

April 24, 1928.

1,667,640

W. STROUD
 APPARATUS FOR THE CONVERSION OF MOTION ACCORDING
 TO ONE LAW INTO MOTION ACCORDING TO ANOTHER LAW
 Filed Feb. 1, 1924 2 Sheets-Sheet 1

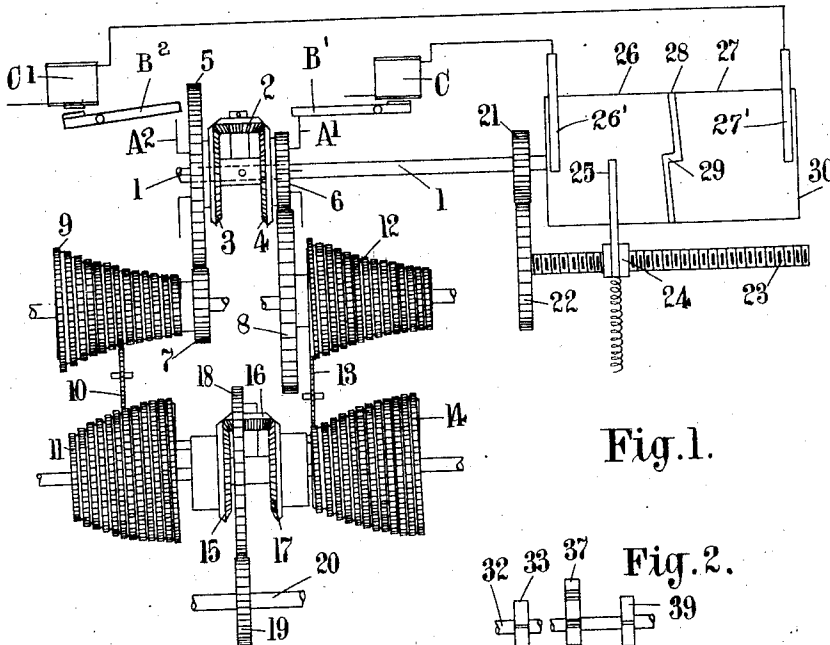


Fig. 1.

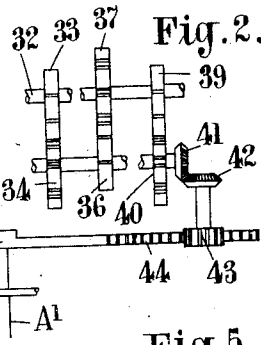


Fig. 2.

Fig. 3.

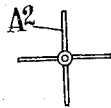
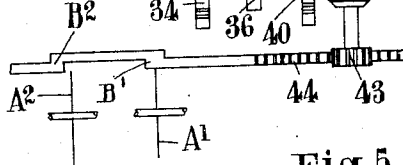


Fig. 5.

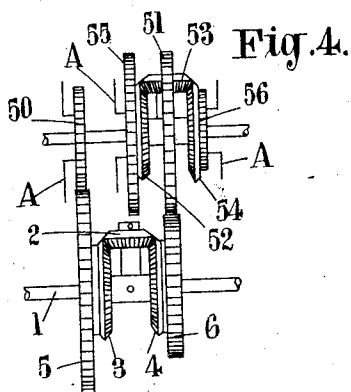
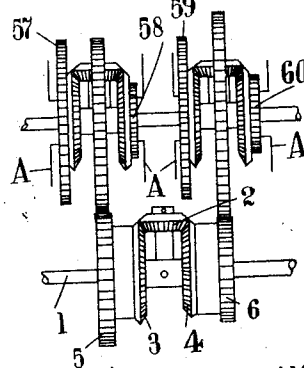


Fig. 4.



