United States Patent [19]

Beezer

[11] 3,869,924

[45] Mar. 11, 1975

[54] **DEVICE FOR TRANSMITTING ACCURATE TRANSLATIONAL AND ROTARY MOVEMENTS**

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[73] Assignee: **Stelron Cam Company,** Saddle Brook, N.J.

[22] Filed: **Feb. 11, 1974**

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[52] **U.S. Cl.** **74/24,** 74/57, 74/567

[51] **Int. Cl.** **F16h 27/04**

[58] **Field of Search** 74/22, 24, 57, 23, 56, 74/567

[56] **References Cited**

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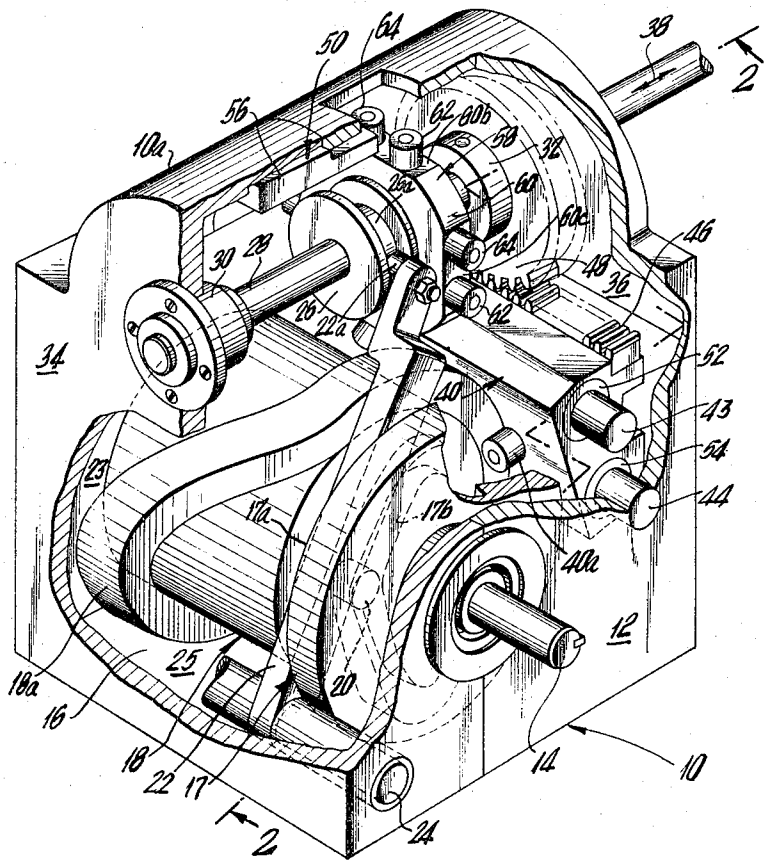
3,731,545 5/1973 Beezer 74/24

Primary Examiner—Wesley S. Ratliff, Jr.

[57] **ABSTRACT**

A device for transmitting accurate translational and rotary movements includes a rotary input shaft on which is mounted a rotary driving cam which is engaged with a pivotal follower carried on a lever which is pivotally mounted at its one end and has said follower intermediate its length so that the lever is moved backwardly and forwardly. The lever carries a drive roller at its outer end which engages in an annular slot of a disc carried on an output shaft and oscillation of the lever by movement of the cam causes a back and forward axial displacement of the output shaft. Rotary movement is imparted to the output shaft after it first moves through a path in which it is constrained against rotary movement by two roller members which are carried on a fixation piece affixed to the shaft and which are guided on respective sides of an elongated keyway of the housing. The rollers move out of engagement with the keyway after a pinion gear carried on the shaft is moved into meshing engagement with a rack which is carried on a slide which is mounted for movement backwardly and forwardly on one or more guide rods. The slide also carries a follower which is moved by a different cam part and, when it is in meshing engagement with the pinion gear, it produces a controlled rotation of the output shaft. A ribbed barrel cam is employed for effecting accurate rotational movement of the output shaft through the use of two roller followers arranged on respective sides of the ribbed cam and which are preloaded against the cam. The rack is arranged so that it is at a slight angle in respect to the horizontal so that it provides an easy entry of the sliding rotatable pinion gear and meshes therewith without interference after engagement.

