June 23, 1964 S. GODEL 3,138,030

PAWL AND RATCHET MECHANISMS

Filed Feb. 14, 1961

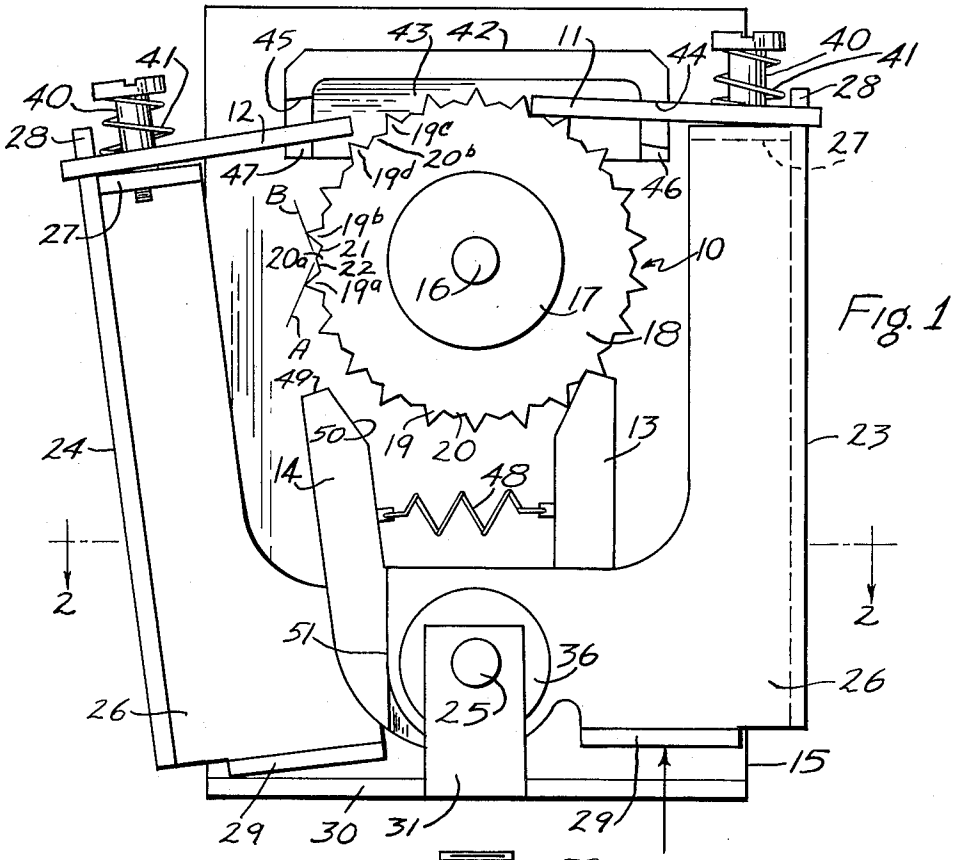


Fig. 1

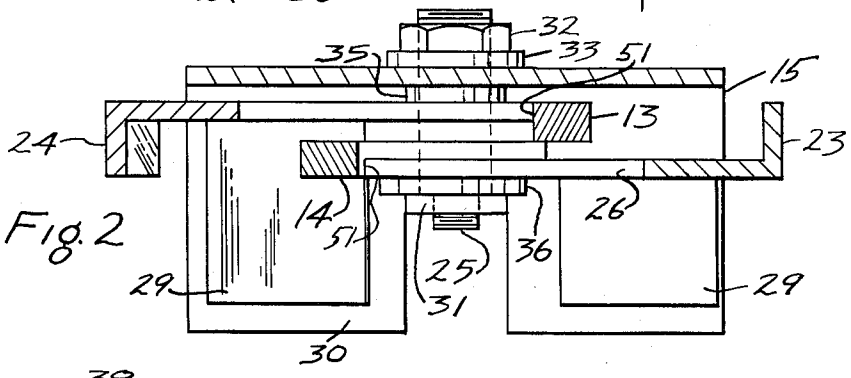


Fig. 2

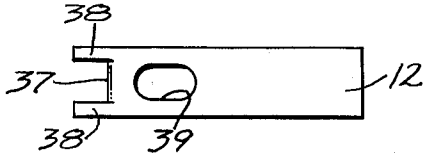


Fig. 3

INVENTOR

SIEGFRIED GODEL

BY Arnold and Roylance

ATTORNEYS

United States Patent Office 3,138,030 Patented June 23, 1964

3,138,030

PAWL AND RATCHET MECHANISMS

Siegfried Godel, Norwalk, Conn., assignor to American Machine & Foundry Company, a corporation of New Jersey

Filed Feb. 14, 1961, Ser. No. 89,244
10 Claims. (Cl. 74—159)

This invention relates to intermittent motion devices and, more particularly, to pawl and ratchet mechanisms of the type adapted to rotate a reversible output shaft in either direction in a step-by-step fashion. While not limited thereto, this invention has particular application to high speed stepper motors of the type disclosed in my copending application Serial No. 89,247 filed concurrently herewith.

In the past, many pawl and ratchet mechanisms have been devised which include a pair of driving pawls selectively actuated to drive a ratchet wheel, in a step-by-step fashion, in either direction. While such devices have been satisfactory for low speed operation, they frequently have proved to be unsatisfactory when operated at high speeds, both because they require excessive operating power and because the increased inertia of the parts during high speed operation causes the mechanism to jam or to overshoot, so that the output shaft is not accurately positioned, i.e., the output shaft is not rotated through the same angular increment when operated at different speeds.

Accordingly, one of the objects of this invention is to provide an improved pawl and ratchet mechanism which can be operated successfully at high speeds.

Another object is to provide an improved pawl and ratchet mechanism wherein an output shaft is rotatable, through successive predetermined angular increments, without variation in the increments of rotation due to operation at different speeds.

A further object is to provide an improved pawl and ratchet mechanism which will not jam when operated at high speeds.

