R. M. RUCK.

VARIABLE SPEED MECHANISM.

APPLICATION FILED MAR. 20, 1911.

1,043,629.

Patented Nov. 5, 1912.

4 SHEETS—SHEET 1.

Fig. 1.

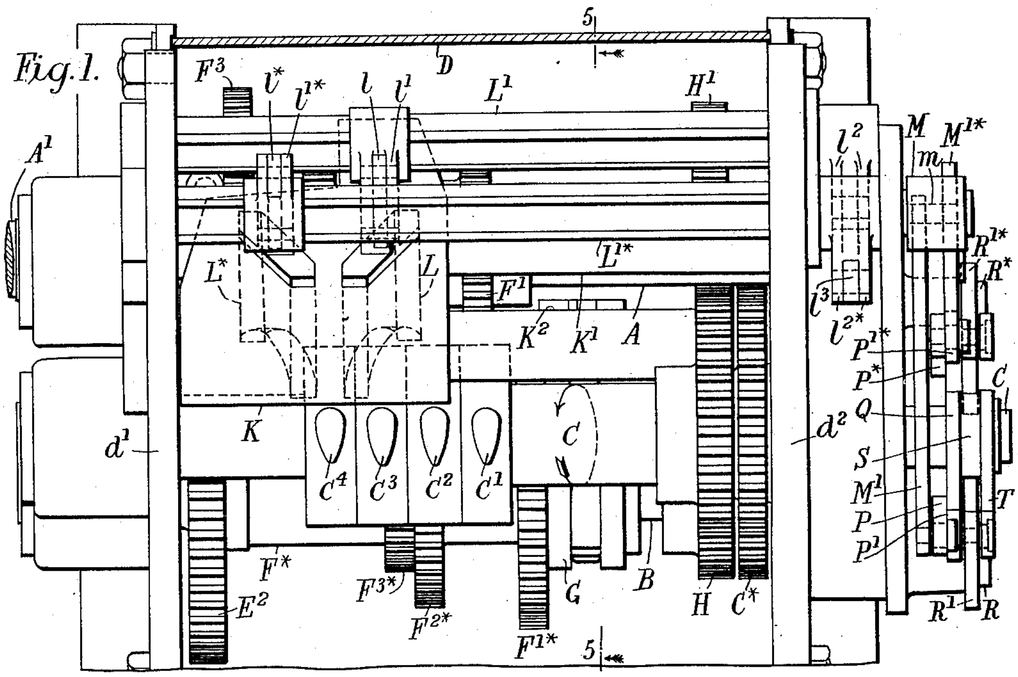
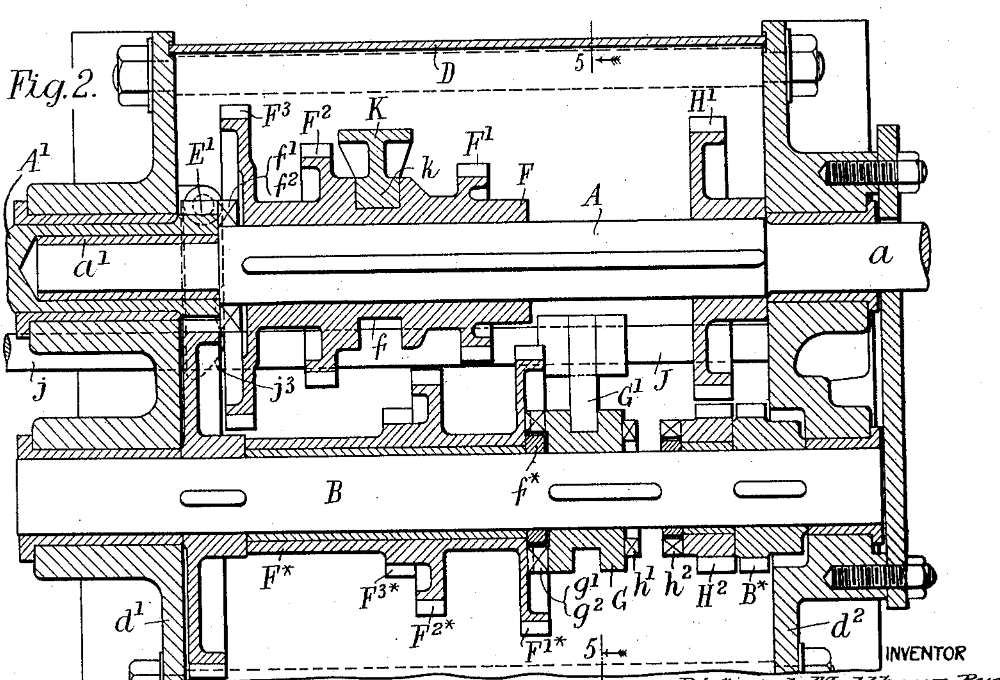


Fig. 2.



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4 SHEETS—SHEET 2.

Fig. 3.

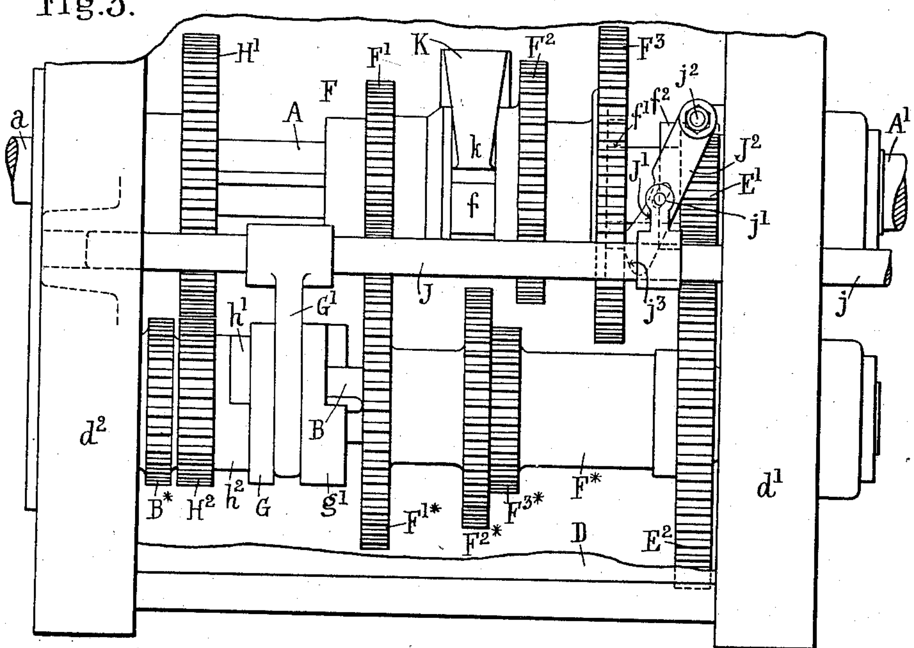
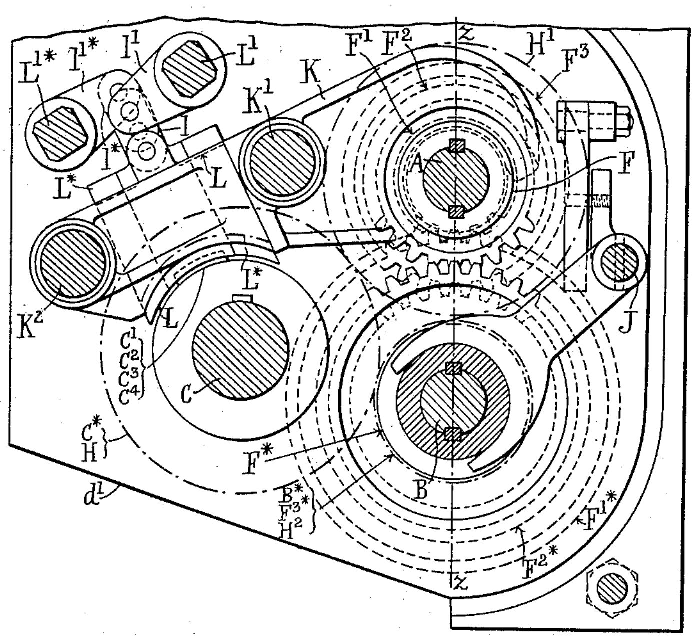


Fig. 4.