12 Claims, 8 Drawing Figures



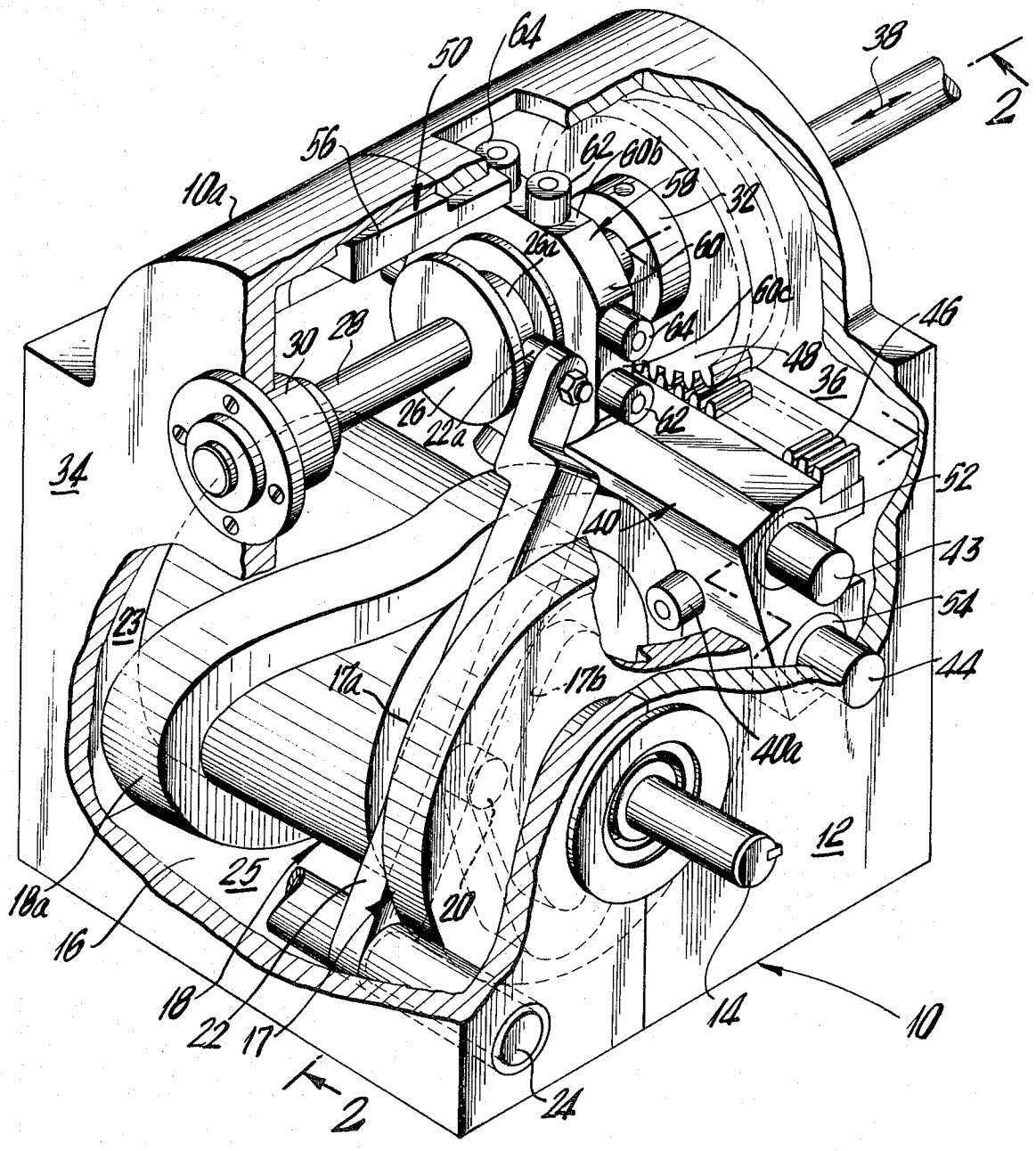

50
64
38
2
56
62
60b
58
32
10a
26a
60
60c
64
46
30
28
48
36
26
22a
62
34
52
40
43
54
44
23
17a
17b
40a
12
25
18a
20
16
18
22
17
2
14
10
24

