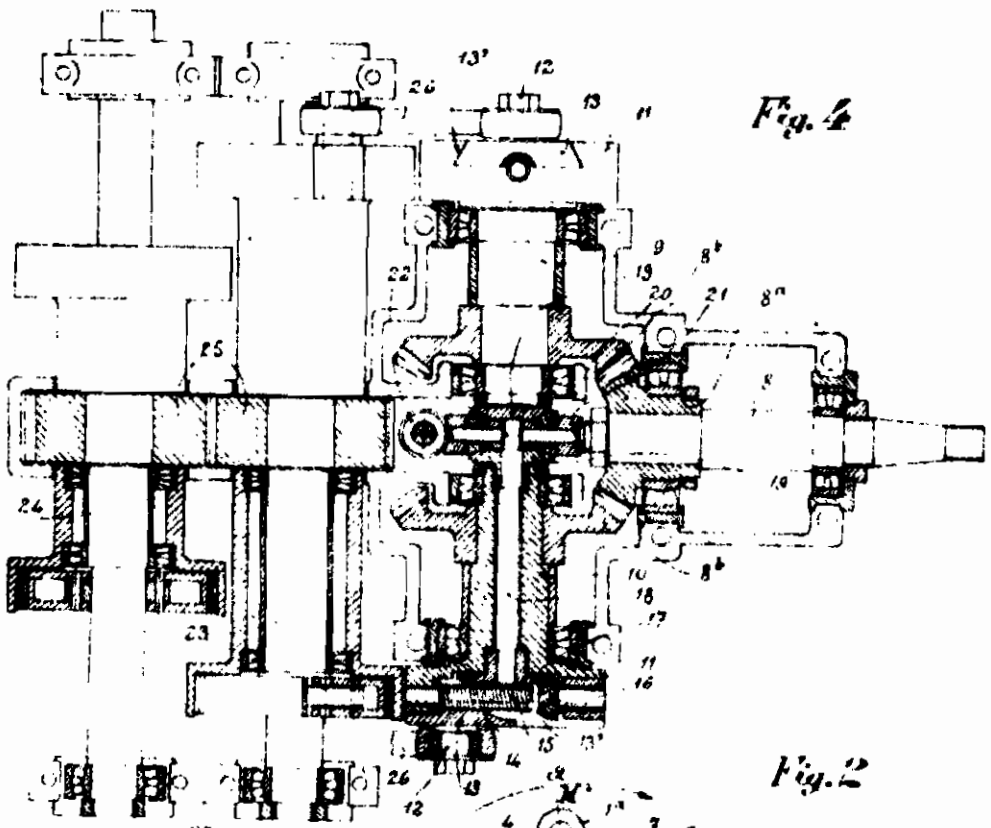


Fig. 2

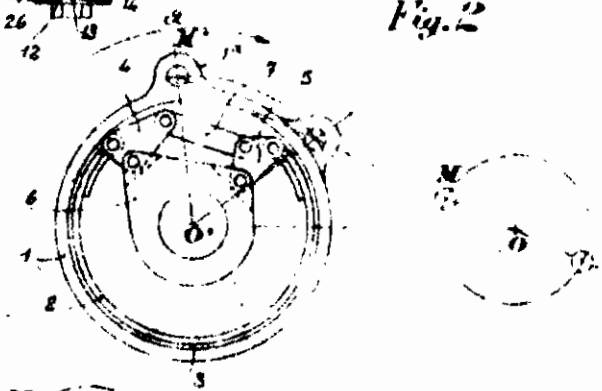
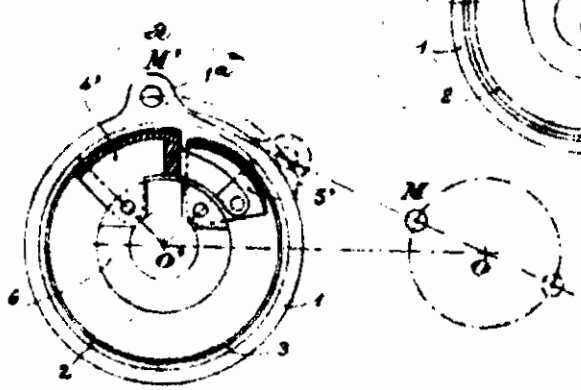