INVENTOR:-

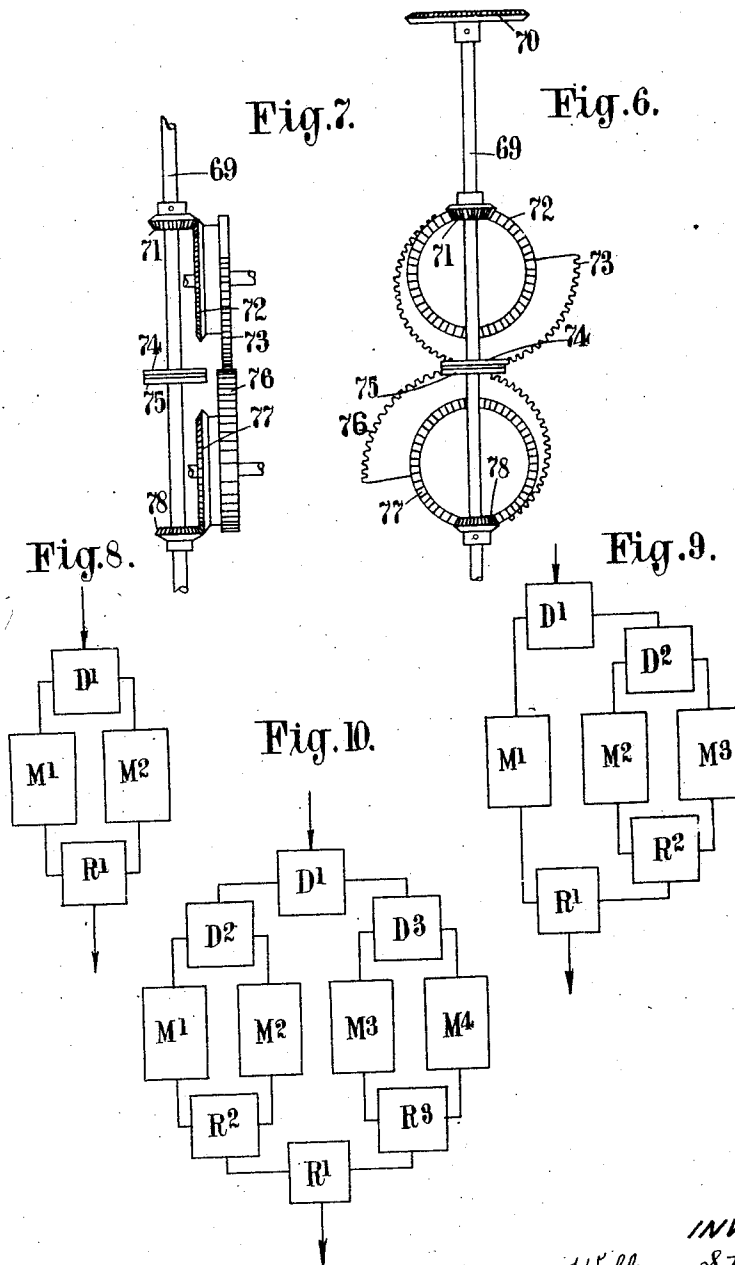
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UNITED STATES PATENT OFFICE.

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APPARATUS FOR THE CONVERSION OF MOTION ACCORDING TO ONE LAW INTO MOTION ACCORDING TO ANOTHER LAW.

Application filed February 1, 1924, Serial No. 689,885, and in Great Britain February 2, 1923.

This invention refers to improved means for the conversion, within the limits of a prescribed extent of movement, of motion according to one law into motion according to another law. For example, it refers to means for the conversion of motions in accordance with those of the working head of a constant base rangefinder—which commonly follow the reciprocal law with reference to changes in range—into motions proportional to the changes of ranges, i. e. the conversion of motions according to a reciprocal scale into motions according to a uniform scale; or again for the conversion of motions according to a uniform scale of ranges into motions according to a scale of gunsight elevations corresponding to the ranges; or for other purposes.

In mechanisms for effecting such transformations of motions a difficulty arises when the velocity-ratio varies over wide limits at different parts of the transformation, e. g. to convert a reciprocal scale of ranges extending from 3,000 to 30,000 yards into a uniform scale, the velocity-ratio varies from 1 to 100. When conversion of this extent of movement is done in one stage the sizes of the parts are necessarily great. To avoid this, gear has been devised, by which a conversion is effected in two steps, each, say, of 1 to 10 by two trains of mechanism in series one with the other both of which act together simultaneously.