FIG. 1

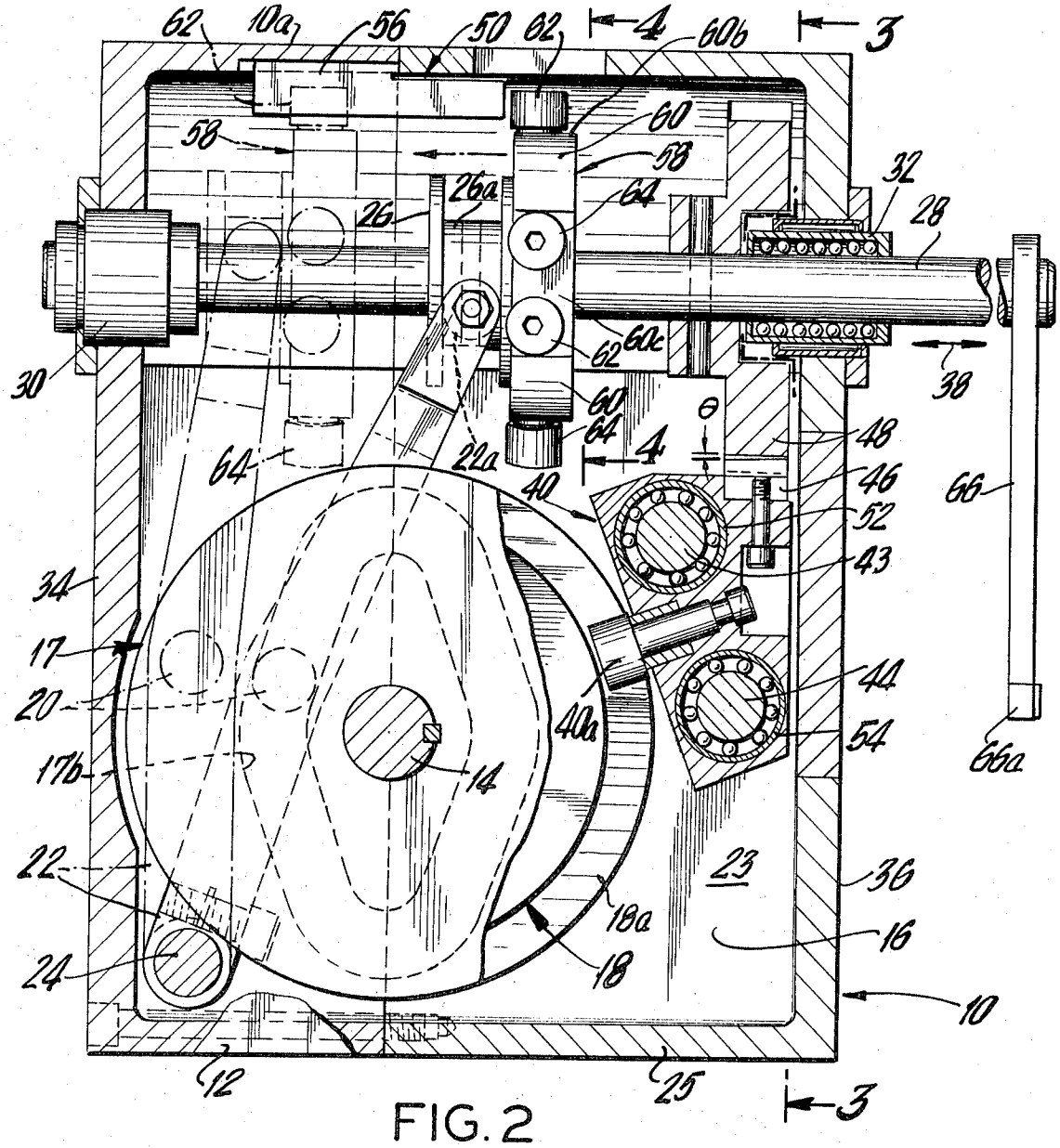

62
10a
56
50
62
4
60b
3
58
60
58
32
64
26a
26
28
30
62c
38
60
θ
64
4
48
64
22a
40
46
66
52
34
43
17
20
44
40a
54
66a
17b
14
22
23
36
18a
16
24
18
10
12
25
3

FIG. 2

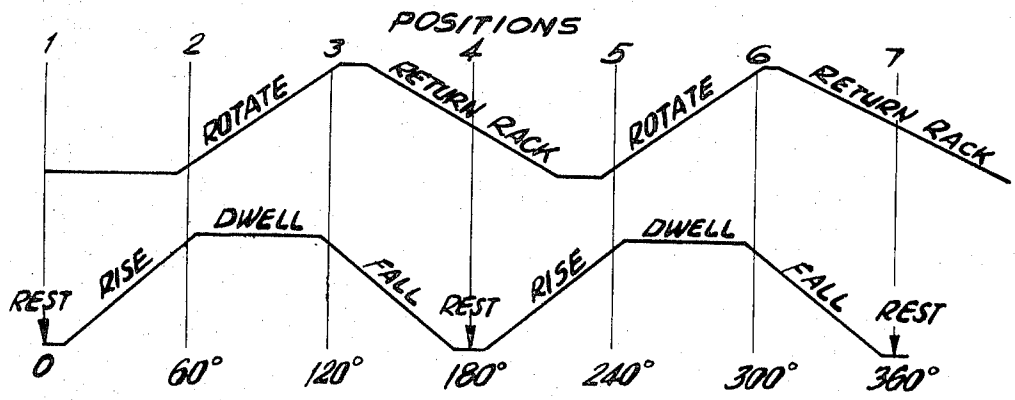

POSITIONS
1
2
3
4
5
6
7
ROTATE
RETURN RACK
ROTATE
RETURN RACK
DWELL
DWELL
REST
RISE
FALL
REST
RISE
FALL
REST
0
60°
120°
180°
240°
300°
360°