Fig. 3



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ALIEN PROPERTY CUSTODIAN

CHANGE SPEED MECHANISM

Paul Garnier, Lyon, France; vested in the Alien Property Custodian

Application filed July 16, 1942

As is known, numerous change speed gears are based on the general principle of transmitting motion from a driving shaft to a driven shaft by means of a plurality of units each of which comprises a pair of cranks interconnected by a pitman, one of said cranks having a constant throw and being connected to the driven shaft by means of a free wheel clutch adapted to impart motion to said shaft in one direction of rotation only, while the other crank is fast upon the driving shaft and has an adjustable length or throw. Owing to this construction, it will be understood that by multiplying the number of driving cranks and driven cranks and by suitably arranging them around their respective axes, the possibility is afforded of converting into a continuous movement the series of elementary impulses received by the driven shaft and of rendering its speed sufficiently uniform, while by adjusting the throw of the cranks mounted on the driving shaft the amplitude of such elementary impulses imparted to the driven shaft and consequently its speed of revolution may be varied, said speed being brought down to zero value when the throw of said cranks is reduced to such value by causing the pitman ends to coincide with the driving axis.

Known gears based on the aforesaid principle show three principal disadvantages: A first disadvantage is the practical difficulty of providing a sufficiently simple and rugged free wheel clutch for use as above stated. A second disadvantage is the difficulty of providing for a variation of the throws of driving cranks during operation by simple and reliable means. A third disadvantage is the difficulty of suitably distributing the operative action of the several driving cranks so as to obtain a regular torque.

An object of the present invention is to provide a new change speed mechanism of improved construction obviating the aforesaid disadvantages and constituting a better construction for carrying into practice the above-cited general principle.

Another object of the invention is to provide an improved change speed mechanism comprising a plurality of free wheel clutches including differentials involving frictional bands or strips of flexible nature cooperating with impulse transmitters so as to properly select impulses to be transmitted.

A further object of the invention is to provide a change speed mechanism of such an improved structure that variation of the throws of the primary or driving cranks is performed by means of slider devices carried in crank disks and actuated through the medium of planet gears.

A still further object of the invention is to provide a change speed mechanism having such an improved structure that its movement is regularized by interconnecting the several driven shafts by suitably arranged toothed pinions and pivoted links.

With these and such other objects in view as will incidentally appear hereafter, the invention comprises the novel construction, combination and arrangement of parts that will now be described with reference to the accompanying diagrammatic drawings exemplifying the same and forming a part of the present disclosure.

In the drawings:

Figure 1 is a diagrammatic illustration showing the kinetic principle on which is based the operation of the improved mechanism according to the invention.

Figure 2 is a view of a constructional embodiment of the clutch comprised in said mechanism and associated with the driven shaft.

Figure 3 is a view similar to Fig. 2 showing a modification of this clutch.

Figure 4 is a plan view showing the device for varying the throw of the primary cranks comprised in the new mechanism.

Figure 5 is an elevational view showing the way in which the several primary cranks may be arranged with respect to one another.

Reference being first had to Fig. 1, O designates the geometrical axis of a driving shaft, and O' the geometrical axis of a driven shaft which it is required to connect up to said driving shaft through a change speed mechanism of the crank and pitman type. A primary crank OM is mounted on the driving shaft, and a secondary crank O'M' (of greater length than the primary crank OM) is mounted fast on the driven shaft. These two cranks are interconnected by a pitman MM' so that to one complete revolution of the driving shaft correspond two equal and oppositely directed oscillations of the crank O'M'. Assuming the driving connection between the crank O'M' and its shaft O' to be in the form of a free wheel clutch adapted to impart the drive in one direction of rotation only (as shown by the arrows *a* in Figs. 2 and 3) it will be understood that a continuous motion of the driving shaft O will impart a series of impulses to the driven shaft O' in the direction permitted by said free wheel clutch.

Owing to this arrangement, it will do to sufficiently multiply the number of driving and driven

cranks and to suitably distribute them around their respective axes to cause the motion of the driven shaft to become continuous and to ensure substantial uniformity of its speed.

It will be also understood that assuming the throw of the driven crank O'M' to remain invariable, where the throw of the driving crank OM is varied, the extent of the elementary impulses imparted to the driven shaft O' will be more and more reduced and the substantially continuous rotational speed which will ensue will be slower and slower. It will even fall to zero if the crank throw OM is itself reduced to zero.