The requirements of modern gunnery demand, however, continually increasing ranges and continually increasing accuracy.

The object of the present invention is generally to meet these new requirements. Further, to produce apparatus without unduly increasing the size, and in which the power required for operation may be reduced.

According to this invention apparatus is provided for the conversion, within the limits of a prescribed extent of movement, of motion according to one law into motion according to another law, comprising conversion mechanisms, operable for converting motion according to one law into motion according to another law, each such conversion mechanism being operable for conversion of a separate portion and one and the same portion only, of the prescribed extent of movement, the sum of the separate portions constituting the prescribed extent of move-

ment, a driving element rotatable according to the prescribed extent of movement to be converted, means for transmitting from the driving element motion according to the portions of movement to be converted, each to its apportioned conversion mechanism respectively, separately and in succession, a driven element rotatable according to the prescribed extent of movement converted, and means for transmitting to the driven element motion according to the portions of movement converted, each from its apportioned conversion mechanism respectively, separately and in succession.

Suppose it is desired to convert a reciprocal scale from 2,000 yards to 32,000 yards into a uniform scale between the same limits, involving variations in velocity-ratio amounting to as much as $1:16^2$ or $1:256$. By the present invention this is accomplished by means of a number of separate conversion mechanisms of which one only is free to operate at one time. Thus, for example, with two mechanisms the first may effect the conversion from say 2,000 yards to 8,000, in which the velocity-ratio will be only $1:4^2$ or $1:16$, while the second operates from 8,000 yards to 32,000 with the same velocity-ratio. In the case of three mechanisms the first may cover the part 2,000 to 5,040, the second 5,040 to 12,700, the third from 12,700 to 32,000, in each of which the velocity-ratios will be as $1:6.35$. In the case of four mechanisms the first may cover the part 2,000 to 4,000, the second, 4,000 to 8,000, the third 8,000 to 16,000 and the fourth 16,000 to 32,000 with in each case a variation of velocity-ratio of only $1:4$.

In the case of the conversion from a reciprocal to a uniform scale the conversion means (say helico-spiral gears connected by a travelling idle wheel as in Figure 1 of United States Patent No. 1,159,463, parts 5, 7, 8, or spirals gearing directly with one another as shown e. g. in Figures 8, 9, 10 and 11 of United States Patent No. 1,322,751) may be arranged to be replicas the one of another. In other cases e. g. for the conversion from a uniform scale of ranges into the appropriate angular elevation of a gun, it may be necessary to construct suitable mechanism for each part of the conversion.

Some examples of construction according

to this invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is an illustration partly in section of apparatus comprising two separate mechanisms.

Figure 2, Figure 4 and Figure 5 are views illustrating modifications.

Figure 3 is another view of part of the mechanism shown in Figure 2.

Figure 6 is a side view and Figure 7 is an end view illustrating a further modification.

Figures 8, 9 and 10 are diagrams of apparatus to be described.

The invention will be described as applied to the conversion of a uniform scale of ranges into a reciprocal scale.

In the apparatus illustrated at Figure 1, shaft 1 is rotatable in conformity with motion according to one law, which in the example to be described is in conformity with change of range according to a uniform scale. Toothed bevel 2 is carried by shaft 1 and turns with it, bevel 2 being rotatable about an axis perpendicular to the axis of shaft 1. Bevels 3 and 4 gear with bevel 2, bevels 3 and 4 being rotatable about the axis of shaft 1. The three bevels 3, 2, 4, form an ordinary differential gear. Gear wheel 5 rotates with bevel 3 and gear wheel 6 rotates with bevel 4. Wheel 6 has a detent A^1 , and wheel 5 has a detent A^2 . Holder B^1 is engageable with detent A^1 , and when in engagement prevents wheels 6 and 4 from rotating. Holder B^2 is engageable with detent A^2 , and when in engagement prevents wheels 5 and 3 from rotating. Means, examples of which will be described later, are provided for bringing the holder B^1 into engagement with detent A^1 while keeping B^2 out of engagement with detent A^2 , and vice versa. The associated elements so far described are for distributing motion to be converted obtained from shaft 1 to 5 or 6, distributing it to 5 or to 6 according to whether 6 or 5 is prevented from rotating. Thus, when 5 is held 6 is free to rotate, motion of shaft 1 being then transmitted to 6, and when 6 is held 5 is free to rotate, motion of shaft 1 being then transmitted to 5.

