Feb. 24, 1948. J. MARTIN 2,436,588

CAM GRINDING MACHINE

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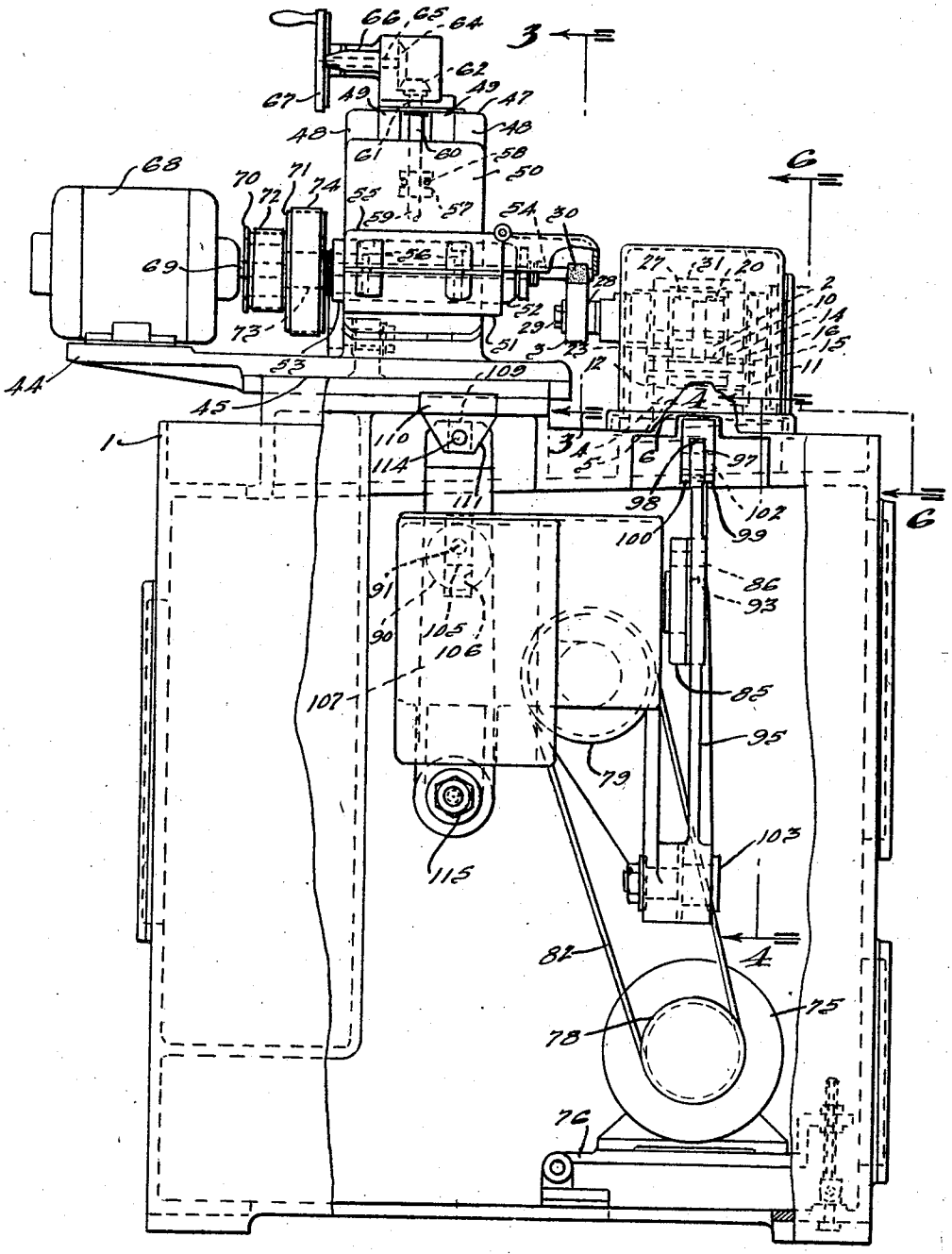


Fig. 1.