Therefore, assuming the driving shaft O to revolve at a uniform speed, the possibility is afforded to transmit a varying speed to the shaft O' by a mere variation of the throw or throws of the driving crank or cranks such as OM.

In order to obviate the disadvantages of the several change speed gears based on the aforesaid operative principle, the following arrangements of parts have been devised according to the invention.

Free wheel clutch (Figs. 2 and 3)

The actuation of the driven shaft is performed not by ratchet wheels, pawls, balls and wedges but by a flexible ring constituting a band clutch whose operation corresponds with the one of so-called differential band brakes the characteristic feature of which is to become tightened or applied in a predetermined rotational direction and untightened or released in the opposite direction.

As shown in Fig. 2 a cup-shaped transmitter member 1 is freely centered on the driven shaft O' and has an apertured lug 1^a on its periphery for connection to the pitman MM'. As the driving shaft O rotates clockwise, the pitman MM' is reciprocated so that its end M' assumes the position shown in dotted lines and then resumes its rear position. Against the inner rim of this cup-shaped member 1 is applied over approximately two thirds of its circumference a ring segment 2 made of a steel strip endowed with qualities of strength and flexibility. The ring segment 2 is provided on its surface contacting the impulse transmitter member 1 with a friction lining 3. The ring segment 2 constitutes the driven ring element and is connected at both ends to toggle levers 4, 5 hinged to a sleeve 6 firmly girdling the driven shaft O'.

As is known, when a drive of this category comprises as above described a flexible tie, the tensions T and t which prevail at both ends during the operation are in the following ratio:

$$\frac{T}{t}=ef\theta$$

wherein f is the coefficient of friction of the interposed lining, θ is the angle corresponding to the portion of the circumference on which said lining bears, and e is the base of Neper logarithms.

Where three quarters of the circumference are encompassed by the lining and the latter is of medium type, the ratio may be

$$\frac{T}{t}=4$$

As is also known, the tangential stress which provides frictional drive is equal to the difference of both tensions, namely $T-t$ so that, in the present instance, $F=3t$.

Therefore, assuming the flexible ring segment 2 to be applied as usual against the cup-shaped member 1 and to bear on it with a very weak preliminary force, as soon as said member 1 is actuated in the required direction, each end of the ring segment 2 transmits to the lever which carries it a tension of such magnitude that one of them is four times as large as the other.

By interconnecting the levers 4, 5 by means of a coupling link 7, the effect of these two tensions can be carried from one upon the other. As a result of this, assuming for example a small tension to be initiated at one end, a more or less large portion of the tension T which is set up at the opposite end may be carried over to the tension t which will thus grow to become t', thereby giving rise to a tension T' which will also be larger, and so forth until proper driving force is obtained.

For a reverse drive, it will be understood from analogous reasons that full release is also automatic.

Depending upon the position of the hinges which pivotally connect the link 7 to the levers 4, 5, a possibility is obtained of varying the ratio in which the tensions T and t react upon each other.

An absolutely immediate drive is thus secured which, besides not being violent, is devoid of jerks and rattle.

In practical construction, the number of hinges or pivotal joints should be minimized. Thus, for example, both ends of the ring segment 2 may be interconnected as shown in Fig. 3. In this constructional form, the hinges of the ring segment to the levers are replaced by a direct fastening of the flexible strip forming said segment 2 to the levers 4' and 5' and the inherent flexibility of the strip permits, for those very small oscillations which are necessary, relative motions between the ring segment and the levers. Moreover, these levers have a particular shape which enables them to be interconnected by a mere contact. These shapes are not, however, limitative. The cup-shaped member might be pulled back by a return spring. Thus changes in the contacting point of the trunnions are avoided when the direction of operation is inverted.

Crank throw varying device

A device for varying crank throw is illustrated in Figs. 4 and 5. The shaft 8 is assumed to be driven from a motor, engine or other prime mover and actuates through the medium of a set of gears the shaft which carries the crank pins or trunnions, said shaft to be hereafter referred to, for the sake of clearness, as the "driving shaft". This shaft is made up of two parts or stub shafts 9, 10 each of which receives the motion from the shaft 8 through a double bevel gear 8^a, 8^b so that said stub shafts 9, 10 rotate at equal speeds but in opposite directions.