Gear wheel 5 meshes with gear wheel 7. Toothed helico-spiral member 9 rotates with wheel 7. Travelling gear wheel 10 meshes with member 9. Toothed helico-spiral member 11 meshes with gear wheel 10. The members 9, 11 and gear 10 represent a known form of conversion mechanism, see United States Patent 1,159,463, suitable for converting, within the limits of a prescribed extent of movement, motion according to one law into motion according to another law. Gear wheel 6 meshes with gear wheel 8 and toothed helico-spiral member 12 rotates with wheel 8. Toothed helico-

spiral member 12, travelling gear wheel 13 and toothed helico-spiral member 14 represent conversion mechanism similar to 9, 10 and 11. The gear ratios 5 and 7 are different from 6 and 8. These conversion mechanisms are for converting motion according to a uniform scale derived from wheels 5 and 6 into motion according to a reciprocal scale, the mechanism 9, 10 and 11 being for converting motion derived from 5, and the mechanism 12, 13 and 14 for converting motion derived from 6. Thus, with gear wheel 10 at the extreme left, and gear wheel 13 at the position shown, which is the extreme left, holder B^1 engaged with detent A^1 , preventing wheel 6 from rotating, holder B^2 disengaged from detent A^2 , permitting wheel 5 to rotate, rotation of shaft 1 causes wheel 5 only to rotate and the mechanism 9, 10 and 11 only to operate, in the process of which wheel 10 travels to the right and when it reaches the extreme right the conversion of motion for the extent of movement to which the mechanism 9, 10, 11 is limited is thereby completed. When this is accomplished, holder B^2 is engaged with detent A^2 , preventing wheel 5 from rotating, and holder B^1 disengaged from A^1 , permitting wheel 6 to rotate, and continued rotation of shaft 1 now causes wheel 6 only to rotate and the mechanism 12, 13 and 14 only to operate, in the process of which wheel 13 travels to the right and when it reaches the extreme right the conversion of motion for the extent of movement to which the mechanism 12, 13, 14 is limited is thereby completed. In the operation of these two mechanisms the members 11 and 14 rotate each according to a reciprocal scale. The helico-spiral members 11 and 14 are co-axial, rotating about what will be termed a principal axis.

Bevel 15 rotates with member 11 and bevel 17 rotates with member 14. Bevel 16 gears with bevels 15 and 17 and rotates about an axis perpendicular to said principal axis, and turns about the principal axis. Gear wheel 18 rotates about the principal axis and rotates with the turning of 16. The three bevels 15, 16, 17, form an ordinary differential gear, and are for collecting motion which has been converted obtained from helico-spiral members 11 and 14. Thus, gear 16 is caused to turn, and with it wheel 18 to rotate about the principal axis by motion obtained from 11 when mechanism 9, 10, 11 is operating, and by motion obtained from 14 when mechanism 12, 13, 14 is operating.

The extent of movement which is capable of conversion with the apparatus depends upon the length of gears on the helico-spiral members 9, 11 and 12, 14, and the prescribed extent of conversion is dealt with in two portions. Thus, starting from the lowest

range, with gear 10 at the extreme left, the first portion of conversion is performed by mechanism 9, 10, 11 in the process of which gear 10 travels from the extreme left to the extreme right, and the second portion of conversion is performed by mechanism 12, 13, 14 in the process of which gear 13 travels from the extreme left to the extreme right, the change over occurring when an intermediate range between the lowest and highest range is reached, say, when a range is reached corresponding to the middle point of the reciprocal scale according to which the conversion is being made. Similarly conversion from high to lower ranges may be performed with the change over occurring when conversion is continued through the intermediate range. Gear wheel 18 rotates gear 19 and shaft 20 rotates with 19. A frictional drive may, if necessary, be applied from shaft 1 to gear 18 or to shaft 20.