Still another object is to provide an improved reversible ratchet wheel.

In order that the manner in which these and other objects are attained, in accordance with the invention, can be understood in detail, reference is had to the accompanying drawing, which forms a part of this specification, and wherein:

FIG. 1 is a front elevational view of one embodiment of this invention;

FIG. 2 is a plan view, partly in section, along line 2—2 of FIG. 1; and

FIG. 3 is a plan view illustrating one of the driving pawls.

Referring now to the drawings, the embodiment of the invention there shown includes a ratchet wheel **10**, a pair of driving pawls **11** and **12**, a pair of detent pawls **13** and **14**, and a frame or support **15**. Ratchet wheel **10** is fixedly secured to a driven or output shaft **16** which is suitably journalled in support **15** for rotation relative thereto in either direction about a fixed axis. Ratchet wheel **10** includes a cylindrical hub **17** and a cylindrical body portion **18** which extends transverse to the axis of rotation of the ratchet wheel and shaft **16**, the body portion **18** having a plurality of teeth, described in detail below, spaced about the periphery thereof.

The teeth of ratchet wheel **10** are of two types: major teeth, indicated by reference numeral **19**, and minor teeth, indicated by reference numeral **20**. The teeth are evenly spaced about the periphery of body portion **18**, there being one minor tooth between each pair of adjacent major teeth.

Each tooth projects radially outwardly from body

portion **18** and has flat side surfaces which intersect at an apex so that a radial line passing through the apex bisects the angle between the side surfaces. The planes in which the side surfaces lie are parallel to the axis of rotation so that the teeth also can be considered parallel to the axis. In a broader sense, the teeth also can be considered to extend transverse to the direction or path of movement thereof since the instantaneous direction of movement of a point on a rotating body is along a tangential path.