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4 SHEETS—SHEET 3.

Fig. 5.

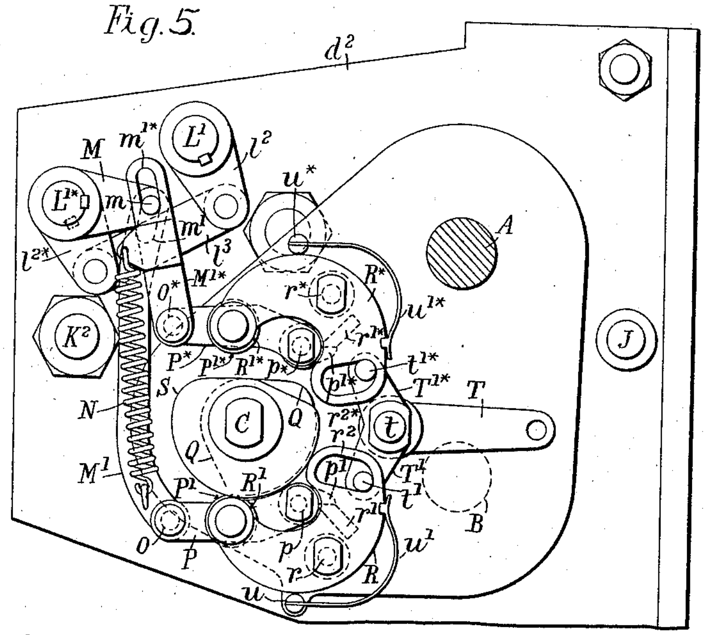
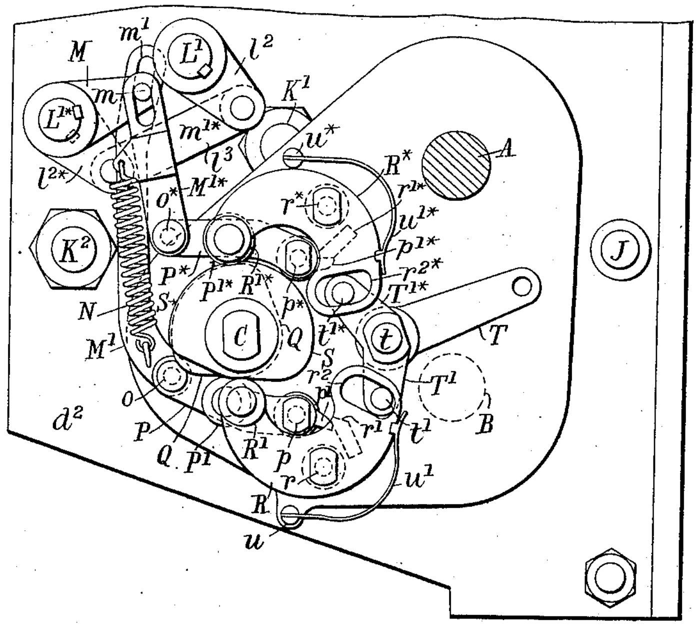


Fig. 6.



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4 SHEETS—SHEET 4.

Fig. 8.

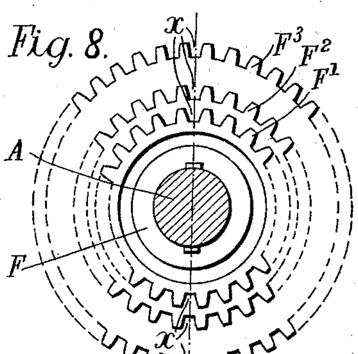


Fig. 9.

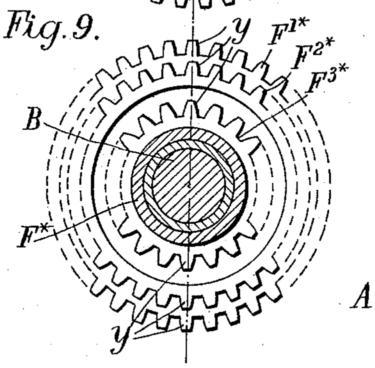
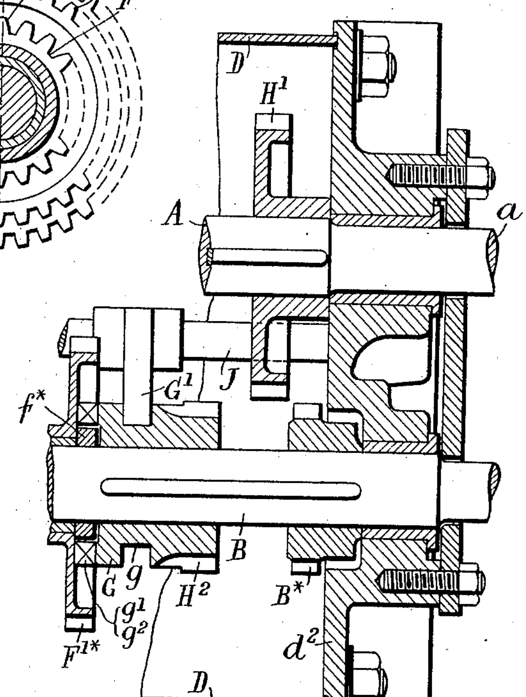


Fig. 7.



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VARIABLE-SPEED MECHANISM.

1,043,629. Specification of Letters Patent. Patented Nov. 5, 1912.

Application filed March 20, 1911. Serial No. 615,528.

To all whom it may concern:

Be it known that I, RICHARD MATTHEWS RUCK, a subject of the King of Great Britain, and resident of 44 Thurloe Square, South Kensington, London, S. W., England, have invented certain new and useful Improvements in Variable - Speed Mechanism, of which the following is a specification.

This invention relates to variable-speed mechanism of the kind wherein rotary motion is transmitted at different velocities alternatively at will through the medium of two shafts parallel to one another and each carrying a plurality of toothed wheels turning together as one and having different diameters so as to be adapted to mesh, alternatively with one another, with the respective wheels of reciprocal diameter on the other shaft, the one set of wheels being stationary lengthwise of its shaft while the other is slidable relatively thereto in order to permit of the ratio of transmission being varied by changing the pair of wheels which for the time being are in mesh with one another.

The primary object of the present invention is to provide means for so timing the changes of speed relatively to the speed of a member which rotates at a constant velocity, as to enable the bringing into operation of the various pairs of change-wheels alternatively, to be effected without the necessity of exerting any appreciable manual effort, and without the occurrence of the violent shocks (and consequent risk of injury to the teeth) which are commonly experienced when, as has been the usual practice hitherto, ordinary "clash-in" gearing is employed, that is to say gearing wherein, for the purpose of bringing a pair of wheels into mesh with one another by a lateral movement, the teeth of the one wheel (which is slidably mounted) are pressed laterally against those of the other wheel (whose position lengthwise of its shaft is stationary) until the revolution of one or of both wheels has brought the teeth of the one wheel opposite to the tooth-gaps of the other wheel so as to permit of the continued pressure causing the slidable wheel to be suddenly shifted into gear with the relatively stationary wheel.

For the purpose of the invention the wheels of progressively varying diameter in the respective sets are arranged to form, in effect, toothed cones whose inclinations are opposed to one another; while the relative positions of the wheels in the two sets are such that only a single pair of change-wheels can be in gear with one another at a time and that progressively varying speed-ratios may be obtained by shifting the slidable set of wheels through progressively varying distances lengthwise of its shaft so as to bring successive pairs of change-wheels into operation.

