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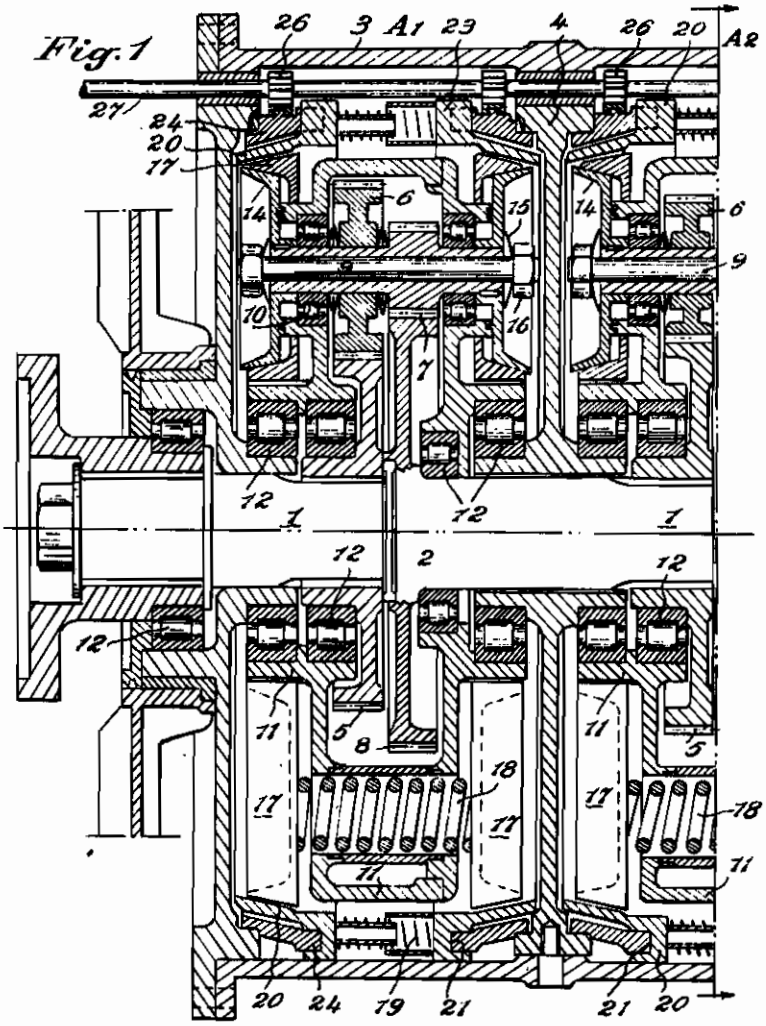
JUNE 1, 1943.
BY A. P. C.