FIG. 5

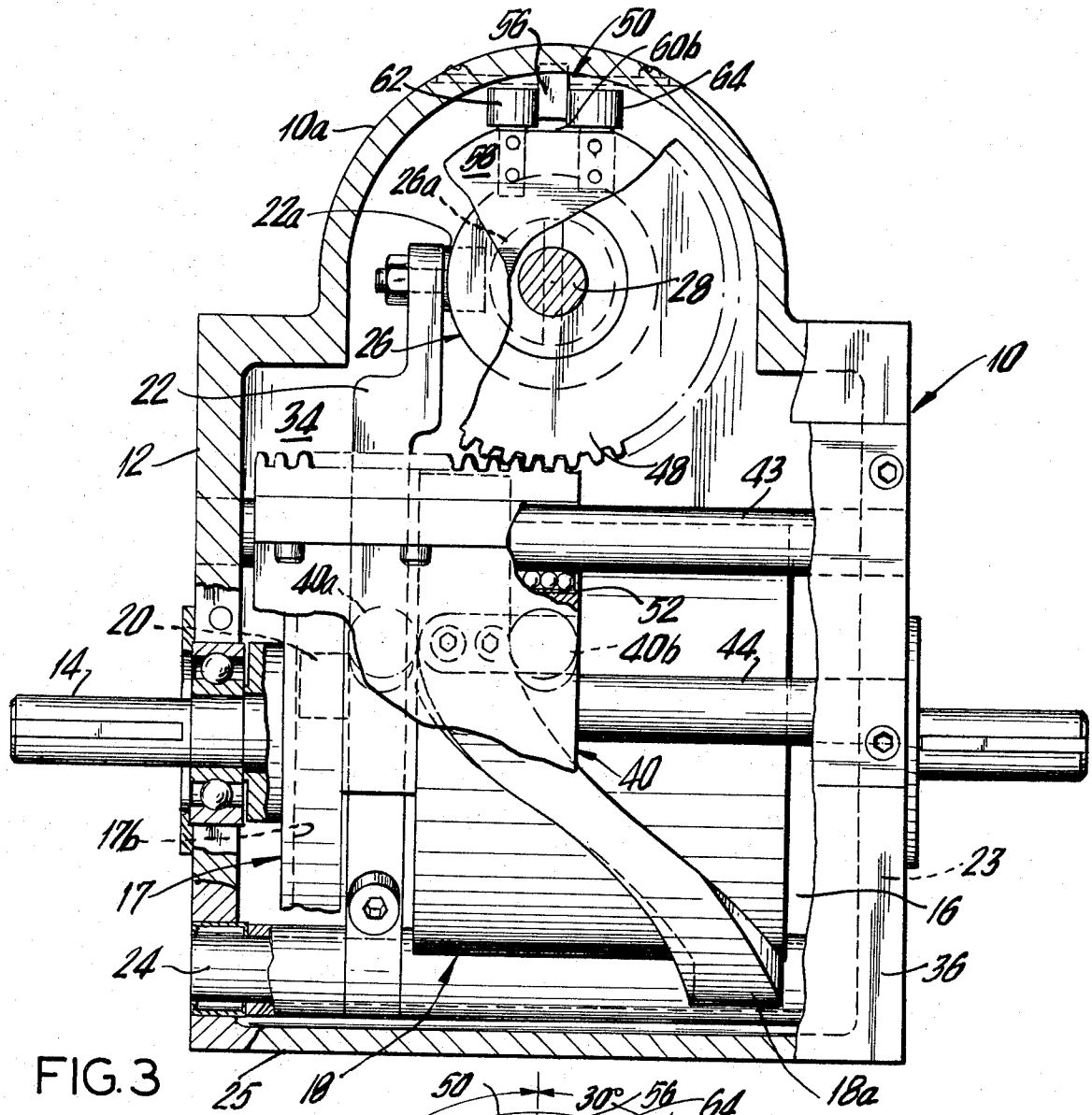


FIG. 3

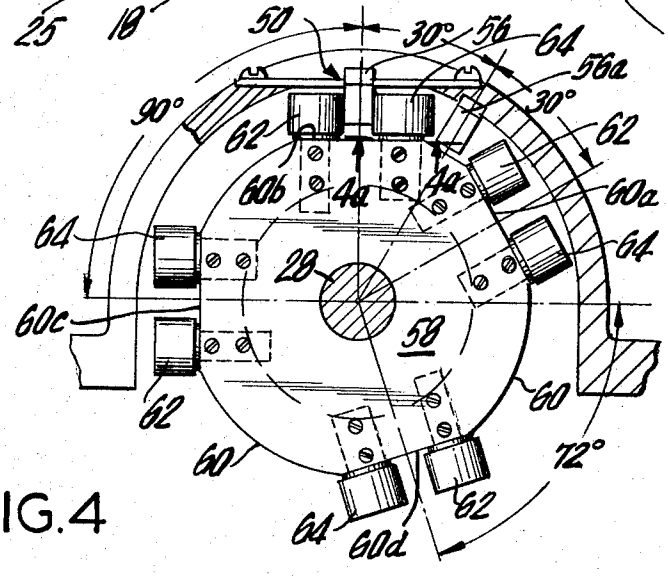


FIG. 4

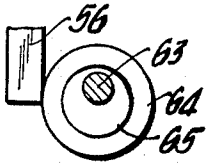


FIG. 4a

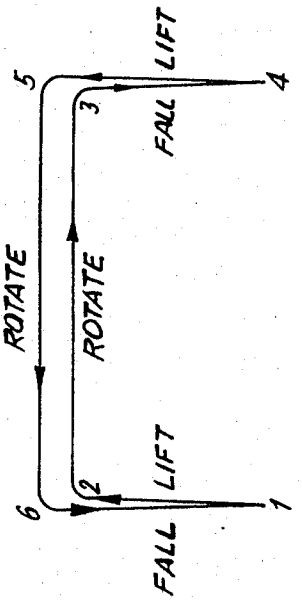

ROTATE
ROTATE
LIFT
FALL
LIFT
FALL
1
2
3
4
5
6

FIG. 6

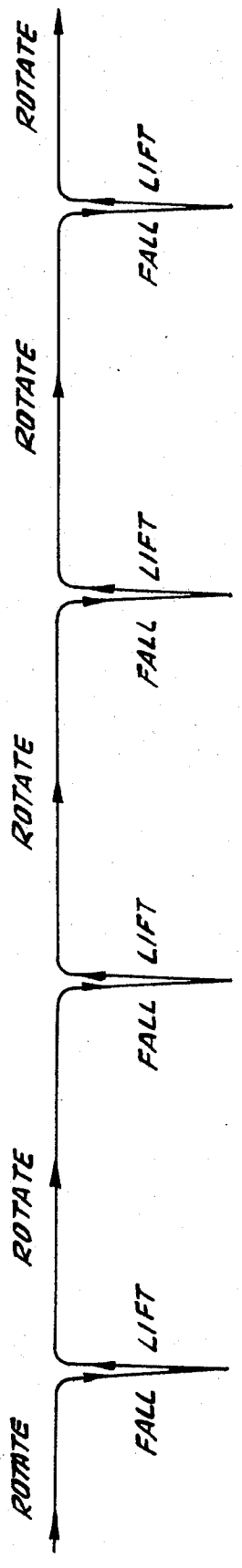

ROTATE
FALL
LIFT
ROTATE
FALL
LIFT
ROTATE
FALL
LIFT
ROTATE
FALL
LIFT
ROTATE

FIG. 7

DEVICE FOR TRANSMITTING ACCURATE TRANSLATIONAL AND ROTARY MOVEMENTS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to the construction of automatic motion transmitting machines and, in particular, to a new and useful device for transmitting accurate translational and rotary movements to an output shaft from a rotary input shaft.

2. Reference to Prior Issued Patent

The present invention is an improvement over the invention disclosed and claimed in U.S. Pat. No. 3,731,545 by the present inventor in respect to the means for controlling the rotational movement of the output shaft and in respect to the construction which permits a wider selection of the start and stopping of the rotational movement.

DESCRIPTION OF THE PRIOR ART

As indicated in U.S. Pat. No. 3,731,545, it is known to provide a mechanism for transmitting accurate translational and rotary movements from a rotary input shaft to an output shaft. With the known device, the movement is transmitted from rotary cams on the input shaft to effect a translatory movement of the output shaft or a shifting of the output shaft in an axial direction. The apparatus includes means for guiding the shaft axially so as to prevent its rotation until a driving pinion on the output shaft is moved into meshing engagement with a quadrant gear. A device of this character operates satisfactorily to produce most rotational and translatory movements, but in some instances it is desirable that the rotary drive be effected through means which will ensure an easier means for engaging and disengaging the drive gears and for providing engagement without teeth interference and through a drive system which operates with a minimum of friction and play. In addition, it is desirable that the operation of the output shaft can be effected through a complete 360° rotational range and that the starting and stopping position may be controlled at will so that no mechanical disadvantages result by starting a particular angle of position of the output shaft.