The radial distance to the apex of each minor tooth **20** is less than the radial distance to a chord extending between the apexes of the adjacent major teeth **19**. Each of the side surfaces of each minor tooth lies in a plane which passes through the apex of the major tooth adjacent the other side of the minor tooth. Thus, by way of example, minor tooth **20***a* is between major teeth **19***a* and **19***b* and has flat side surfaces **21** and **22** which lie in planes A and B, respectively, such planes passing through the apexes of major teeth **19***a* and **19***b*, respectively. The apex of each major tooth **19** can be pointed, as illustrated, or can be rounded to provide operational clearance.

Driving pawls **11** and **12** are carried by actuating levers **23** and **24**, respectively, the levers being mounted for pivotal movement about a shaft **25** suitably mounted upon support **15** and extending parallel to shaft **16**. Each of levers **23** and **24** has a flat body portion **26**, which extends transversely to the pivotal axis of the lever, and a flange **27** which extends perpendicular to body portion **26** at the upper edge thereof. Each lever also has a lug **28** which projects upwardly from flange **27**. At its lower end, each lever has an arm **29** which extends perpendicular to body portion **26** and is spaced from shaft **25**, the arms providing means by which actuating forces can be applied to the levers for pivoting them about shaft **25**. Support **15** includes a horizontal base **30** and a vertical support member **31**. Base **30** underlies each of arms **29** so that when levers **23** and **24** are in their unactuated positions, the arms **29** thereof rest on the top surface of base **30**.

As viewed in FIG. 2, the ends of shaft **25** are threaded, the lower end being of reduced diameter and being threadedly received in a threaded aperture in support member **31**. The upper end of shaft **25** is secured by a nut **32** and washer **33** to support **15**. The medial portion of shaft **25** is smooth so that levers **23** and **24** and detent pawls **13** and **14** can rotate about the shaft. A pair of washers **35** and **36** are disposed adjacent levers **23** and **24**.

Pawls **11** and **12** are identical so that only one need be described in detail. As illustrated, pawl **12** has a rounded end edge **37** which abuts lug **28** and provides a pivot about which pawl **12** can move, within limits, relative to the lever. Pawl **12** also has a pair of ears **38** which straddle lug **28** and prevent pawl **12** from moving laterally. Pawl **12** also is provided with an elongated slot **39** through which a stud **40** extends, the stud being secured to flange **27** and extending generally perpendicular thereto. A helical compression spring **41** bears against the head of stud **40** and biases pawl **12** toward flush engagement with flange **27**.

The free end of pawl **12** is suitably shaped so that when it engages and rotates ratchet wheel **10**, the pawl can rotate or pivot relative to the ratchet wheel about an axis which lies generally at the intersection of the sides of the major and minor teeth engaged therewith, without becoming disengaged therefrom. As illustrated, the edge of the free end is flat and is perpendicular to the bottom surface thereof so that the end surfaces form an angle less than the angle which exists between adjacent sides of a major tooth and a minor tooth.

A stop member 42 is fixedly secured to support 15 adjacent the upper end thereof and has a flat body portion 43, a pair of laterally spaced stops 44 and 45 and a pair of laterally spaced guides 46 and 47 which project outwardly from body portion 43. Stop 44 and guide 46 are disposed on opposite sides of driving pawl 11 and stop 45 and guide 47 are disposed on opposite sides of driving pawl 12, as illustrated in the drawing. When levers 23 and 24 are unactuated, springs 41 bias pawls 11 and 12 into engagement with guides 46 and 47, respectively, the guides being positioned so that actuation of a lever causes the driving pawl associated therewith to move into engagement with the rear face of the major tooth aligned therewith, in a manner more fully described hereinafter. Stops 44 and 45 are located so that the angular increments of rotation of ratchet wheel 10 are equal to the angular spacings of adjacent major teeth or adjacent minor teeth. That is, actuation of either pawl to the extent allowed by the corresponding stop causes each major tooth to move into the position previously occupied by the preceding major tooth. For example, if lever 24 is actuated, ratchet wheel 10 is rotated in a clockwise direction so that major tooth 19*a* moves from the position shown into the position which major tooth 19*b* occupies.