M. DE FALCO
CHANGE SPEED GEAR
Filed Aug. 26, 1939

Serial No.
292,126
5 Sheets-Sheet 1

Fig. 1



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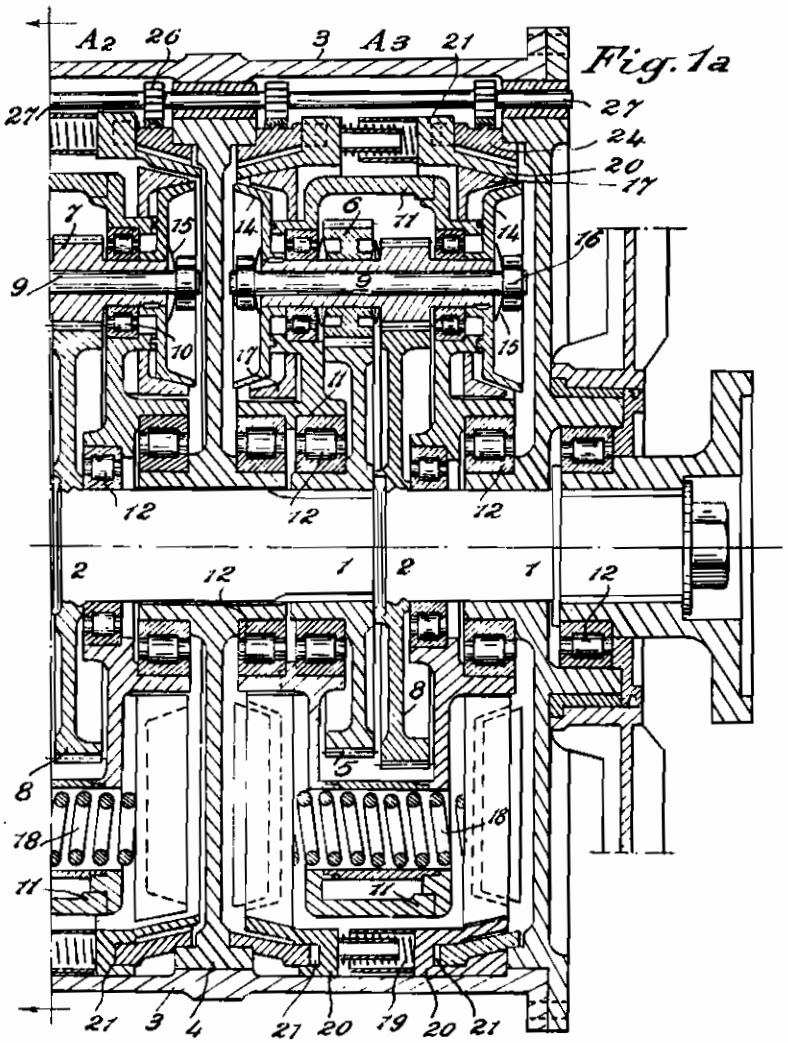

Fig. 1a

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Fig. 2

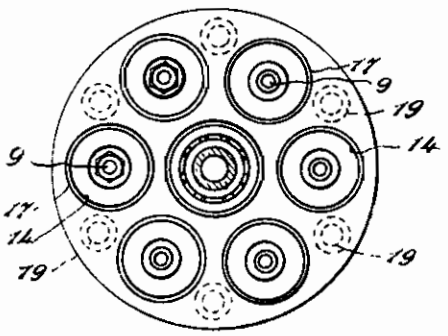

Fig. 3

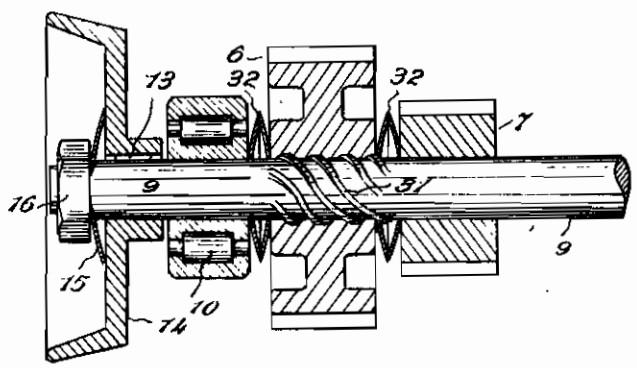

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Fig. 10

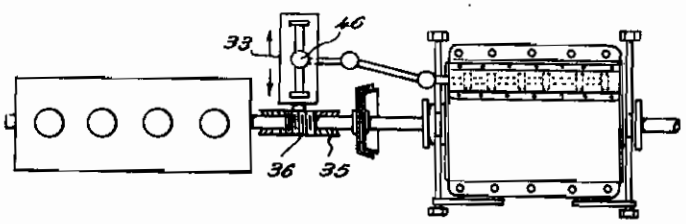
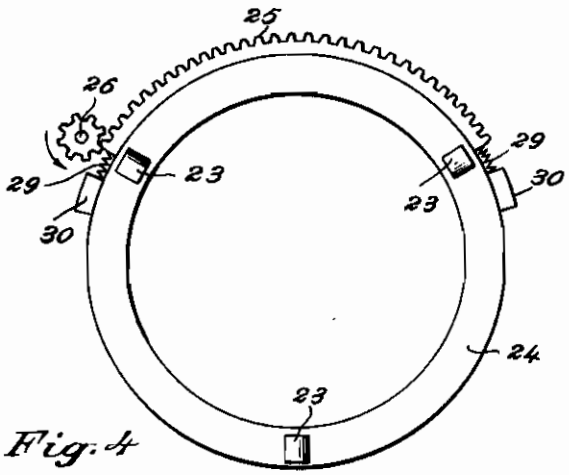