According to the present invention all the gear-wheels comprised in each toothed cone (or set of wheels) have one tooth (or tooth-gap) alined to form a straight row extending in a plane wherein also lies the common axis of all the wheels of the set; so that transference of the slidable cone from the position corresponding to transmission of motion at one speed - ratio to the position corresponding to transmission at the next higher or lower speed-ratio may be effected, readily and smoothly, when both cones are in that angular position which may (for convenience) be called the transference position, *i. e.* that position wherein the straight row of teeth and of tooth gaps in the respective cones are simultaneously brought, by the revolution of both cones, into what may be termed the transference plane, *i. e.* the common plane of the axes of the respective cones.

The actual transference movement is effected mechanically, as required, through the agency of means whereby the position and movements of the slidable cone lengthwise of its shaft are so controlled with reference to the occurrence of the transference position in the case of both cones, as to insure that the transference movement can be initiated only when both cones are simultaneously in the transference position, and that the transference movements, when once initiated, shall be completed. These means comprise a drum (or equivalent rotary member) which is caused to rotate about an axis parallel to those of the main shaft and countershaft at the requisite angular velocity, and which carries a row of tappets corresponding in number and distance apart to the number of wheels in each cone and the length of the several movements of transference; a carrier engaging the slidable cone and movable in a direction parallel to the axis thereof so as to be adapted to impart motion to said cone lengthwise of its shaft; a pair of oppositely inclined cams mounted on the carrier and normally retained in the inoperative position but respectively adapted to be brought into position to be acted upon by the tappets so as to cause the carrier and cone, according as the one or the other cam is brought into operative position, to be shifted in one or the other direction through a distance equal to the extent of the motion of transference whereby consecutive pairs of change-wheels are brought into operation; and means for enabling either of the cams at will to be moved into and out of operative position, but only at the proper moments with reference to the bringing of both cones simultaneously into the transference position.

In the accompanying drawings which illustrate a convenient arrangement embodying the invention (as applied to the variable-speed mechanism employed in connection with the driving gear of a motor car wherein provision is made for a "direct drive" at maximum speed and for reversal of motion at one speed only), Figure 1 is a general plan view of the apparatus, the casing which incloses the same being in section so as to display the contents, and the parts being in position for transmitting motion by direct drive at maximum speed. Fig. 2 is a plan view in section on the common plane of the axes of the main shaft and countershaft. Fig. 3 is an inverted plan with the casing broken away, and the camshaft and parts more immediately associated therewith omitted, showing the parts in position for transmitting motion at a lower velocity than in Figs. 1 and 2. Fig. 4 is a section on line 4—4 of Figs. 1 and 2, showing one of the cams in operative position and acted upon by one of the tappets. Fig. 5 is an outside end view showing, in normal position, the mechanism for controlling the bringing of the cams into operation. Fig. 6 is a view similar to Fig. 5, showing the same mechanism in the position occupied when one of the cams is in operative position. Fig. 7 is a part view similar to Fig. 2, showing a modified construction of reversing mechanism. Figs. 8 and 9 are end views of the slidable and of the relatively stationary toothed cones respectively, showing the straight rows of tooth gaps and teeth in the respective cones.

A, B and C are the main shaft, countershaft, and cam shaft respectively, these three shafts being mounted to rotate parallel to one another in bearings provided in the end plates d^1 d^2 of the casing D of the apparatus. One end of the main shaft A (in Fig. 2, the left-hand end) is however, journaled in a bearing a^1 in the contiguous end of an independent shaft A^1 which revolves in alinement with the main shaft itself; the shaft A^1 projecting outside the end plate d^1 of the casing and serving to transmit motion to the apparatus from the engine, while motion may be transmitted from the shaft A^1 to the main shaft A as hereafter described. The opposite end a of the shaft A projects outside the end plate d^2 of the casing and serves for transmitting motion to the road-wheels of the vehicle in any convenient manner.

Fast upon the inner end of the independent shaft A^1 is a toothed pinion E^1 which is permanently in gear with a toothed wheel E^2 fast upon the countershaft B, so that as long as the shaft A^1 is running, the countershaft B will revolve at a uniform speed lower than and bearing a predetermined ratio to that of the shaft A^1.

Toward the left-hand end (Fig. 2) of the main shaft A a sleeve F is splined thereon, the left-hand extremity of this sleeve being provided with a clutch-face f^1 adapted to engage a corresponding clutch-face f^2 on the inner end of the independent shaft A^1, so that as long as the sleeve is in its extreme left-hand position, the main shaft A (and therefore also the road wheels of the vehicle) will be driven direct from the engine at maximum speed. The sleeve F has fast upon or integral with it a plurality of toothed wheels (three are shown in the example) F^1, F^2, F^3 respectively adapted to gear with toothed wheels F^{1*}, F^{2*}, F^{3*} fast upon or integral with a sleeve F^* which is free to rotate upon the countershaft B whereon it is confined against longitudinal movement between shoulders constituted on the one hand by the hub of the wheel E^2 and on the other hand by a collar f^*. The wheels F^1, F^2 and F^3 severally are of progressively increasing diameter, while the wheels F^{1*}, F^{2*} and F^{3*} severally are of reciprocally diminishing diameter; the respective pairs F^1 F^{1*}, F^2 F^{2*} and F^3 F^{3*} constituting pairs of change-wheels which are capable of being brought into operation alternatively with one another when the clutch f^1, f^2 is out of gear. For this purpose the positions of the respective wheels are such that continued displacement of the sleeve F toward the right in Fig. 2 will first disengage the clutch-faces f^1, f^2 from one another and will thereafter bring the pairs of change-wheels F^1 F^{1*}, F^2 F^{2*}, and F^3 F^{3*} successively into mesh with one another and vice versa. The means whereby the sleeve F is so controlled as to enable these changes, or any of them, to be produced automatically when once initiated by a simple manual operation, will be described hereafter.

The sleeve F^* (and therefore also any of the wheels F^{1*}, F^{2*} or F^{3*}) can be thrown into driving engagement with the shaft B by means of a clutch member G which is splined upon the shaft and which has a clutch face g^1 on its left-hand end adapted to engage a corresponding clutch-face g^2 on the right-hand end of the sleeve F^*. Hence, if, while the clutch-faces g^1 g^2 are in engagement with one another, either of the pairs of change-wheels F^1 F^{1*}, F^2 F^{2*}, or F^3 F^{3*} is in operative position, motion will be transmitted from the constantly running countershaft B to the main shaft A at a velocity corresponding to the pair of change-wheels which for the time being is in use. Inasmuch, however, as no pair of change-wheels can be in use when the sleeve F is in engagement with the shaft A^1 through the clutch f^1, f^2, it will be evident that by no possibility can the parts assume a position wherein motion would be transmitted from the shaft A^1 to the shaft A directly at maximum speed (through the clutch f^1, f^2) and indirectly at a lower speed (through either of the pairs of change-wheels) simultaneously.

The clutch-member G is capable of occupying three positions alternatively, namely, either the extreme left-hand position shown in Fig. 2, wherein the clutch-faces g^1 g^2 are engaged with one another so as to permit the transmission of motion from the shaft B to the sleeve F*, and thence to the shaft A (through one or other of the pairs of change-wheels) in what is assumed to be the forward direction; or an extreme right-hand position wherein the clutch serves to transmit motion to the shaft A in the reverse direction as hereafter described; or a neutral position (intermediate between the other two) wherein the clutch is inoperative.