Detent pawls 13 and 14 are also mounted for rotation about shaft 25, the detent pawls being biased toward each other by a helical tension spring 48. When neither lever 23 nor lever 24 is actuated, both detent pawls 13 and 14 engage, and prevent rotation of ratchet wheel 10. Each of pawls 13 and 14 has a flat end face 49 and a flat side face 50 arranged so that, when engaged with wheel 10, end face 49 is flush with the side surface of the abutting major tooth and side face 50 is flush with the side face of the adjacent minor tooth.

Pawls 13 and 14 are arranged so that when engaged with ratchet wheel 10, the pawls prevent rotation of the ratchet wheel. As illustrated, when the pawls are engaged with the ratchet wheel, any torque applied to the wheel biases the proper pawl toward the center of the wheel and thereby positively prevents rotation of the wheel.

Levers 23 and 24 and detent pawls 13 and 14 are interlocked, as indicated at 51, so that, first, when one lever is actuated, the detent pawl interlocked therewith is disengaged from the ratchet wheel; second, when the actuating force is withdrawn, spring 48 rotates the disengaged detent pawl and the lever interlocked therewith to their unactuated positions; and third, when one lever is actuated, the ratchet wheel can rotate relative to the detent pawl engaged therewith.

It is also to be understood that each of pawls 11 and 12 is movable between an unactuated position and a fully actuated position and that, for the purposes of illustration, driving pawls 11 and 12 are shown in fully actuated and unactuated positions, respectively.

The operation of each of pawls 11 and 12 is similar, the operation of pawl 12 being as follows: When an actuating torque is applied to lever 24, as by applying an upwardly directed force to arm 29 thereof, lever 24 pivots and disengages detent pawl 13 from ratchet wheel 10. As lever 24 pivots, driving pawl 12 slides over guide 47 and moves into engagement with the rear face of major tooth 19*c*, which lies in the path of movement of the free end of the pawl. Continued movement of lever 24 causes pawl 12 to rotate ratchet wheel 10 in a clockwise direction.

As ratchet wheel 10 rotates, pawl 12 is lifted from engagement with guide 47 and moves toward stop 45. Ratchet wheel 10 continues to rotate until pawl 12 engages stop 45. When this happens, the front face of minor tooth 20*b* lies flush with pawl 12 so that further actuating movement of lever 24 and pawl 12 is prevented. Thus, the momentum of the moving parts is absorbed by the stop 45 and overshooting of the ratchet wheel is prevented.

As ratchet wheel 10 rotates, one of the major teeth engages side face 50 of detent pawl 14 and cams it outwardly until this tooth passes by the side surface at which times spring 48 pivots detent pawl 14 into its unactuated position. Pawl 14 is located so that this movement occurs at or slightly before pawl 12 engages stop 45.

When the actuating torque is removed, spring 48 pivots detent pawl 13 and lever 24 in a counterclockwise direction to their unactuated positions. Such movement causes pawl 12 to disengage stop 45 and slide over the apex of tooth 19*d* and fall into engagement with guide 47. Subsequently actuation and deactuation of lever 24 repeats this cycle so that the ratchet wheel 10 is rotated stepwise through equal increments, in a clockwise direction.

Attention is directed to the aforementioned copending application Serial No. 89,247 which discloses a high speed stepper motor and relay structure embodying this invention. Said copending application discloses various ways in which the pawl and ratchet mechanism of the present invention can be driven and utilized. Reference may be had to that application for a more detailed description of specific means for actuating levers 23, 24, for example. While only one embodiment of the present invention has been illustrated, it is to be understood by those skilled in the art that various changes and modifications can be made in the details and arrangement of parts without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. In a pawl and ratchet mechanism, the combination of

a ratchet member having a plurality of major teeth and a plurality of minor teeth,

said major teeth being disposed in a spaced series with the spaces between adjacent pairs of said major teeth equal,