Some examples of means for controlling the actions of holders B^1 B^2 will now be described. The means provided may for example be actuated electrically as in Figure 1 or mechanically as in Figures 2 and 3.

In Figure 1 toothed wheel 21 rotates with shaft 1, toothed wheel 22 is rotated by 21. Screw 23 rotates with wheel 22 and carries nut 24 with brush 25. Contact drum 30 rotates with shaft 1 and is divided into two electrically conducting parts 26 and 27 with an insulated path 28 between them. The path 28 is formed with what will be termed a gate 29. Brush 26¹ bears on part 26 and brush 27¹ on part 27, electromagnet C is in circuit with 26¹ and magnet C¹ in circuit with 27¹. The magnets C C¹ when energized operate each to bring its associated holder into engagement, B^1 with detent A¹, and B^2 with detent A², and when not energized each allows its holder to become disengaged. In the conditions illustrated at Figure 1, brush 25 is upon part 26, magnet C is energized, holder B^1 is engaged with detent A¹, magnet C¹ is not energized and holder B^2 is not engaged with detent A². Thus, wheel 5 is free to rotate and wheel 6 is held against rotation, and with conversion due to operation of mechanism 9, 10, 11 proceeding to higher ranges, nut 24 travels to the right, taking brush 25 with it, in the process of which brush 25 passes on to gate 29 of path 28 and bridges it causing magnet C¹ to be energized whereby the operation of mechanism 9, 10, 11 is stopped. Brush 25 is now in contact with 26 and 27 and both magnets C C¹ are energized, whereby wheel 5 and wheel 6 are both held against rotation until brush 25, in travelling to the right, has passed out of contact with 26, whereupon magnet C becomes de-energized, holder B^1 disengaged from detent A¹, wheel 6 free to rotate and mechanism 12, 13, 14 to operate. Thus, in continued travel to the right brush

25 is in contact with 27 only, holder B^1 is disengaged from A¹, holder B^2 engaged with A², wheel 5 is held against rotation and wheel 6 free to rotate. The change over to be effected, which in this example is effected as brush 25 passes over gate 29, must be arranged to occur when conversion by mechanism 9, 10, 11 to higher ranges is completed and conversion by mechanism 12, 13, 14 is to begin, and vice versa if proceeding from higher to lower ranges.

When wheels 5 and 6 are momentarily held shock to the apparatus as may occur, can be reduced by the drive applied to bevel 2 being transmitted, say, from shaft 1 through a spring device which under normal conditions will produce a positive drive without lag, but when excessive resistance occurs will yield, whereby shaft 1 can turn through a small angle, carrying drum 30 with it, although wheels 5 and 6 are both held. As soon as brush 25 passes clear of gate 29 one or other of the mechanisms 9, 10, 11 or 12, 13, 14 is released for operation.

The apparatus illustrated at Figure 1, conforms to the general description given of the invention in that it comprises conversion mechanisms 9, 10, 11 and 12, 13, 14, operable for converting motion according to one law into motion according to another law, each such conversion mechanism being operable for conversion of a separate portion and one and the same portion only, of the prescribed extent of movement, the sum of the separate portions constituting the prescribed extent of movement, a driving element, shaft 1 or bevel 2, movable according to the prescribed extent of movement to be converted, means, differential gears 2, 3, 4, gears 5, 7, and gears 6, 8, detents A¹, A², holders B^1 , B^2 and their control, for transmitting from the driving element motion according to the portions of movement to be converted, each of its apporportioned conversion mechanism respectively, separately and in succession, a driven element shaft 20 or wheels 19 or 18 or bevel 16 movable by the conversion mechanisms according to the prescribed extent of movement converted, and means, differential gear 15, 16, 17 and its control, for transmitting to the driven element motion according to the portions of movement converted, each from its apporportioned conversion mechanism, respectively, separately and in succession.