When motion is to be transmitted in the reverse direction, the shafts A and B are geared together not directly but through the medium of an idle wheel. For this purpose a toothed wheel H^1, fast on the shaft A toward its right-hand end, gears constantly with an idle wheel H which for the sake of convenience is mounted to revolve freely upon the shaft C, the idle wheel H receiving motion, when required, from a pinion H^2 carried by and turning as one with the shaft B. The pinion H^2 may, as in Fig. 2, be constantly in gear with the wheel H, in which case the pinion is mounted to revolve freely upon the shaft B and held against sliding lengthwise of said shaft, and is provided with a clutch-face h^2 adapted to be engaged by a corresponding clutch-face h^1 on the right-hand end of the clutch-member G, when the latter occupies its extreme right-hand position. Or, the pinion H^2 may, as in Fig. 7, be attached to or integral with the clutch-member G so as to be slidable therewith lengthwise of the shaft B, in which case the pinion H^2 is thrown into mesh with the wheel H only when the clutch-member G is in its extreme right-hand position.

The position of the clutch-member G is manually controlled by means of a rod J mounted to slide parallel to the shafts A, B and C and having fast on it a fork G^1 which engages a peripheral groove g on the clutch-member G, one end j of the rod J extending beyond the casing so as to be capable of being operated from any convenient point. In order to prevent the possibility of motion being transmitted to the shaft A in the reverse direction from the shaft B while motion is being transmitted to the shaft A in the forward direction from the shaft A^1 through the clutch f^1, f^2, means are provided for insuring that when the clutch-faces f^1, f^2 are in engagement, the clutch-member G shall be prevented from assuming the extreme right-hand position or, in other words, that before the clutch-member G, in being moved toward the right in Fig. 2, can reach its extreme right-hand position, the sleeve F shall be displaced so far toward the right as to cause the clutch-faces f^1, f^2 to become disengaged from one another. For this purpose the manually operable slide-rod J has fast on it an arm J^1 which has a pin-and-slot engagement as at j^1 with a lever J^2 fulcrumed at j^2 to the casing and adapted to contact with the left-hand face (Fig. 2) of the wheel F^3. This contact is made with the free end j^3 of the lever J^2, which is made of appropriate cam-shape as indicated, the pin-and-slot device j^1 being situated between this free end j^3 and the fulcrum j^2. Hence if the clutch-faces f^1, f^2 and g^1 g^2 be assumed to be respectively in engagement, then any movement of the slide-rod J toward the right (for the purpose of withdrawing the clutch-faces g^1, g^2 from engagement preparatory to bringing the clutch-member G into position for effecting reversal of motion of the shaft A) will produce a magnified movement of the free end j^3 of the lever J^2, and consequently, even before the clutch-member G can be brought to its neutral position, the clutch-faces f^1, f^2 will have been disengaged from one another. Similarly, so long as the clutch-faces f^1 f^2 are in engagement, the lever J^2 will be held, by its contact with the wheel F^3, in such a position that the slide-rod J will be prevented from being moved toward the right even so far as to assume the position corresponding to the neutral position of the clutch-member G, which will thus be effectually prevented from being shifted to the position corresponding to reversal of the motion transmitted to the shaft A.

Inasmuch as the sleeve F* is freely rotatable on the shaft B, it is necessary that this sleeve and its wheels F^{1*}, F^{2*}, F^{3*} shall be prevented from "falling out of time" with the sleeve F and its wheel F^1, F^2, F^3 and vice versa. For this reason, and also in order to avoid shocks when the gearing-ratio is changed, it is obvious that, at the moment of changing gear, that pair of wheels which are passing out of gear must remain in mesh with one another until the succeeding pair have begun to gear with one another; such overlapping of the gears being of course only momentary, and the sliding movement of the sleeve F being performed as rapidly as is practicable. The same conditions must also be observed with regard to the change of gear from the clutch f^1, f^2 to the pair of wheels F^1, F^{1*} and vice versa. To enable these conditions to be fulfilled, the toothed cone (or set of wheels) carried by each sleeve has one tooth (or tooth-gap) in each wheel of the set alined to form a straight row lying in a plane wherein also lies the axis of the cone, as indicated at x (Fig. 8) with regard to tooth gaps in the cone carried by the sleeve F, and at y (Fig. 9) with regard to teeth on the cone carried by the sleeve F*; the sliding movement of the sleeve F being allowed to take place only when both rows x and y are brought, by the revolution of the respective shafts A and B, into the common plane z—z (Fig. 4) of the axes of these shafts. Moreover, each of the clutches f^1, f^2 and g^1, g^2 is a dog-clutch whose members are capable of becoming mutually engaged only when the respective clutch-faces occupy one angular position relatively to one another, the clutch-face f^2 being suitably disposed with reference to the angular position of the row of tooth gaps x while the clutch-face g^2 is also suitably disposed with reference to the angular position of the row of teeth y. Furthermore, the several wheels carried by each sleeve F and F* are set at such distances apart from one another, relatively to the position of the clutch-face f^2 when engaged with the clutch-face f^1, as to insure the necessary overlapping of the gears at the moment of changing speed. Finally, the effective length and proportions of the lever J^2 are made such that the movement of the slide-rod J from the position shown in Figs. 2 and 3 to positions corresponding to the neutral and reversing positions of the clutch G must invariably leave one or other of the pairs of change-wheels F^1 F^{1*}, F^2, F^{2*}, F^3 F^{3*} in engagement with one another.

It will be obvious that, if the numbers of teeth in the respective wheels of either cone possess a common divisor greater than unity, a greater number of straight rows of tooth gaps or teeth x or y than the single row above mentioned will exist in the respective cones. This will afford a correspondingly increased number of opportunities for the concurrent passage of the rows x and y through the transference plane z—z. In such circumstances each clutch f^1, f^2 and g^1, g^2 may be capable of coming into engagement in as many angular positions of the respective members relatively to one another, as there are straight rows of tooth gaps or teeth x or y in the cones to which the respective clutches appertain. In the example illustrated, each cone is understood to have two straight rows of tooth gaps or teeth, as indicated in Figs. 8 and 9 respectively.

The various positions of the sleeve F are controlled by means of a carrier K mounted to slide on guides K^1, K^2 parallel to the shafts A, B, and C and jawed as at k to engage a peripheral groove f on the sleeve F, this sleeve (together with the gear-wheels F^1, F^2, F^3 and the clutch-face f^1) participating in the movements of the carrier K lengthwise of its guides. The carrier extends in a general direction tangentially of the shaft C, and is provided with sockets through which a pair of cams L, L* are fitted to slide in a direction perpendicular to the axis of the shaft C. These cams, viewed in the direction in which they are capable of sliding through their sockets in the carrier K, are respectively inclined in opposite directions, and are normally both held in a neutral or inoperative position. Either cam L or L* may however be caused at will to project from its socket toward the axis of the shaft C so as to be presented in position for engagement, at each revolution of said shaft, by one of a series of tappets C^1, C^2, C^3, C^4 forming a straight row which projects from and rotates as one with the shaft C.

The result of such engagement of a cam L or L* by any one of the row of tappets is that the carrier K, together with all those parts which participate in its movement, is caused to slide along its guides K^1, K^2 in the direction determined by that cam which has been brought into operation, and through a distance equal to the effective length of the cam. The effective length of each cam L and L*, and also the distance apart of the several tappets C^1 . . . C^4, must obviously be equal to the distance between the successive positions which the sleeve F may be required to assume; while the number of the tappets (in the example illustrated, four) must equal the number of such positions.

The cam-shaft C has fast upon it a toothed wheel C* which is constantly in gear with a toothed wheel B* fast on the shaft B, and in order that the sliding movement of the sleeve F (or in other words, the change of gear) shall be permitted to occur only when a row of tooth gaps and of teeth x and y respectively are both in the transference plane z—z, it is important that the ratio of gearing B* C* whereby the shaft B is driven shall be such that the row of tappets C^1 . . . C^4 will be brought into position to operate on the cam L or L* only when a straight row of tooth gaps and of teeth x

and y respectively come into engagement with one another.