said minor teeth being disposed each between a different adjacent pair of said major teeth,

means mounting said ratchet member for reversible movement to cause said teeth all to follow the same fixed path,

each of said major teeth being defined by two flat side surfaces which converge outwardly and intersect to define an apex,

said minor teeth being shorter than said major teeth and each having a flat side surface slanting from one adjacent major tooth toward the apex of the other adjacent major tooth, the plane of said last-mentioned flat side surface passing through the apex toward which it slants; and

a pawl;

means mounting said pawl for movement toward and away from said ratchet member to actuate said ratchet member through predetermined increments of movement along said path in one direction, said pawl comprising

an end disposed for successive engagement with a side surface of each of said major teeth, and

a flat side face of such length as to be simultaneously engageable with said side surface of the adjacent one of said minor teeth and the corresponding one of said apexes when said pawl has engaged one of said major teeth and actuated said ratchet member through one of said predetermined increments of movement.

2. A pawl and ratchet mechanism in accordance with claim 1 and wherein

said minor teeth each have two flat side surfaces each slanting toward the other,

each of said side surfaces of each of said minor teeth lying in a plane which passes through the apex of the one of said major teeth adjacent the other side surface of such minor tooth,

the mechanism further comprising

a second pawl;

means mounting said second pawl for movement toward and away from said ratchet member to actuate the same through predetermined increments of movement along said path in the other direction, said second pawl comprising

an end disposed for successive engagement with the side surfaces of said major teeth opposite those with which said first-mentioned pawl is disposed to engage, and

a side face of such length as to be simultaneously engageable with the other side surfaces of said minor teeth and the corresponding one of said apexes when said second pawl has engaged one of said major teeth and actuated said ratchet member through one of said predetermined increments of movement.

3. A pawl and ratchet mechanism in accordance with claim 1 and further comprising

stop means disposed for engagement by said pawl to prevent further movement thereof in an actuating direction whenever said flat side face of said pawl has come into simultaneous engagement with said side surface of one of said minor teeth and said corresponding apex.

4. In a pawl and ratchet mechanism, the combinations of

a ratchet wheel;

means mounting said ratchet wheel for rotation in opposite directions about a fixed axis, said ratchet wheel having

a plurality of evenly spaced major teeth each defined by first and second outwardly converging flat side surfaces which intersect each other and each of which extends parallel to said axis, and

a plurality of minor teeth disposed each between a different adjacent pair of said major teeth,

each of said minor teeth having two outwardly converging flat side surfaces each lying in a plane which passes through the apex of the one of said major teeth adjacent the other side surface of such minor tooth, said minor teeth being shorter than said major teeth;

a first driving pawl;

means mounting said first driving pawl for movement between an inactive position and a fully actuated position to rotate said ratchet wheel in one direction through predetermined equal angular increments, said first driving pawl having

an end disposed to successively engage said first side surfaces of said major teeth as said first pawl is operated, and

a straight side face so dimensioned and disposed as to come into simultaneous engagement with a flat side surface of a minor tooth and the corresponding one of said apexes whenever said first pawl is moved to its fully actuated position; and

a second driving pawl;

means mounting said second driving pawl for movement between an inactive position and a fully actuated position to rotate said ratchet wheel in the other direction through predetermined equal angular increments, said second driving pawl having

an end disposed to successively engage said second side surfaces of said major teeth as said second pawl is operated, and

a straight side face so dimensioned and disposed as to come into simultaneous engagement with a side surface of a minor tooth and the corresponding one of said apexes whenever said second pawl is moved to its fully actuated position.

5. A pawl and ratchet mechanism in accordance with claim 4 and wherein

the side surfaces of each of said minor teeth intersect with each other at an apex.