SUMMARY OF THE INVENTION

The present invention provides an improved device for transmitting accurate translational and rotary movement to an output shaft from a rotary input shaft, which includes a slide which is movable backwardly and forwardly and which carries a rack gear which engages with a pinion on the output shaft after the output shaft is first guided for linear axial movement by roller elements which bear against respective opposite sides of an elongated key. The rack slide advantageously includes a roller follower which is preloaded against a ribbed cam of a barrel cam so that it moves precisely and without play. The rack itself is cocked at a very slight angle to allow entry of the pinion gear which moves with the cam in an axial direction and which rotates after engagement with the rack. This allows the entry of the sliding rotating gear at appropriate times without teeth interference and effects a slight pitch line interference when the rack and gear are in engagement in order to eliminate gear and rack backlash. The slide carrying the rack moves backwardly and forwardly on linear ball bearings in order to minimize friction. All

play is eliminated between the various parts which control the rotation of the output shaft and this is very important in actual operation since accurate rotary positioning is of paramount importance.

The invention is kinematically an improvement over the prior art because of the construction which permits easy interengagement of the rotary pinion on the rotatable output shaft with the driving rack and the beginning and end of rotation are constrained with no mechanical disadvantage. The start and stop position may be at any angular position so that the control of the starting and stopping is not difficult.