The mechanism for bringing the cams L and L* alternatively into operative position comprises a pair of shafts L^1, L^{1*} extending parallel to the shaft C and rotatably mounted in bearings in the frame; a corresponding pair of radius-arms l^1, l^{1*} of equal length splined upon the respective shafts and extending in opposite directions therefrom; and a pair of links l, l^* coupling the respective arms to the rear ends of the corresponding cams L, L*. Outside the end plate d^2 of the casing the respective shafts L^1 L^{1*} have fast upon them a pair of radius-arms l^2, l^{2*} of equal length which extend parallel to one another and are coupled together by a link l^3, so that, if either shaft be rotated through a small angle in one or the other direction, the other shaft will participate in the movement and the arms l^1, l^{1*} will move in opposite directions with the result that the cams L L* respectively will be depressed into and raised out of operative position or vice versa.

As that cam L or L* which has thus been brought into operative position is acted upon by the tappets C^1 . . . C^4, the carrier K and parts connected therewith will slide along the guides K^1 K^2 as already described, and the radius-arms l^1, l^{1*} being coupled to the respective cams, will slide with the latter along the shafts L^1, L^{1*}.

It is essential that, when once a cam L or L* has actually begun to be operated upon by any one of the tappets C^1 . . . . . . C^4, such action should proceed without interruption until the change of gear has been fully accomplished by the completion of the sliding movement of the sleeve F from its old to its new position. Hence, provision is made for insuring that either cam L or L* on being brought into operative position before the passage of the row of tappets C^1 . . . C^4 past the cams, shall be locked in that position until the tappets have passed clear of what may be called the operative arc of their revolution; and it is found convenient to hold both cams locked in the inoperative position except for an interval (during each revolution of the tappets) corresponding in time to, but slightly longer than, the passage of the tappets through said operative arc. For this purpose the shaft L^{1*} (but it might obviously have been the shaft L^1) has fast on one of its ends a crank-arm M (Figs. 5 and 6) whereby to communicate the necessary partial rotary movement to the shaft, this arm carrying a crank-pin m, which may project from both sides of the arm as indicated. The pin m engages in slots m^1, m^{1*} in a pair of links M^1, M^{1*} which extend at approximately right angles to the arm M and are capable of sliding one over the other in parallel planes so as to cause the arm M to move in one direction or the other according as the link M^1 or M^{1*} is brought into operation. The slots m^1, m^{1*} extend in opposite directions from the crank-pin m which, when in its normal or mid position (shown in Fig. 5) occupies one end of the slot m^1 and the opposite end of the slot m^{1*}, the links themselves under these circumstances being held locked so that the pin m is maintained stationary, with the result that the shafts L^1 L^{1*} cannot rotate and neither of the cams L, L* can be brought into operative position.

The links M^1, M^{1*}, which respectively serve for bringing the cams L, L* into operative position, are actuated only one at a time, that link which for the time being is not in use being held locked. The links are coupled together by a spring N which constantly tends to so move them both as to reverse the direction in which the slots m^1, m^{1*} extend from the pin m, the consequence being that if (say) the link M^1 be released from normal position, this link will be drawn by the spring so as (after taking up the lost motion allowed by its slot m^1) to shift the pin m to the opposite end of the slot m^{1*}, as shown in Fig. 6, thus rotating the shafts L^1 L^{1*} so as to bring the cam L into operative position, as shown in Fig. 4. In this new position the link M^1 (and therefore the pin m) will be retained (the cam L being meanwhile held in operative position) until the action of the mechanism has caused the link M^1 (and therefore the pin m and cam L) to be returned and re-locked in normal position. A similar cycle of consequences will ensue if the link M^{1*} be released from normal position, except that this link will be moved by the spring N in the opposite direction to the link M^1, with the result that the pin m will likewise be shifted in the corresponding direction so as now to bring the cam L* into operative position, wherein it will be retained until the parts have been automatically returned and re-locked in normal position as before.

The release and return of the links M^1, M^{1*} from and to normal position is effected by trip-mechanism under the control of rotary cams revolving in unison with the row of tappets C^1 . . . C^4, the action of the cams rendering it possible to release either of the links (and therefore to bring into operative position either of the cams L or L*) only during a period corresponding to the interval occupied by the tappets in passing through the operative arc of each revolution. For this purpose the links M^1, M^{1*} are coupled as at o, o^* to a pair of levers P, P* which extend, at approximately right angles to the links (and therefore approximately parallel to one another), on opposite sides of the cam-shaft C at one end of the latter; these levers, which are fulcrumed to the frame at p, p^* respectively carrying anti-friction rollers P^1, P^{1*} which are adapted to bear, from opposite directions, against a cam Q fast on the shaft. The normal position of the levers P, P^* corresponds to that wherein the rollers P^1, P^{1*} just contact with that portion of the cam Q which has the largest radius, and to this position each of said levers is automatically returned by the cam Q after having been released from said position and displaced by the action of the spring N.

Both levers P and P^* (which for convenience may be called main levers) are normally held (by the stress of the spring N) locked in normal position by the engagement of nibs or trip-noses p^1, p^{1*} forming short arms on the respective levers, with stops r^1, r^{1*} carried by a corresponding pair of locking-levers R, R^* fulcrumed to the frame at r, r^* so as to be capable of motion in a plane parallel to that wherein the levers P, P^* move; the point of contact between each nib and the co-acting stop (so long as the corresponding stop-lever is in normal position) being so situated with reference to the fulcrums of the corresponding main lever and locking-lever respectively as to prevent displacement of the main lever from normal position by the stress of the spring N. Hence, unless the locking-lever be forcibly displaced, both the main and the locking-lever will tend, under the stress of the spring N, to remain in normal position.

On either locking-lever R or R^* being displaced, however, (by angular movement about its fulcrum r or r^*), so as to remove the stop r^1 or r^{1*} from contact with the nib p^1 or p^{1*} of the corresponding main lever P or P^*, the main lever thus released from normal position will be caused by the spring N to swing toward the axis of the shaft C until the roller P^1 or P^{1*} comes in contact with the cam Q, this movement being sufficient, when that portion of the cam which has the least diameter is in operative position, to permit of the link M^1 or M^{1*} being moved so as to bring the corresponding cam L or L^* into operative position. Now, the operative positions, and relative angular extents, of those portions of the cam Q which have the minimum and maximum diameters, correspond respectively to the operative and inoperative arcs of the revolution of the row of tappets $C^1 \ldots C^4$. Consequently, whichever main lever P or P^* has been released, will automatically perform at the proper moments those movements from and back to normal position which are required for the purpose of moving the corresponding cam L or L^* into and out of operative position in time with the revolution of the tappets $C^1 \ldots C^4$ or, in other words, in time with the simultaneous bringing of the rows of tooth gaps and teeth x and y respectively into the transference plane z—z.

The locking levers R, R^* are displaced alternatively from normal position so as to unlock the respective main levers P, P^* by moving, in one direction or the other, a manually operable trigger-lever T fulcrumed at t to the frame. This lever has arms T^1, T^{1*} carrying studs t^1, t^{1*} which respectively engage in slots r^2, r^{2*} in the stop-levers R, R^*; the lever T normally occupying a mid or inoperative position wherein it permits both levers R R^* to remain in their normal positions, but the pin-and-slot connection in each case being such that movement of the trigger-lever T in either direction will displace one (and only one) of the levers R, R^* in such manner as to withdraw the corresponding stop r^1 or r^{1*} from contact with the nib p^1 or p^{1*}. The respective locking-levers R, R^* overlie the corresponding main levers P, P^* and carry anti-friction rollers R^1, R^{1*} which are adapted to bear, from opposite directions, against a cam S fast on the shaft C alongside of the cam Q. The normal position of the levers R, R^* corresponds to that wherein the rollers R^1, R^{1*} just contact with that portion of the cam S which has the largest radius, and to this position each of said levers is automatically returned by the cam Q after having been displaced from said position (by the action of the trigger-lever T) so as to cause the roller R^1 or R^{1*} to approach the axis of the shaft C.