6. In a pawl and ratchet mechanism, the combination of

a ratchet wheel;

means mounting said ratchet wheel for reversible rotation about a fixed axis, said ratchet wheel having a plurality of evenly spaced major and minor teeth,

there being one of said minor teeth between each adjacent pair of said major teeth,

each of said major teeth having two outwardly converging flat sides which intersect each other to define an apex and which lie in planes parallel to said axis,

each of said minor teeth having two outwardly converging flat sides, each flat side of each of said minor teeth lying in a plane which includes the apex of the one of said major teeth adjacent the other side of such minor tooth;

a first driving pawl having an end surface successively engageable with one side of each of said major teeth for rotating said ratchet wheel in a forward direction;

means mounting said first driving pawl for cyclic movement between an inactive position and a fully actuated position,

said first driving pawl having a straight side face engageable simultaneously with a side of one of said minor teeth and the corresponding apex of one of said major teeth, to stop rotation of said ratchet wheel, whenever said first driving pawl reaches its fully actuated position; and

a second driving pawl having an end surface successively engageable with the other side of each of said major teeth for rotating said ratchet wheel in the reverse direction;

means mounting said second driving pawl for cyclic movement between an inactive position and a fully actuated position,

said second driving pawl having a straight side face engageable simultaneously with a side of one of said minor teeth and the corresponding apex of one of said major teeth, to stop rotation of said ratchet wheel, whenever said second driving pawl reaches its fully actuated position.

7. In a pawl and ratchet mechanism, the combination of

a ratchet wheel;

means mounting said ratchet wheel for rotation in a predetermined direction about a fixed axis, said ratchet wheel having a plurality of evenly spaced major and minor teeth,

there being one of said minor teeth between each adjacent pair of said major teeth,

each of said major teeth having a front face and a rear face with said front and rear faces converging outwardly and intersecting in an apex which extends parallel to said axis,

each of said minor teeth having a flat front face and a flat rear face with said front and rear faces converging outwardly, said front face of each of said minor teeth lying in a plane which includes the apex of the one of said major teeth which trails such minor tooth and said rear face of each of said minor teeth lying in a plane which includes the apex of the one of said major teeth which leads such minor tooth;

a driving pawl;

means mounting said driving pawl for cyclic movement between an inactive position and a fully actuated position to drive said ratchet wheel stepwise in said predetermined direction, said driving pawl having

an end face, and

a straight side face,

each movement of said pawl toward its fully actuated position causing said end face to engage said rear face of one of said major teeth,

said straight side face being disposed to simultaneously engage the front face of one of said minor teeth and the apex of the one of said major teeth which trails such one minor tooth whenever said pawl reaches its fully actuated position; and

stop means engageable by said pawl to stop the same in said fully actuated position.

8. A pawl and ratchet mechanism in accordance with claim 7 and further comprising

a detent pawl engageable with said ratchet wheel to prevent reverse movement thereof.

9. A pawl and ratchet mechanism in accordance with claim 8 and wherein

said detent pawl includes

an end face successively engageable with the rear faces of said major teeth, and

a straight side face disposed for simultaneous engagement with the front face of the minor tooth adjacent the rear face of the major tooth engaged by said detent pawl and the apex of

the one of said major teeth which trails such minor tooth.

10. A ratchet wheel comprising

a cylindrical body adapted to be mounted for rotation about its central longitudinal axis and having

a plurality of major teeth each having outwardly converging side surfaces which intersect to form an apex extending parallel to said axis, said major teeth being equally spaced about the periphery of said body; and

a plurality of minor teeth disposed each between a different adjacent pair of said major teeth,

each of said minor teeth having outwardly converging side surfaces each lying in a plane which is parallel to said axis and which includes the apex of the one of said major teeth adjacent the other side surface of such minor tooth.

References Cited in the file of this patent

UNITED STATES PATENTS

738,012	Dodge	Sept. 1, 1903
1,365,892	Craver	Jan. 18, 1921
2,377,583	Smith	June 5, 1945
2,414,112	Malone et al.	Jan. 14, 1947
2,638,789	Binks et al.	May 19, 1953
2,684,597	Binks	July 27, 1954