The mechanical means for controlling the actions of holders B^1 , B^2 illustrated at Figures 2 and 3 will now be described. As in Figure 1 the detents A¹ A² are associated with wheels 6 and 5 and B^1 B^2 are the holders therefor. Shaft 32 rotates with shaft 1. Shaft 32 has a wheel 33 the first of a train comprising gear wheels, 33, 34, 36, 37, 39 and 40, of which 33, 36 and 39 each have, say, one tooth, the others each having ordinary teeth. Bevel 41 rotates with wheel 40 bevel 42 gears

with 41, gear 43 rotates with 42 and rack 44 gears with 43. Rack 44 is formed with an extension provided with holders B^1 B^2 , B^1 engageable with detent A^1 , and B^2 engageable with detent A^2 , and in one position B^1 and B^2 are engageable both at one and the same time. Thus, in application to apparatus as described with reference to Figure 1, when wheel 32, rotating with shaft 1, makes one revolution wheel 37 is advanced one step and finally wheel 40 is advanced one step thereby slightly rotating 41, 42, 43 and thereby moving rack 44 and with it the holders B^1 B^2 . In one position of the holders B^1 B^2 the position for change over, both detents A^1 and A^2 are engaged, this position occurring when the change over, as explained with reference to Figure 1, is to be effected, and movement of B^1 and B^2 by rack 44 causes either B^1 or B^2 to pass out of engagement with its detent, the other remaining engaged. Thus, the motion imparted to rack 44 transmitted by the train of gear from shaft 1, must be so apportioned that the position for change over is reached when mechanism 9, 10, 11 has completed conversion and mechanism 12, 13, 14 is to begin, and vice versa.

Figures 4 and 5 show how three or four sets of mechanisms may be used. In these views parts 1, 2, 3, 4, 5, 6 are, as in Figure 1. In Figure 4, 5 gears with 50, and 6 with 51 carrying the planet 53 of the differential gear 52, 53, 54. One conversion mechanism is geared to 50, a second to a gear 55 which rotates with 52 and a third to a gear 56 which rotates with 54, similar to the arrangement shown in Figure 1 for two mechanisms. Similarly in Figure 5 with two differential gears, four gear wheels, 57, 58, 59 and 60, can be associated with four separate mechanisms, one with each. In Figures 4 and 5 detents A are indicated on the members which are required to be held.

Figure 6 represents a side view and Figure 7 an end view of one separate mechanism in which spirals are used instead of helico-spiral gears as in Figure 1. When this mechanism is in operation over a part of the reciprocal scale, the bevel 70 is rotated through angles proportional to the change in range. 70 is fixed to shaft 69 to which is also fixed bevel 71 gearing with bevel 72 and thereby rotating toothed spiral 73 gearing with toothed spiral 76 carrying bevel 77 driving bevel 78 whose motion is communicated to the reciprocal scale. 74 and 75 represent friction discs which may be provided to assist in the drive.

In Figures 8, 9 and 10, D^1 , D^2 , D^3 , designate differential means for distributing motion differential means, M^1 , M^2 , M^3 , M^4 , conversion of motion mechanisms, say, of the helico-spiral, spiral or other type of conversion mechanism, and R^1 , R^2 , R^3 , differential

means for collecting motion. In Figure 8 which represents a system such as described with reference to Figure 1, motion applied to D^1 , operates through, say, firstly M^1 and R^1 and secondly M^2 and R^1 . In Figure 9 which represents a system such as described with reference to Figure 4, motion applied to D^1 operates through, say, firstly, M^1 and R^1 , secondly D^2 , M^2 , R^2 and R^1 , and thirdly D^2 , M^3 , R^2 and R^1 . In Figure 10 which represents a system such as described with reference to Figure 5, motion applied to D^1 operates through, say, firstly, D^2 , M^1 , R^2 and R^1 , secondly D^2 , M^2 , R^2 and R^1 , thirdly D^3 , M^3 , R^2 and R^1 , fourthly D^3 , M^4 , R^2 and R^1 .