It will be seen that, although manual pressure in either direction may at all times be applied to the lever T while in normal position, this lever will be prevented from moving so as to displace either of the locking-levers R, R^* except at such times as a part of the cam S having a radius less than the maximum is presented opposite to the roller R^1 or R^{1*}. It will also be seen that neither of the main levers P, P^* (even if unlocked by such displacement of the locking-lever R or R^*) will be able to move from normal position except at such times as a part of the cam Q having a radius less than the maximum is presented opposite to the roller P^1 or P^{1*}. Hence, by making the cams Q and S of proper form and mounting them on the shaft C in proper angular relation to each other and to the row of tappets $C^1 \ldots C^4$, it is rendered impossible to bring either of the cams L or L^* into operative position except when the tappets $C^1 \ldots C^4$ are approaching the operative arc of their revolution. For this purpose, whereas on the one hand that part of the cam Q which is of minimum radius is presented to the roller P^1 or P^{1*} during the entire period occupied by the passage of the tappets $C^1 \ldots C^4$ through said operative arc, on the other hand that part of the cam S which is of minimum radius is presented to the roller R^1 or R^{1*} during only a brief interval at or just before the commencement of said period.

Moreover, the forms and relative disposition of the respective cams Q and C are made such that, immediately after either of the main levers P or P* has been unlocked and permitted to move from normal position so as to bring the corresponding cam L or L* into operative position, the corresponding locking-lever R or R* is quickly restored to normal position, leaving the main lever P or P* in its abnormal or active position. Hence the stop r^1 or r^{1*} now engages the back of the nib or trip-nose p^1 or p^{1*} with the result that whichever main lever P or P* has moved (and therefore, also, whichever cam L or L* has been brought into operative position), will be prevented from returning to normal position until after that part of the cam Q which is of minimum radius has passed the roller P^1 or P^{1*}, or in other words, until the row of tappets $C^1 \ldots C^4$ has passed beyond the operative arc of their revolution. In consequence of this arrangement, once a movement of transference of the sleeve F (with its wheels F^1, F^2, F^3) has been initiated, such movement will of necessity be completed without interruption, and thus the possibility will be entirely prevented of either the clutch f^1, f^2 and the pair of change-wheels F^1, F^{1*}, or of any two of the pairs of change-wheels F^1 F^{1*}, F^2 F^{2*}, F^3 F^{3*} remaining simultaneously in gear longer than during the momentary interval required for effecting a change of speed-ratio.

It will be observed that at each revolution of the shaft C, the main lever P or P*, if previously unlocked and brought to operative position, will be automatically restored to and re-locked in normal position. This action will occur, even in the event of the trigger-lever T (whereby the change of gear was initiated) being held over continuously in one direction or the other, since the manual pressure upon the lever T is assumed to be elastic or yielding. Hence, even if the lever T be thus held over, the slidable sleeve F will be moved lengthwise of the shaft A not continuously, but only step-by-step in time with the revolution of the shaft C. Moreover, once the pressure upon the trigger-lever T is relieved, the sliding movement of the sleeve F will cease automatically at the next restoration of the main and locking levers to normal position, or in other words, next time the shaft C in the course of its revolution brings the cams Q and S to the angular position corresponding to such restoration.

The normal position of the locking-levers R, R* may be determined by stops u, u^* in contact with which the respective levers may be normally retained by springs u^1, u^{1*}. These springs also serve to return the trigger-lever T to normal position after displacement therefrom in either direction, the effort exerted by the respective springs being transmitted in opposite directions to the lever T through its pin-and-slot connections with the levers R, R*.

Claims:

1. In variable-speed mechanism, the combination of two rotary shafts parallel to one another, a set of toothed change-wheels of different diameters mounted to turn together as one freely upon the one shaft, and a set of toothed change-wheels splined upon the other shaft and respectively adapted to gear alternatively with the wheels of the first-mentioned set, the one set of wheels having a straight row of teeth and the other a straight row of tooth-gaps, comprising respectively one tooth and one tooth-gap of each wheel of the set, extending in a plane wherein also lies the common axis of all the wheels of the set.

2. In variable-speed mechanism, the combination of two rotary shafts parallel to one another, a set of toothed change-wheels of different diameters mounted to turn together as one freely upon the one shaft, a set of toothed change-wheels splined upon the other shaft and respectively adapted to gear alternatively with the wheels of the first-mentioned set, the one set of wheels having a straight row of teeth and the other a straight row of tooth-gaps, comprising respectively one tooth and one tooth-gap of each wheel of the set, extending in a plane wherein also lies the common axis of all the wheels of the set, and means for varying the ratio of transmission by sliding the splined set of wheels lengthwise of its shaft when the straight row of teeth and the straight row of tooth-gaps are simultaneously in the common plane of the axes of both sets of wheels.

3. In variable-speed mechanism, the combination of a main shaft and a counter-shaft mounted to rotate parallel to one another, a set of toothed change-wheels of different diameters mounted to turn together as one freely upon the counter-shaft, a set of toothed change-wheels splined upon the main shaft and respectively adapted to gear alternatively with the wheels of the first-mentioned set, one set of wheels having a straight row of teeth and the other a straight row of tooth-gaps, comprising respectively one tooth and one tooth-gap of each wheel of the set, extending in a plane wherein also lies the common axis of all the wheels of the set, and means for varying the ratio of transmission by sliding the splined set of wheels length-

wise of the main shaft when the straight row of teeth and the straight row of tooth-gaps are simultaneously in the common plane of the axes of both sets of wheels, said means comprising a clutch-member rotatable as one with the set of change-wheels on the counter-shaft, a corresponding clutch-member splined on the counter-shaft, an independent shaft rotatable in alinement with the main shaft, gearing for maintaining driving connection at a constant velocity-ratio between the counter-shaft and the independent shaft, a clutch-member fast on the independent shaft, a corresponding clutch-member movable as one with the set of change-wheels splined on the main shaft, dog-clutch faces on said members adapted to engage with one another when, the sets of change-wheels being mutually disengaged, the straight row of teeth and the straight row of tooth-gaps are simultaneously in the common plane of the axes of both sets of change-wheels, gearing for transmitting motion between the main shaft and counter-shaft in the reverse direction to that transmitted by the change-wheels, and means for bringing said reverse-motion gearing into operation alternatively both with the clutching of the counter-shaft to the set of change-wheels carried thereby, and also with the clutching of the main shaft to the independent shaft, substantially as described.

4. In variable-speed mechanism, the combination of a main shaft and a counter-shaft mounted to rotate parallel to one another, a set of toothed change-wheels of different diameters mounted to turn together as one freely upon the counter-shaft, a set of toothed change-wheels splined upon the main shaft and respectively adapted to gear alternatively with the wheels of the first-mentioned set, the one set of wheels having a straight row of teeth and the other a straight row of tooth-gaps, comprising respectively one tooth and one tooth-gap of each wheel of the set, extending in a plane wherein also lies the common axis of all the wheels of the set, and means for varying the ratio of transmission by sliding the splined set of wheels lengthwise of the main shaft when the straight row of teeth and the straight row of tooth-gaps are simultaneously in the common plane of the axes of both sets of wheels, said means comprising a clutch-member rotatable as one with the set of change-wheels on the counter-shaft, a corresponding clutch-member splined on the counter-shaft, an independent shaft rotatable in alinement with the main shaft, gearing for maintaining driving connection at a constant velocity-ratio between the counter-shaft and the independent shaft, a clutch-member fast on the independent shaft, a corresponding clutch-member movable as one with the set of change-wheels splined on the main shaft, dog-clutch faces on said members adapted to engage with one another when, the sets of change-wheels being mutually disengaged, the straight row of teeth and the straight row of tooth-gaps are simultaneously in the common plane of the axes of both sets of change-wheels, a toothed wheel fast on the main shaft, a toothed pinion rotatable freely on the counter-shaft, an idle wheel in gear with said wheel and pinion, a clutch-member rotatable as one with the pinion, a corresponding clutch-member splined on the counter-shaft and movable as one with the other clutch-member splined on said shaft, a slide-rod for controlling the last-mentioned clutch-members, an arm on said rod, and a lever having a pin-and-slot connection with said arm and adapted to contact with one of the wheels of the set of change-wheels which is splined upon the main shaft, substantially as described.