In accordance with a further feature of the invention, the holding plate carrying constraining rollers which engage with an elongated axially extending keyway to constrain the shaft against rotation when it is not meshed with the rack, are such that the operation of rotation may be carried out through 360° of movement and the starting and stopping of the rotational movement may be effected at any designed angle. The construction is such that there is no requirement that the shaft be returned to its original starting position before its axial and rotational movements are begun.

Accordingly, it is an object of the invention to provide an improved device for transmitting accurate translational and rotary movement which includes an output shaft which is rotatable and axially movable under the control of a rotatable cam and which includes a rack gear driving through a pinion gear contained on the output shaft.

A further object of the invention is to provide a device for transmitting accurate translational and rotary movement which includes an output shaft which is axially displaceable and which is held against rotation by one of a plurality of angularly spaced pairs of position rollers which bear on respective opposite sides along the edges of a key which is affixed to a housing for the shaft and which also includes a pinion gear on the shaft which is moved into engagement with a rack on a slide after the output shaft moves a predetermined amount in an axial direction, the rack having a pitch which is cocked at a very slight angle to allow easy entry of the pinion gear on the output shaft which moves into engagement therewith and without teeth interference and also provides a slight pitch line interference to eliminate gear and rack backlash when the two gears are engaged.

A further object of the invention is to provide an improved motion transmitting device which includes a slide which is guided for back and forth movement on linear ball bearings and which includes roller followers which may be preloaded against respective side edges of a ribbed barrel cam in order to transmit precise movements without play or backlash to a rotary output shaft.

A further object of the invention is to provide a motion transmitting device which is simple in design, rugged in construction and economical to manufacture.

For an understanding of the principles of the invention, reference is made to the following description of a typical embodiment thereof as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the Drawings:

FIG. 1 is a front top perspective view with a portion of the housing broken away of a motion transmitting device constructed in accordance with the invention;

FIG. 2 is a section taken along the line 2—2 of FIG. 1;

FIG. 3 is a section taken along the line 3—3 of FIG. 2;

FIG. 4 is a section taken along the line 4—4 of FIG. 2;

FIG. 4a is a section taken along the line 4*a*—4*a* of FIG. 4;

FIG. 5 is a timing diagram for the operation of the device;

FIG. 6 is a timing diagram for a back and forth oscillation of the output shaft; and

FIG. 7 is a timing diagram for effecting continuous intermittent rotation and lift of the output shaft.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to the drawings in particular, the invention embodied therein, comprises a motion transmitting device including a housing, generally designated **10**, of a block-shaped configuration having a rounded end portion **10***a* and with a front wall **12** in which is rotatably mounted an input shaft **14**. The input shaft extends to the interior space **16** of the housing where it carries cams **17** and **18**. The cam **17** is a plate or disc cam, and it has an interior face **17***a* with a cam groove **17***b* which is engaged by a roller follower **20** of an oscillatable drive lever **22**. Drive lever **22** is secured to a shaft **24** which is journalled in front wall **12** and rear wall **23** close to a bottom wall **25**. The upper end of lever **22** includes a drive member **22***a* which engages in annular groove **26***a* of a control disc **26** which is affixed to output shaft **28**. The output shaft **28** is journalled in the recirculating linear ball bearing bushings **30** and **32** carried in respective side walls **34** and **36**. Ball bearing bushings **30** and **32** are combination rolling and linear bearings and ensure an easy and accurate guiding of the shaft **28**. When input shaft **14** is rotated, it causes rotation of cam **17** and oscillation of lever **22** through engagement of the follower **20** in control groove or cam **17***b*, and this causes drive member **22***a* to produce a back and forward axial sliding movement of output shaft **28**, in the directions indicated by the double arrow **38**.

In accordance with a feature of the invention, output shaft **28** is imparted with a controlled rotational movement in addition to its controlled translatory movement, by a cam driving mechanism including the cam **18**, which comprises a ribbed barrel cam having an outstanding ribbed cam portion **18***a*. Ribbed cam portion **18***a* imparts a controlled movement to a slide, generally designated **40**, which is guided on linear ball bearings for front and back movement substantially parallel to input shaft **14** on rods **43** and **44**, which are supported in front wall **12** and rear wall **23**, respectively. Slide **40** may be guided very accurately and without any loss of motion or inaccuracy because of the use of the linear ball bearings and also because it includes drive rollers **40***a* and **40***b* which engage against respective sides of the ribbed cam portion **18***a* and may be preloaded in engagement therewith so as to eliminate all backlash and shake.

In accordance with a further feature of the invention, the slide **40** carries a drive gear in the form of a rack **46** which meshes with a pinion gear **48** carried on output shaft **28**.

As shown in FIGS. **1** and **2**, the pinion **48** is moved into engagement with rack **46** when output shaft **28** is moved substantially to the end of its linear movement and this engagement is effected before output shaft **28** is moved out of association with its linear guiding means, generally designated **50**.