Fig. 8

Fig. 9



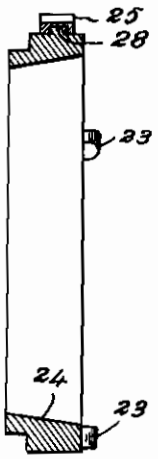


Fig. 4

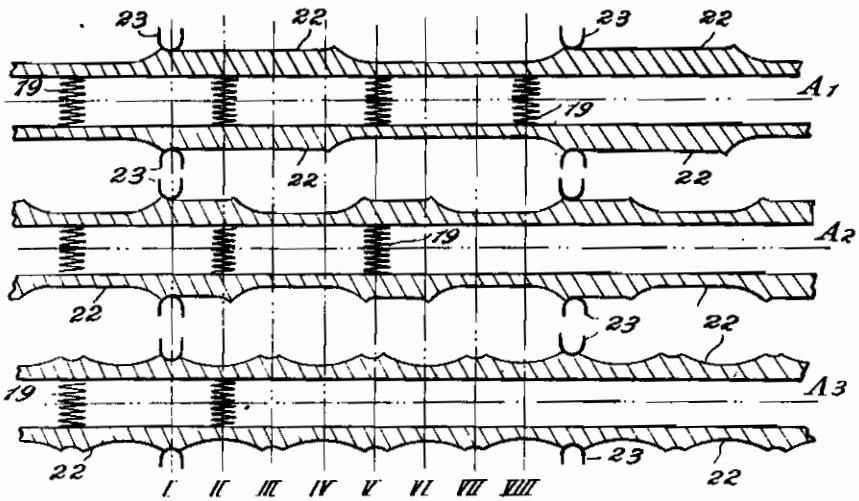


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Fig. 5

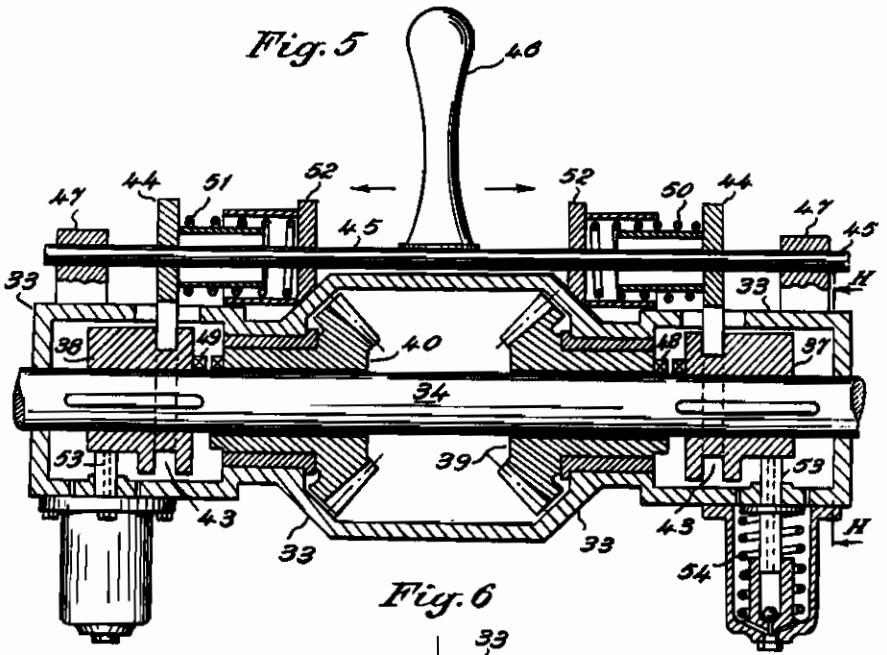
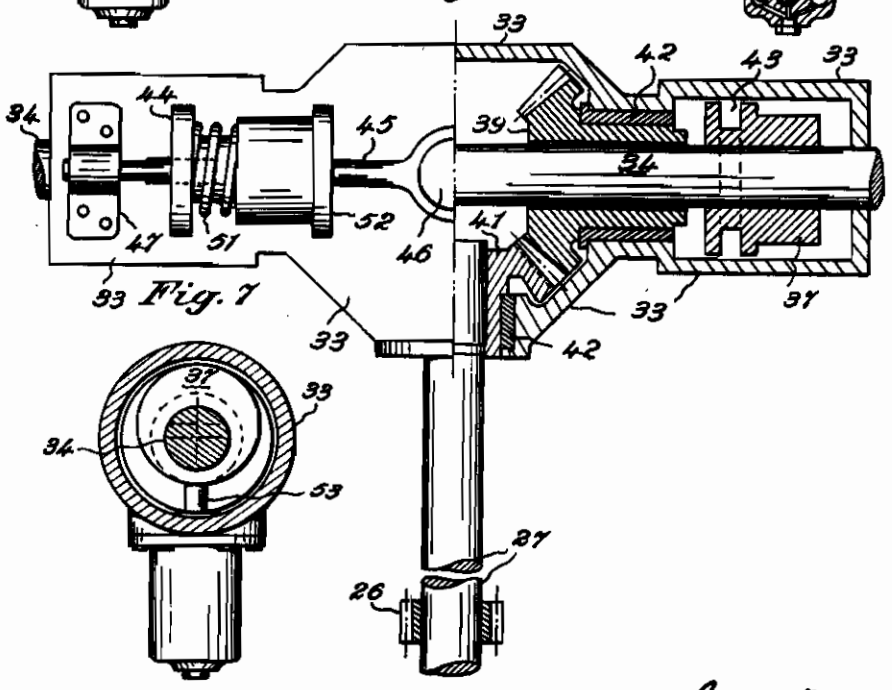


Fig. 6



33 Fig. 7

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ALIEN PROPERTY CUSTODIAN

CHANGE SPEED GEAR

Mario de Falco, Rome, Italy; vested in the Alien Property Custodian

Application filed August 26, 1939

The present invention relates to a change speed gear controlled by servomotors for the sequence of runnings.

The invention is illustrated in the accompanying drawings in which:

Fig. 1 shows the change speed gear in longitudinal section;

Figures 2, 3, 4, 5, 6, 7, 8 and 9 illustrate some details;

Fig. 10 is a schematic view of the whole.

The device comprises two or more similar, coaxial change elements A_1 A_2 A_3 . . . mounted in series in such a way that the driven axle of the first functions as a driving axle of the second and so on, all being enclosed in a general casing 3 divided in so many compartments as the number of elements by means of diaphragms 4 solidary to the casing.

Each element A consists of a driving shaft 1 and of a driven shaft 2, both coaxial, transmitting the motion to one another by means of the toothed wheels 5, 6, 7, 8, wheel 5 being solidary to the driving shaft 1, wheel 8 solidary to the driven shaft 2 and wheels 6 and 7 solidary to countershafts 9. These countershafts are in number of two or more, symmetrical with respect to the main shafts with their own axle parallel to the central axle of the change speed gear and their own supports 10 fixed to a drum 11, this drum being in its turn free to rotate around the main shafts 1 and 2 by means of bearings 12.