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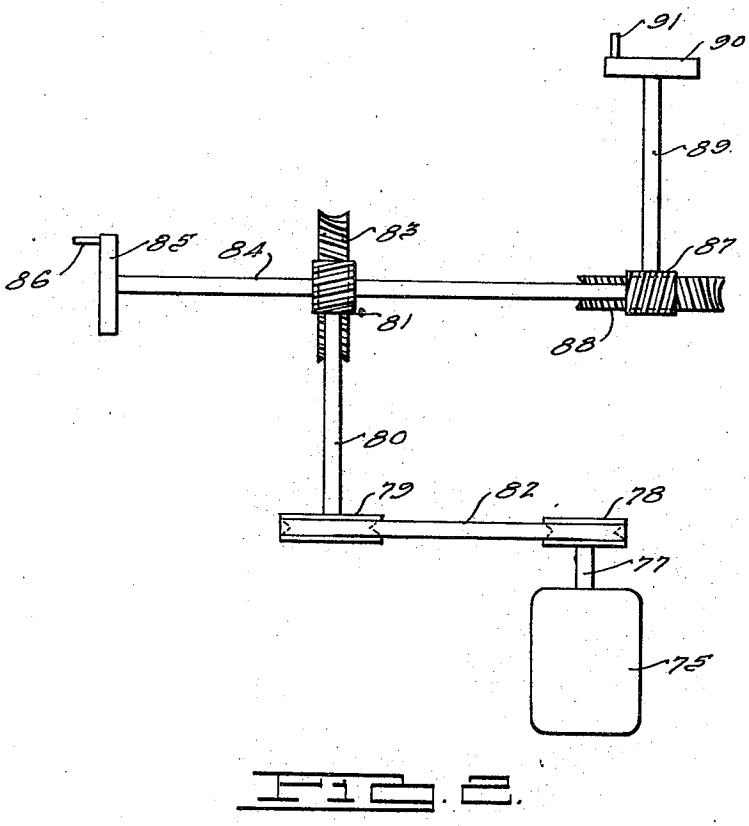


FIG. 2.

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CAM GRINDING MACHINE

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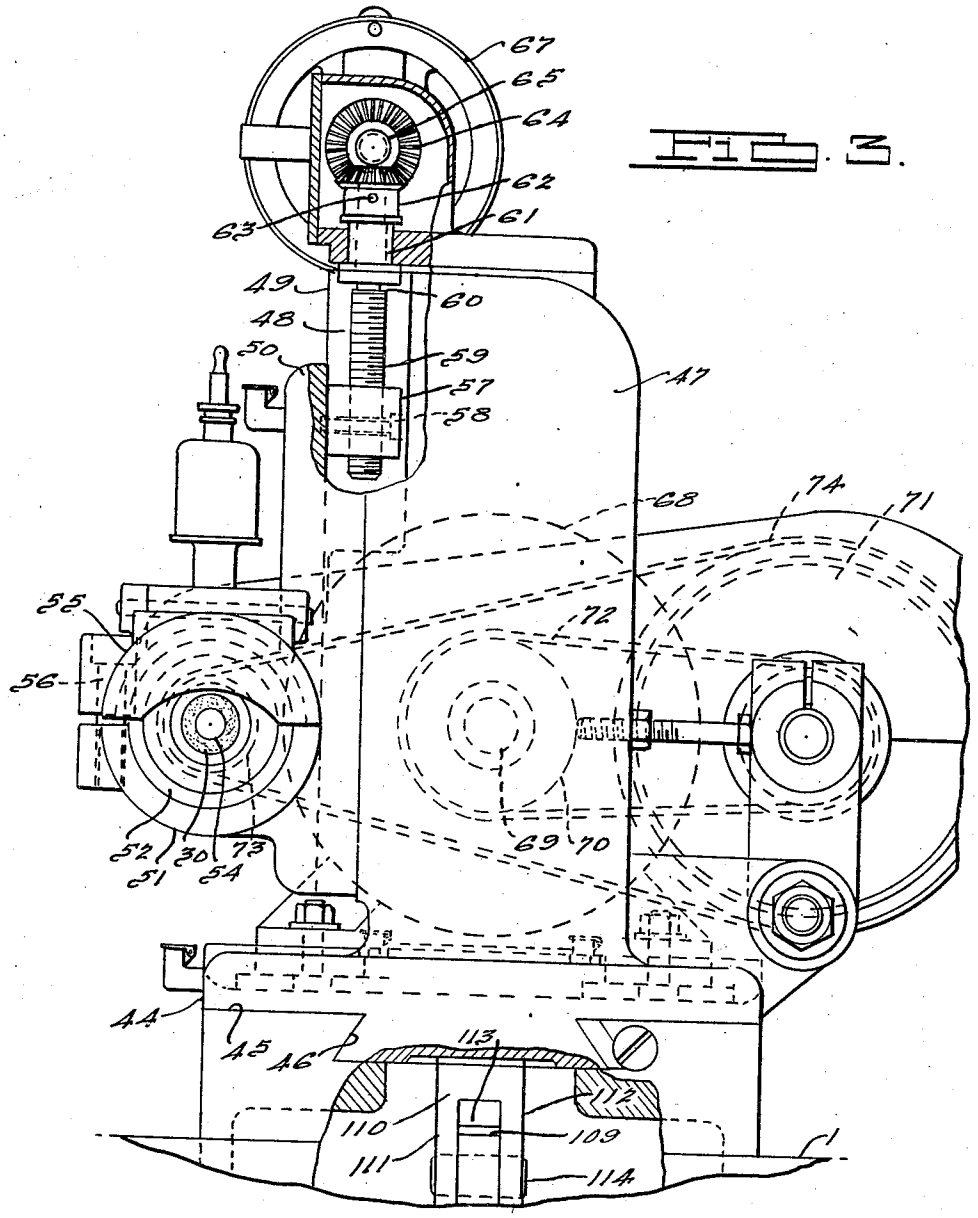