In accordance with a further feature of the invention, the rack **46** is carried on slide **40** in a manner such that it makes a small angle θ in respect to gear **48**, so that it is cocked at this very slight angle to allow easy entry of gear **48** when output shaft **28** is moved to effect this interengagement. The interengagement occurs without teeth interference, but when the gears are fully in mesh, they have a slight pitch line interference between them, in order to eliminate gear and rack backlash. Slide **40** carries linear ball bearings **52** and **54**, which engage rods **43** and **44**, respectively. With the construction, all friction is minimized, and the play between the parts is eliminated so that the rotation of output shaft **28** is controlled very accurately. This is a very important consideration when a device is employed for accurately placing various machine parts or operating parts independent on both the linear and rotational movements of the output shaft **28**.

In accordance with another feature of the invention, output shaft **28** is guided by shaft linear guiding means **50** so that it moves axially without rotation except when the gear **48** is engaged with rack **46**. Guiding means **50** includes an axially elongated key **56** which is secured to the curved portion of the housing **10***a* in a position to overlie shaft **28** on the side thereof opposite to cams **17** and **18**. Guiding means **50** includes a control plate or disc, generally designated **58**, which, as shown in FIG. **4**, has a rounded outer circumference **60** with a plurality of flats in this case four **60***a*, **60***b*, **60***c* and **60***d*, which are provided for mounting pairs of positioning or holding rollers **62** and **64**, which are mounted so that when in operation, they bear against respective sides of the key **56**. As shown in FIG. **4**, the control plate **58** is provided with the plurality of flats which may be set by design in order to achieve a plurality of positions in which the output shaft **28** to which it is affixed may be held when it is moved linearly. In the four positions shown in FIG. **4**, the separating angles between the various centers of the flats are indicated. In order to provide for a further variation of the positioning of the shaft when it is moved linearly, an additional key, such as a key **56***a*, may also be provided, which, as indicated, is located 30° away from key **56**.

The construction of a control plate **58** which permits the various output shaft guidance arrangements provides an improved kinematic arrangement for the mechanism for controlling both the translatory and rotary movement of output shaft **28**. The arrangement ensures that there will be no mechanical disadvantage due to the requirement that the beginning or end of rotation of the shaft be effected at a predetermined angular position thereof. Due to this arrangement, it is assured that there will be no starting or stopping at a disadvantageous position in respect to the operating cams **17** and **18** and there will be no limitations in respect to the angular position to an end **66***a* of an operational arm which is affixed to the output shaft **28**.

Thus, with the inventive arrangement, there is no requirement that the arm **66** be returned to a starting po-

sition before it is moved on its next cycle. The mechanism is capable of operating in this manner, but it is also possible with the arrangement, to complete a full 360° arc of rotation and to effect a large variation of discrete angular incremental movements of shaft **28** and hence, the arm **66,** as desired. An example of such movements may be: two positions 180°; four positions 90°; five positions 72°; six positions 60°, and by adding a second lock key, such as lock key **56***a* shown in FIG. **4,** there may be additional positions up to **8, 10,** or **12,** for example. The number of positions can be increased by making the component parts larger to accommodate more guide rollers **62** and **64.**

Rollers **62** and **64** may be pre-loaded against key **56,** and for this purpose, at least one roller, e.g. roller **64,** is eccentrically mounted on a rotatable shaft **63** by a roller bearing collar **65.** Shaft **63** is rotated to effect tight loading engagement of roller **64** on key **56** and then it is locked in position such as by a clamp (not shown) engageable with a flat on the shaft and thus all possibility of shake is eliminated from the mechanism.

The arrangement of the invention also makes it possible for the unit to operate as an oscillating device or function as an intermittently rotating device. In addition, the device may be used to effect rotation of the output shaft **28** to an angle of rotation such as 37° or 129° since the ribbed cam **18** produces a stroke movement which is a direct function of the required gear pitch line distance corresponding to the required angle of oscillation.

The intermittent rotation of the device is accomplished by returning the rack **46** to its starting position at a time when it is out of contact with pinion gear **48** so that the next engagement can provide a continuous rotation in the same direction. It is necessary that an integral number of teeth of the rack **46** and the pinion gear **48** go into and out of engagement during each interengagement and to do this, the following table illustrates how this may be accomplished:

NO. OF POSITIONS	ANGLE OF ROTATION	NO. OF TEETH INDEX		NO. OF TEETH ON ROTATE GEAR		REVOLUTION
2	180°	12	Teeth	24	Teeth	(½)
4	90°	12	do.	48	do.	(¼)
5	72°	8	do.	40	do.	(1/5)
6	60°	8	do.	48	do.	(1/6)
8*	45°	6	do.	48	do.	(⅛)
10*	36°	44	do.	40	do.	(1/10)
12*	30°	4	do.	48	do.	(1/12)

*Cam stroke = ½ that of 4, 5, 6 Positions.