On both ends of each countershaft there are mounted two friction disks 14, which by means of keys 13 are obliged to turn with the countershaft, but they may be submitted to small axial displacements and normally they are against the supports 7 by spring 15 and regulating nuts 16. Two large disks 17 rotate solidarily with the drum 11, but conveniently guided, they may be axially displaced forward and backward with respect to drum 11. The outside band of the disks 17 presents a conical friction surface, the axle of which coinciding with the central axle of the change gear and the outside wall of the same disks 17 is provided with as many conical friction surfaces coaxial with the countershafts as the respective friction disks 14 are. The springs 18 freely crossing the drum 11 normally push the disks 17 against the disks 14 securing thus the contact of the relative friction surfaces with such a pressure as to brake and prevent the movement of the countershafts 9 with respect to the drum 11.

Two more drums 20 coaxial with the central axle of the change gear, conveniently guided may be displaced forward and backward in axial direction, but they cannot turn and are normally kept at a distance by convenient springs 19. Said drums 20 are provided towards their inside with a conical friction surface arranged in such a way as to come into contact with the outside surface of the disks 17 when the drums 20 are approached to one another as further on explained. In this case the drums 20 oblige the disks 17 to go backwards setting free the disks 14 and allowing them to turn freely while they remain blocked owing to the friction between 17 and 20. In the crown of each drum there is provided a circular groove 21 with projections 22 of a convenient length on the bottom. Fig. 4 shows the section of the bottom wall of said groove with relative projections and depressions developed for clearness' sake on the plane.

Two rings 24, they also coaxial with the central shafts of the change gear, each provided on the periphery with a toothed sector 25, may rotate in one sense or the other of a maximum angle determined by the length of the toothed sector by means of a pinion 28 engaging the said sector and keyed on the actioning shaft 27 connected to the servomotor. Each ring 24 is commonly provided with three projections 23 sliding on the bottom of the groove 21, the contact being kept owing to the action of the springs 19. The toothed sector 25 instead of being solidary with ring 24 may be submitted to small displacements by sliding along the guide 28, while said sliding is opposed by the pull off springs 29 acting on notches 30 provided on ring 24. Finally the general casing 3 containing all the elements of the change gear instead of being solidarily fixed to the body of the machine, utilising the change gear may be mounted thereon by means of any elastic suspension system with the object of yielding when there is a sudden increase of torque.

It is to be remarked that in each element of the change gear with the object of securing the uniform distribution of the load among the different transmission countershafts 9, there is provided an automatic adjusting device formed by mounting on each countershaft one at least of the planetary pinions 8 by means of helicoidal keys 31 conveniently inclined between a couple of springs 32 opposing the axial displacement of the pinion caused by the torsional strain. Object of this is to obtain through rotation the yielding of the pinion in order to avoid the overloading of the tooth due to imperfections of mounting by transmitting it on the contrary proportionally on the teeth of the pinions of the other countershafts.

The servomotor for controlling the change gear is illustrated in one of its possible forms of realisation in Figures 5 and 6 and substantially comprises a fixed casing 33 traversed by a shaft 34 whose slow motion of rotation is derived from the driving shaft in whatever way, for instance by means of a worm gear 35, 36 as shown in Fig. 10. On the shaft 34 there are mounted the two cams 37, 38 obliged to turn with shaft 34 by means of the relative keys, but they may be displaced axially on the same shaft. On the contrary the two coaxial pinions 39, 40 are simply slipped on the shaft 34, they are consequently freely turnable thereon, said pinions on their turn permanently engaging a third conical pinion 41 solidary to the end of the manoeuvering shaft 27 of the change gear. Suitable bearings 42 are interposed between the hubs of the pinions and casing 33.

The cams by being displaced axially may become solidary to the respective conical pinions by means of the toothed couplings 48, 49. The axial displacements of the cams 37, 38 are obtained by means of the two fork plates 44 inserted through clip connection in the circular groove 43 and solidary to the manoeuvering rod 45, which, by means of the handle 46 may be caused to slide forward or backward in the supports 47 fixed to the casing 33.