Each stub part of the driving shaft is provided at its other end with a crank disk 11 whose crank pin 12 is connected to a runner or slider 13 which can be moved diametrically in a dovetail runway 13' formed in the crank disk 11 so that the crank pin can be brought to the center of said disk.

The slider which carries the pin 12 is provided with a nut 14 actuated by a screwed rod 15 the rotation of which can shift said slider 13 longitudinally in the disk 11. Rotation of the screwed rod 15 is performed by a bevel gear formed of a pair of bevel pinions. One of these pinions designated by 16 is integral with the rod 15 while the other pinion 17 is connected to one end of a spindle 18 revolubly housed in an axial bore of the stub shaft and fitted at its other end with a bevel pinion 19. Therefore both bevel pinions 19 and their carrying spindles rotate normally at equal speeds but in opposite directions. These

two bevel pinions 19 are the sun elements of a planetary differential system made up of the pinions 19, planet pinions 20 and planet pinion carrier 21 the outer periphery of which has skew teeth to form a worm wheel.

Normally the worm wheel 21 forming a planet gear carrier is motionless since the pinions 19 rotate at equal speeds but in opposite directions. Said carrier is furthermore held stationary by a cooperating worm 22 which may be driven in the one or the other direction, for example manually by means of an actuator such as a hand wheel 22' or by any equivalent manually or mechanically controlled contrivance.

In view of this construction, as long as the planet gear carrier 21 remains stationary, the bevel pinions 19 rotate at a speed equal to that of the driving shaft so that no motion is produced which might shift the crank pins 12 and alter the primary crank throw. However, any rotation of the planet gear carrier 21 in either direction brings about a variation of speed of the pinions 19 and consequently a relative movement with respect to the driving shafts. This causes a rotation of the spindles 18 of the pinions 17, 16, of the screwed rod 15 and therefore a displacement of the nut 14 and crank pin 12, i. e. an alteration of the primary crank throw.

It will be seen that variation of the crank throw is consequently obtained by a very accurate and easily operable drive either directly as shown or by means of any servo motor (not shown) of conventional structure.

Distribution of the action of the secondary cranks

The showing of fig. 5 makes it quite clear how the action of the secondary cranks can be so used as to cause the rotation of the driven shaft to be sufficiently continuous and uniform. In this figure is shown one of the crank disks 11 which may be considered, for the sake of convenience, as the left hand crank disk. This disk revolves clockwise and drives during a partial revolution the driven shaft 23 which carries the free wheel clutch described above with reference to fig. 3.

However, this partial revolution is carried over to a third shaft 24 by a set of intermeshing equal gears 25. Therefore, whenever the crank disk 11 effects half a revolution, the shaft 24 effects a partial revolution counter-clockwise.

As will be understood, however, for the second half revolution of the crank disk, the action of the pitman 26 which, owing to the provision of the free wheel clutch, remains without any effect upon the shaft 23 during the return motion of said pitman is carried over to the shaft 24 owing to the presence of a coupling link 27 which controls a free wheel clutch similar to the clutch mounted on the shaft 23 but operating in a reverse direction.

Consequently the shaft 24 is imparted a second impulse counter-clockwise. This impulse immediately follows the first one. A full revolution of the crank disk 11 imparts two impulses in the same direction to the shaft 24.

The right hand crank disk (not visible in fig. 5) operates in a similar way but in such a manner that the impulses imparted thereby to the shaft 24 should be combined in the most suitable way with the first two impulses so as to regularize the motion. This result is obtained by suitably offsetting the right hand crank pin with respect to the left hand crank pin and by correspondingly arranging the operating pitmans. As a result of this, four impulses are obtained at each revolution of the driving shaft. Any such slight speed variations as may subsist are made good by the inherent inertia of the gear or by fitting the same with a fly wheel.

The differential gear for operating the crank pins is shown in a simplified embodiment in fig. 4 so as to do away with superfluous descriptive matter. However, it will be understood that this embodiment is only diagrammatic and that many constructional variations may be introduced particularly by using sun and planet spur gears. Likewise, the crank pins might be replaced in numerous instances by eccenters, whereby the shaft carrying them could be directly actuated by being merely coupled up with the driving shaft. Such a constructional form would enable the number of impulses to be multiplied and such impulses to be transmitted by single acting cranks.

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