In FIG. **5,** a cam timing diagram is indicated for effecting intermittent rotation. It is possible to provide a standard unit which offers a predetermined linear movement of shaft **28** for a certain amount of degrees of timing of the cam and an oscillating movement with a different predetermined degree of timing if desired. The mechanism is such that it is a simple matter to effect a changing of the timing which may be effected by rotation of the input shaft. For example, the standard gearing may be with a 1:1 ratio for a certain amount of degrees of transfer of the oscillating arm **66** or with a 2:1 ratio for another predetermined amount of degrees of movement.

Additionally, FIGS. **6** and **7** show timing diagrams for, respectively, effecting a back and forth oscillation movement of the output shaft and a progressive intermittent complete rotational movement and lift of the output shaft.

While a specific embodiment of the invention has been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A motion transmitting device, comprising a rotary input shaft having rotary control cam means thereon, a rotary and axially movable output shaft having a pinion gear thereon, means supporting said input shaft for rotary movement and said output shaft for rotary and axial movement, a lever engaged with said cam means and said output shaft and being movable by said cam means to shift said output shaft axially, rotary drive means connected to said cam means and including a drive gear moved by said cam means engageable with said pinion gear to rotate said output shaft when it is in a predetermined axial position, said pinion gear being disengageable from said drive gear to permit axial movement without rotation, and holder means to hold said output shaft against rotation at positions of said output shaft when said pinion gear is out of engagement with said drive gear and to permit easy interengagement of said gears including at least one key elongated in the axial direction of said shaft and fixed in said housing and a control plate affixed to said shaft for rotation therewith having a plurality of circumferentially spaced pairs of transversely spaced guide rollers adapted to bear along respective sides of said key to hold the said output shaft in a fixed angular position during its linear movement.

2. A motion transmitting device, according to claim **1,** wherein said control plate has a periphery with a plurality of circumferentially spaced flat chordal mounting surfaces for each of said sets of guide rollers.

3. A motion transmitting device, according to claim **1,** wherein said drive gear comprises a rack, a slide carrying said rack, means in said housing for guiding said slide backwardly and forwardly.

4. A motion transmitting device, according to claim **3,** wherein said cam means includes a separate disc cam and ribbed barrel cam with an outwardly projecting cam rib, said slide having a roller which is preloaded against each side of said cam rib whereby said slide is moved without play backwardly and forwardly.

5. A motion transmitting device, according to claim **4,** wherein said rack gear is cocked at a small angle in respect to said pinion gear in order to permit easy interengagement thereof and to provide a slight pitch interference during engagement so as to eliminate gear backlash.

6. A motion transmitting device comprising a housing, a rotary input shaft rotatably mounted in said housing, a rotary and axially movable output shaft mounted in said housing for rotatable and axial movement, a lever pivoted in said housing and having a drive member engaged with said output shaft to move it axially backwardly and forwardly, cam means on said input shaft including a first cam portion engageable with said lever to oscillate it backwardly and forwardly in a second cam portion, a slide, means in said housing for guiding said slide from backward and forward move-

ment transverse to the axis of said output shaft, a pinion gear carried on said output shaft at a fixed location along its length and being engageable with said rack at a predetermined axial position of said output shaft, said slide having follower means engaged with said second cam portion and being movable by rotation of said second cam portion backwardly and forwardly, and holder means to hold said output shaft against rotation at positions of said output shaft when said pinion gear is out of engagement with said drive gear and to permit easy interengagement of said gears.

7. A motion transmitting device, according to claim **6,** wherein said second cam portion comprises a barrel cam having an outwardly projecting rib cam portion, said slide having a roller engaged with each side surface of said ribbed cam portion and comprising said follower means.

8. A motion transmitting device, according to claim **7,** wherein said first cam portion comprises a disc cam having a side face with a cam groove therein, said lever having a follower intermediate its length engaged in said cam groove.

9. A motion transmitting device, according to claim **6,** wherein said holder means comprises an elongated key affixed in said housing and extending along the axis of said shaft, a control plate affixed to said shaft having at least one set of transversely spaced rollers of a size to bear tightly against each side of said key in positions of said shaft when said pinion gear is out of engagement with said rack.

10. A motion transmitting device, according to claim **6,** wherein said input shaft is mounted with its axis extending transversely to the axis of said output shaft, said cam means comprising a disc cam forming said first cam portion and a ribbed barrel cam forming said second cam portion, said lever follower being engaged with said disc cam, said slide carrying said rack having a roller engaged on respective sides of said ribbed barrel cam, said rack gear being cocked at a small angle in respect to said pinion gear for facilitating intermeshing engagement thereof and engagement without backlash during full engagement.

11. A motion transmitting device, according to claim **10,** including a control disc on said output shaft having an annular groove in its circumference, said driver of said lever engaging into said groove, said output shaft and said slide being mounted in linear ball bearings for respective axial movements thereof, said plate having a plurality of circumferentially spaced pairs of holding rollers engageable with said key in accordance with the angular position of said output shaft.

12. A motion transmitting device, according to claim **11,** wherein there are a plurality of keys in said housing extending axially in respect to said output shaft.

* * * * *