The plates 44 and consequently the rod 45, owing to the effect of the balanced springs 50, 51, which react against the fixed walls 52, are normally kept in an intermediary position of rest, in which, as the toothed couplings 48, 49 are both open, the conical pinions and consequently the manoeuvering shaft 27 remain in position of rest.

The displacement of the rod 45 by means of the handle 46 in one direction or the other of the shaft 34 produces either the closing or the toothed coupling 48, while coupling 49 remains open, or the closing of coupling 49 while the coupling 48 remains open, with consequent rotation on the right or left of the shaft 27 and consequently of all the pinions 26 and then definitely a well determined angular displacement of the rings 24 for each turn of the shaft 27 is obtained. When the handle 46 is left free, the maneuvering rod owing to the more compressed spring 50 or 51 is in condition to automatically return into the position of rest.

In correspondence to the two cams 37, 38 hold out two latches 53, pushed by the spring 54, constituting thus a special blocking device. In fact the stroke of said latches or bolts is a little smaller than the eccentricity of the cams 37, 38, the latches being subjected to a reciprocating motion during the rotation of the cams, whenever these cams present to the end of the latches their cylindrical surface. If, while the cams rotate, one of them is sufficiently displaced so as to surpass the end of the latch, this latch will prevent the cam from returning to the starting position during nearly its total turn, the short zone of eccentricity being excepted in correspondence of which the return is possible. On the other side the sufficient displacement of the cam cannot be realised if its coupling tooth is not in correspondence of the coupling cavity of the respective conical pinion. The consequence is that by pressing the controlling handle 46, this handle is not sufficiently displaced till the coupling tooth is entered into the corresponding cavity. When the displacement is at an end the release of the handle 46 does not directly produce the return of the cam and consequently the uncoupling, as meanwhile said cam in rotating has pressed to the latch the zone with an eccentricity greater than the minimum, but it may return backwards under the action of the spring 50 or 51 only when a turn of the cam is entirely completed, that is the return of the cam and the consequent uncoupling take place only for a determined angle position of the cam and then of the shaft 34 and obviously also the couplings can only occur in that same angle position of the cam and consequently of the shaft.

When owing to reasons of construction or incumbrance the phenomenon is wanted to be repeated two or more times during a turn of the cam it is obvious that it will be sufficient to provide the cam with two or more teeth and with two or more zones of minimum eccentricity.

Object of this combined device is to obtain always regular manoeuvres without the necessity of a particular attention of the driver on the duration of the manouvre since the exact duration is synchronically obtained in a turn through the coupling-cam-latch system. In other words the servomotor acts as a preselection or controlling device, the control being able to retard on the preselection at the almost during a turn of the cam. At the same time the device prevents that a manoeuvre already started may remain incomplete.

The whole servomotor has then the object to avoid hydraulic, pneumatic or electric installations, when they are required for other reasons; it is obvious that, should these reasons exist, said servomotor may be replaced by others of an already known type.

The functioning of the change speed gear occurs as follows and only for clearness' sake it is referred to the case illustrated in the accompanying drawings of a change gear comprising the elements $A_1A_2A_3$.

Each element of the change gear has two possibilities of running the one at a ratio, the other at synchronism. The running at a ratio is obtained when the protruding parts 23 of the rings 24 being in correspondence of the projections 22 of the grooves 21 keep the drums axially approached to one another and consequently closed the frictions between 17, 20 and open the frictions 14, 17. In this way the countershaft carrier drum 11 is obliged to stop and transmission takes place at a ratio through the wheels 5, 6, 7, 8.

The running at synchronism is on the contrary obtained when the protruding parts 23 by sliding on the projections 22 owing to the rotation of the manoeuvring shaft 26 and then to the angle displacement of the rings 24, happen to be in correspondence of the depressions between the subsequent projections. In this case the drums 20 owing to the action of the springs 19 are pushed towards the outside releasing the friction between 20, 17, while the disks 17 also pushed by the springs 18 close the frictions between 14, 17 making the countershafts solidary to the drums 11 now free to rotate on its own supports 12. In such a way the pinions 6, 7 not being able to rotate on their own axle operate by means of the teeth in engagement, a true direct coupling between the wheels 5 and 8 entraining in the rotation the drum 11 with a speed equal to the one of the shafts 1, 2, speed of synchronism.