5. In variable-speed mechanism, the combination of two rotary shafts parallel to one another, a set of toothed change-wheels of different diameters mounted to turn together as one freely upon the one shaft, a set of toothed change-wheels splined upon the other shaft and respectively adapted to gear alternatively with the wheels of the first-mentioned set, the one set of wheels having a straight row of teeth and the other a straight row of tooth-gaps, comprising respectively one tooth and one tooth-gap of each wheel of the set, extending in a plane wherein also lies the common axis of all the wheels of the set, a carrier slidable parallel to the shafts for controlling the position of the splined set of change-wheels lengthwise of its shaft, a pair of reversely inclined cams mounted in sockets in the carrier, a row of tappets for operating upon said cams, spaced apart in accordance with the respective positions of the splined set of change-wheels and rotatable together about an axis parallel to the shafts, gearing for causing the tappets to pass through the operative arc of their revolution with reference to the cams when the straight row of teeth and the straight row of tooth-gaps are simultaneously in the common plane of the axes of both sets of wheels, and means for bringing either of the cams alternatively at will into position to be operated upon by the tappets, substantially as described.

6. In variable-speed mechanism, the combination of two rotary shafts parallel to one another, a set of toothed change-wheels of different diameters mounted to turn together as one freely upon the one shaft, a set of toothed change-wheels splined upon the other shaft and respectively adapted to gear alternatively with the wheels of the first-

mentioned set, the one set of wheels having a straight row of teeth and the other a straight row of tooth-gaps, comprising respectively one tooth and one tooth-gap of each wheel of the set, extending in a plane wherein also lies the common axis of all the wheels of the set, a carrier slidable parallel to the shafts for controlling the position of the splined set of change-wheels lengthwise of its shaft, a pair of reversely inclined cams mounted in sockets in the carrier, a row of tappets for operating upon said cams, spaced apart in accordance with the respective positions of the splined set of change-wheels and rotatable together about an axis parallel to the shafts, gearing for causing the tappets to pass through the operative arc of their revolution with reference to the cams when the straight row of teeth and the straight row of tooth-gaps are simultaneously in the common plane of the axes of both sets of wheels, means for bringing either of the cams alternatively at will into position to be operated upon by the tappets, and means for automatically preventing the withdrawal of either cam from operative position so long as a tappet is in operation upon such cam, substantially as described.

7. In variable-speed mechanism, the combination of two rotary shafts parallel to one another, a set of toothed change-wheels of different diameters mounted to turn together as one freely upon the one shaft, a set of toothed change-wheels splined upon the other shaft and respectively adapted to gear alternatively with the wheels of the first-mentioned set, the one set of wheels having a straight row of teeth and the other a straight row of tooth-gaps, comprising respectively one tooth and one tooth-gap of each wheel of the set, extending in a plane wherein also lies the common axis of all the wheels of the set, a carrier slidable parallel to the shafts for controlling the position of the splined set of change-wheels lengthwise of its shaft, a pair of reversely inclined cams mounted in sockets in the carrier, a row of tappets for operating upon said cams, spaced apart in accordance with the respective positions of the splined set of change-wheels and rotatable together about an axis parallel to the shafts, gearing for causing the tappets to pass through the operative arc of their revolution with reference to the cams when the straight row of teeth and the straight row of tooth-gaps are simultaneously in the common plane of the axes of both sets of wheels, means for bringing either of the cams alternatively at will into position to be operated upon by the tappets, means for automatically preventing the withdrawal of either cam from operative position so long as a tappet is in operation upon such cam, and means for automatically returning each cam to inoperative position after it has been operated upon by a tappet, substantially as set forth.

8. In variable-speed mechanism, the combination of two rotary shafts parallel to one another, a set of toothed change-wheels of different diameters mounted to turn together as one freely upon the one shaft, a set of toothed change-wheels splined upon the other shaft and respectively adapted to gear alternatively with the wheels of the first-mentioned set, the one set of wheels having a straight row of teeth and the other a straight row of tooth-gaps, comprising respectively one tooth and one tooth-gap of each wheel of the set, extending in a plane wherein also lies the common axis of all the wheels of the set, a carrier slidable parallel to the shafts for controlling the position of the splined set of change-wheels lengthwise of its shaft, a pair of reversely inclined cams mounted in sockets in the carrier, a row of tappets for operating upon said cams, spaced apart in accordance with the respective positions of the splined set of change-wheels and rotatable together about an axis parallel to the shafts, gearing for causing the tappets to pass through the operative arc of their revolution with reference to the cams when the straight row of teeth and the straight row of tooth-gaps are simultaneously in the common plane of the axis of both sets of wheels, a pair of rotary shafts parallel to the axis of the respective sets of change-wheels, arms splined on said shafts, links for coupling the arms to the respective cams, mechanism for causing said shafts to turn together in the same direction, and means for partially rotating the shafts in either direction at will so as to cause the respective cams to be brought alternately into operative position, substantially as set forth.

9. In variable-speed mechanism, the combination of two rotary shafts parallel to one another, a set of toothed change-wheels of different diameters mounted to turn together as one freely upon the one shaft, a set of toothed change-wheels splined upon the other shaft and respectively adapted to gear alternatively with the wheels of the first-mentioned set, the one set of wheels having a straight row of teeth and the other a straight row of tooth-gaps, comprising respectively one tooth and one tooth-gap of each wheel of the set, extending in a plane wherein also lies the common axis of all the wheels of the set, a carrier slidable parallel to the shafts for controlling the position of the splined set of change-wheels lengthwise of its shaft, a pair of reversely inclined cams mounted in sockets in the carrier, a row of tappets for operating upon said cams, spaced apart in accordance with the respective positions of the splined set of change-wheels and rotatable together about an axis parallel to the shafts, gearing for causing the tappets to

pass through the operative arc of their revolution with reference to the cams when the straight row of teeth and the straight row of tooth-gaps are simultaneously in the common plane of the axes of both sets of wheels, a pair of rotary shafts parallel to the axes of the respective sets of change-wheels, arms splined on said shafts, links for coupling the arms to the respective cams, mechanism for causing said shafts to turn together in the same direction, an arm M fast on one of said shafts, a crank-pin m on said arm, a pair of links M^1, M^{1*} having slots m^1, m^{1*} engaging said crank-pin, a spring N for connecting said links together, levers P, P* pivotally connected to the respective links, a rotary cam Q adapted to engage the levers, gearing for rotating said cam in time with the revolution of the tappets, means for normally retaining both levers out of the path of the cam Q in opposition to the stress of the spring N, and means for releasing either lever from normal position at will, substantially as described with reference to the accompanying drawings.

10. In variable-speed mechanism, the combination of two rotary shafts parallel to one another, a set of toothed change-wheels of different diameters mounted to turn together as one freely upon the one shaft, a set of toothed change-wheels splined upon the other shaft and respectively adapted to gear alternatively with the wheels of the first-mentioned set, the one set of wheels having a straight row of teeth and the other a straight row of tooth-gaps, comprising respectively one tooth and one tooth-gap of each wheel of the set, extending in a plane wherein also lies the common axis of all the wheels of the set, a carrier slidable parallel to the shafts for controlling the position of the splined set of change-wheels lengthwise of its shaft, a pair of reversely inclined cams mounted in sockets in the carrier, a row of tappets for operating upon said cams, spaced apart in accordance with the respective positions of the splined set of change-wheels and rotatable together about an axis parallel to the shafts, gearing for causing the tappets to pass through the operative arc of their revolution with reference to the cams when the straight row of teeth and the straight row of tooth-gaps are simultaneously in the common plane of the axes of both sets of wheels, a pair of rotary shafts parallel to the axes of the respective sets of change-wheels, arms splined on said shafts, links for coupling the arms to the respective cams, mechanism for causing said shafts to turn together in the same direction, an arm M fast on one of said shafts, a crank-pin m on said arm, a pair of links M^1, M^{1*} having slots m^1, m^{1*} engaging said crank-pin, a spring N for connecting said links together, levers P, P* pivotally connected to the respective links, a rotary cam Q adapted to engage the levers, means for normally retaining both levers out of the path of the cam Q in opposition to the stress of the spring N, levers R, R, stops r^1, r^{1*} on said levers for normally engaging nibs p^1, p^{1*} on the respective levers P, P*, a rotary cam S adapted to engage the levers R, R*, gearing for rotating the cams Q and S in time with the revolution of the tappets, and means for displacing either of the levers R, R* from normal position alternatively at will, substantially as described with reference to the accompanying drawings.