I claim:—

1. Apparatus for the conversion, within the limits of a prescribed extent of movement, of motion according to one law into motion according to another law, comprising conversion mechanism of the rotary member type, operable for converting motion according to one law into motion according to another law, each such conversion mechanism being operable for conversion of a separate portion and one and the same portion only, of the prescribed extent of movement, the sum of the separate portions constituting the prescribed extent of movement, a driving element rotatable according to the prescribed extent of movement to be converted, means for transmitting from the driving element motion according to the portions of movement to be converted, each to its apportioned conversion mechanism respectively, separately and in succession, a driven element rotatable according to the prescribed extent of movement converted, and means for transmitting to the driven element motion according to the portions of movement converted, each from its apportioned conversion mechanism respectively, separately and in succession.

2. Apparatus for the conversion, within the limits of a prescribed extent of movement, of motion according to one law into motion according to another law, comprising conversion mechanisms of the helico-spiral member type, operable for converting motion according to one law into motion according to another law, each such conversion mechanism being operable for conversion of a separate portion and one and the same portion only, of the prescribed extent of movement, the sum of the separate portions constituting the prescribed extent of movement, a driving element rotatable according to the prescribed extent of movement to be converted, means for transmitting from the driving element motion according to the portions of movement to be converted, each to its apportioned conversion mechanism respectively, separately and in succession, a driven element rotatable according to the prescribed extent of movement converted, and means

for transmitting to the driven element motion according to the portions of movement converted, each from its apportioned conversion mechanism respectively, separately and in succession.

3. Apparatus for the conversion, within the limits of a prescribed extent of movement, of motion according to one law into motion according to another law, comprising two conversion mechanisms of the helicospiral member type, operable for converting motion according to one law into motion according to another law, each such conversion mechanism being operable for conversion of a separate portion and one and the same portion only, of the prescribed extent of movement, the sum of the two separate portions constituting the prescribed extent of movement, a driving element rotatable according to the prescribed extent of movement to be converted, means for transmitting from the driving element motion according to the portions of movement to be converted, each to its apportioned conversion mechanism respectively, separately and in succession, a driven element rotatable according to the prescribed extent of movement converted, and means for transmitting to the driven element motion according to the portions of movement converted, each from its apportioned conversion mechanism respectively, separately and in succession.

4. Apparatus for the conversion, within the limits of a prescribed extent of movement, of motion according to one law into motion according to another law, comprising conversion mechanisms of the rotary member type, operable for converting motion according to one law into motion according to another law, each such conversion mechanism being operable for conversion of a separate portion and one and the same portion only, of the prescribed extent of movement, the sum of the separate portions constituting the prescribed extent of motion, a driving shaft rotatable according to the prescribed extent of movement to be converted, means for transmitting from the driving shaft rotary motion according to the portions of movement to be converted, each to its apportioned conversion mechanism re-

spectively, separately and in succession, a driven element rotatable according to the prescribed extent of movement converted, and means for transmitting to the driven element rotary motion according to the portions of movement converted, each from its apportioned conversion mechanism respectively, separately and in succession.

5. Apparatus for the conversion, within the limits of a prescribed extent of movement, of motion according to one law into motion according to another law, comprising two, a first and a second, conversion mechanisms of the rotary member type, operable for converting motion according to one law into motion according to another law, each such conversion mechanism being operable for conversion of a separate portion and one and the same portion only, of the prescribed extent of movement, the sum of the two separate portions constituting the prescribed extent of movement, a driving shaft rotatable according to the prescribed extent of movement to be converted, a differential device having its third element turnable by the driving shaft, its first element in driving connection with the first conversion mechanism and its second element in driving connection with the second conversion mechanism, and having control means for permitting and preventing rotation of the first and second elements, said differential device being operable for transmitting from the driving shaft rotary motion according to the portions of movement to be converted, the first element of the device rotating when transmitting to the first conversion mechanism, the second element rotating when transmitting to the second conversion mechanism, separately and in succession, a driven element rotatable according to the prescribed extent of movement converted, and differential gear for transmitting to the driven element rotary motion according to the portions of movement converted, each from its apportioned conversion mechanism respectively, separately and in succession, substantially as set forth.

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