By conveniently combining the two possible runnings for each element of the change gear A with the one of the other elements composing the whole gear a number of runnings, or speeds, may be realised much higher than the number of the-

elements and more exactly four runnings may be realised with two elements, eight runnings with three elements, sixteen runnings with four elements and so on.

With reference to the case illustrated in the drawings with three elements the possible combinations are the following

	1st element A_1	2nd element A_2	3rd element A_3	Speed or ratio
1st running	At ratio	At ratio	At ratio	q^7
2nd running	do	do	At synchronism	q^6
3rd running	do	At synchronism	At ratio	q^5
4th runnidg	do	do	At synchronism	q^4
5th running	At synchronism	At ratio	At ratio	q^3
6th running	do	do	At synchronism	q^2
7th running	do	At synchronism	At ratio	q^1
8th running	do	do	At synchronism	$q^0=1:1$

If the gear ratios of the three elements are in proportion to one another as $q^4:q^2:q^1$ the eight general runnings or ratios will have the values indicated in the last column of the preceding table.

The servomotor, as mentioned, by setting in rotation the driving shaft **27**, secures by means of the pinions **26** and toothed sectors **25** the simultaneous and equal angle displacement of all the rings **24** and consequently of the relative protruding parts **23**. It will then be sufficient to conveniently dispose the shape of the grooves **21**, that is lengths of projections and depressions, so that at the end of each angle displacement of the rings **24** the protruding parts **23** are found in each single change element either in correspondence of the projections (running at ratio) or in correspondence of the depressions (running at synchronism) according to the preestablished order.

Fig. 4 shows by way of example the shape of the three couples of rings **24** in a change gear of three elements in order to obtain the combinations reported in the preceding table and the disposition of the protruding parts **23** at the end of the eight angle displacements which realise the eight runnings indicated by Roman numbers I, II, III, IV, VI, VII and VIII.

It is evident that the passage from one running to the other takes place in a direction or the other always, however, according to the preestablished order, that is by passing from one running to another without passing through the intermediary one. It is furthermore evident that the toothed sector being strictly limited to the total angle displacement, this being the sum of the single displacements necessary for the maximum number of the runnings allowed, it is not possible effecting further displacements beyond the extreme runnings when even through inadvertence or other causes the manoeuvring handle on the servomotor should be still in a working position.

The passage from one running to the other is effected as follows:

The handle **46** of the servomotor is pushed in the convenient direction till the perception is acquired of the coupling of the cam tooth, an instant afterwards the handle being released. The control is produced during the rotation of the cam **37** or **38** which will be released from its own pinion only when the manoeuvre is over. Should subsequent rash controls for hard accelerations or retardations be wanted the handle is kept displaced till the wanted speed is obtained.

The servomotor simplifies the control extraordinarily even when this control should take place at distance as in the case of railway driving machines running in double traction. In fact in this case only the control in one sense or in the other is allowed in order to obtain any speed whatever and the repetition of the same control is allowed to pass to subsequent speeds instead of effecting successive controls through successive circuits.

The advantages obtained by employing the speed control above specified and make it especially suitable for high powers may be summed up as follows:

(*a*) Toothed wheels always engaged,

(*b*) Subdivision of the effort to be transmitted on multiple countershafts with evident economy of material, greater balance and duration especially for high powers,

(*c*) Possibility of arranging the bearings very near to the gears,

(*d*) Absence of epicycloidal and hypocycloidal movements during power transmission,

(*e*) No interruption of driving power during the working of the change gear,

(*f*) Possibility of obtaining with few change elements many degrees of speed.

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