11. In variable-speed mechanism, the combination of two rotary shafts parallel to one another, a set of toothed change-wheels of different diameters mounted to turn together as one freely upon the one shaft, a set of toothed change-wheels splined upon the other shaft and respectively adapted to gear alternatively with the wheels of the first-mentioned set, the one set of wheels having a straight row of teeth and the other a straight row of tooth-gaps, comprising respectively one tooth and one tooth-gap of each wheel of the set, extending in a plane wherein also lies the common axis of all the wheels of the set, a carrier slidable parallel to the shafts for controlling the position of the splined set of change-wheels lengthwise of its shaft, a pair of reversely inclined cams mounted in sockets in the carrier, a row of tappets for operating upon said cams, spaced apart in accordance with the respective positions of the splined set of change-wheels and rotatable together about an axis parallel to the shafts, gearing for causing the tappets to pass through the operative arc of their revolution with reference to the cams when the straight row of teeth and the straight row of tooth-gaps are simultaneously in the common plane of the axes of both sets of wheels, a pair of rotary shafts parallel to the axes of the respective sets of change-wheels, arms splined on said shafts, links for coupling the arms to the respective cams, mechanism for causing said shafts to turn together in the same direction, an arm M fast on one of said shafts, a crank-pin m on said arm, a pair of links M^1, M^{1*} having slots m^1, m^{1*} engaging said crank-pin, a spring N for connecting said links together, levers P, P* pivotally connected to the respective links, a rotary cam Q adapted to engage the levers, means for normally retaining both levers out of the path of the cam Q in opposition to the stress of the spring N, levers R, R*, stops r^1, r^{1*} on said levers for normally engaging nibs p^1, p^{1*} on the respective levers P, P*, a rotary cam S adapted to engage the levers R, R*, gearing for rotating the cams Q and S in time with the revolution of the tappets, and a manually-operable lever T

having a pin-and-slot connection with both the levers R and R*, substantially as described with reference to the accompanying drawings.

12. In variable-speed mechanism, the combination of two rotary members for conjointly transmitting motion at variable velocity-ratio, one of said members being slidable, lengthwise of its axis relatively to the other member, for effecting such variation of velocity-ratio, and means for producing such sliding movement of said member in either direction at will, comprising a pair of levers, connections between the individual levers of the pair and the means for producing motion of the slidable member in opposite directions respectively, a rotary cam for controlling the displacement of said levers from normal position and for automatically returning them to normal position, a spring for bringing said levers into contact with the cam, a second pair of levers for normally retaining the respective levers of the first-mentioned pair out of contact with the cam, a second cam, rotatable as one with the first-mentioned cam, for controlling the displacement of the levers of the second pair from normal position and for automatically returning them to normal position, springs for bringing the levers of the second pair into contact with said second cam, manually operable means for displacing either lever of the second pair alternatively at will from normal position, and gearing for rotating both cams at a speed bearing a predetermined ratio to the angular velocity of the aforesaid slidable member, substantially as described.

13. In variable-speed mechanism, the combination of two rotary members for conjointly transmitting motion at variable velocity-ratio, one of said members being slidable, lengthwise of its axis relatively to the other member, for effecting such variation of velocity-ratio, and means for producing such sliding movement of said member in either direction at will, comprising a pair of levers, connections between the individual levers of the pair and the means for producing motion of the slidable member in opposite directions respectively, a rotary cam for controlling the displacement of said levers from normal position and for automatically returning them to normal position, a spring for bringing said levers into contact with the cam, a second pair of levers for normally retaining the respective levers of the first-mentioned pair out of contact with the cam, a second cam, rotatable as one with the first-mentioned cam, for controlling the displacement of the levers of the second pair from normal position and for automatically returning them to normal position, springs for bringing the levers of the second pair into contact with said second cam, a manually-operable lever and pin-and-slot connections between two of its arms and the respective levers of the second pair, for displacing either lever of said pair alternatively at will from normal position, and gearing for rotating both cams at a speed bearing a predetermined ratio to the angular velocity of the aforesaid slidable member, substantially as described.

14. In variable-speed mechanism, the combination of two rotary members for conjointly transmitting motion at variable velocity-ratio, one of said members being slidable, lengthwise of its axis relatively to the other member, for effecting such variation of velocity-ratio, a carrier movable parallel to the axis of the slidable member for controlling the position of said member, a pair of reversely inclined cams mounted in sockets in the carrier, a row of tappets for operating upon said cams, spaced apart in accordance with the respective positions of the slidable member and rotatable together about an axis parallel to that of said member, gearing for rotating said tappets at a predetermined velocity-ratio relatively to the angular velocity of the slidable member, and apparatus for controlling the bringing of said cams alternatively at will into position to be operated upon by the cams, said apparatus comprising a pair of levers, connections between the individual levers of the pair and the respective cams, a rotary cam for controlling the displacement of said levers from normal position and for automatically returning them to normal position, a spring for bringing said levers into contact with the cam, a second pair of levers for normally retaining the respective levers of the first-mentioned pair out of contact with the cam, a second cam, rotatable as one with the first-mentioned cam, for controlling the displacement of the levers of the second pair from normal position and for automatically returning them to normal position, springs for bringing the levers of the second pair into contact with said second cam, manually operable means for displacing either lever of the second pair alternatively at will from normal position, and gearing for rotating both cams at a speed bearing a predetermined ratio to the angular velocity of the aforesaid slidable member, substantially as described.

15. In variable-speed mechanism, the combination of two rotary members for conjointly transmitting motion at variable velocity-ratio, one of said members being slidable, lengthwise of its axis relatively to the other member, for effecting such variation of velocity-ratio, a carrier movable parallel to the axis of the slidable member for controlling the position of said member, a pair of reversely inclined cams mounted in sockets in the carrier, a row of tappets for op-

erating upon said cams, spaced apart in accordance with the respective positions of the slidable member and rotatable together about an axis parallel to that of said member, gearing for rotating said tappets at a predetermined velocity-ratio relatively to the angular velocity of the slidable member, a pair of rotary shafts parallel to the axis of said member, arms splined on said shafts, links for coupling the arms to the respective cams, gearing for causing the shafts to turn together in the same direction, an arm fast on one of said shafts, a pair of links each having a pin-and-slot connection with said arm, a pair of levers coupled to the respective links, a rotary cam for controlling the displacement of said levers from normal position and for automatically returning them to normal position, a spring for bringing said levers into contact with the cam, a second pair of levers for normally retaining the respective levers of the first-mentioned pair out of contact with the cam, a second cam, rotatable as one with the first-mentioned cam, for controlling the displacement of the levers of the second pair from normal position and for automatically returning them to normal position, springs for bringing the levers of the second pair into contact with said second cam, manually operable means for displacing either lever of the second pair alternatively at will from normal position, and gearing for rotating both cams at a speed bearing a predetermined ratio to the angular velocity of the aforesaid slidable member, substantially as described.

RICHARD MATTHEWS RUCK.

Witnesses:
GEORGE E. MINTERN,
WILLIAM G. E. DAVIES.