FIG. 3.

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CAM GRINDING MACHINE

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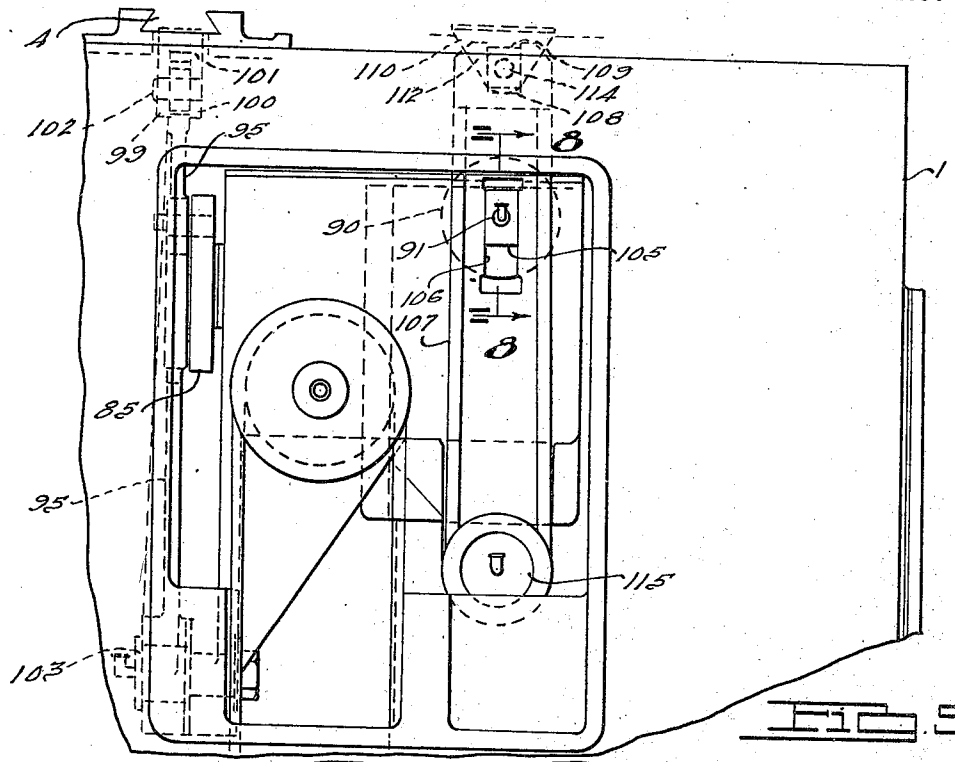


Fig. 5.

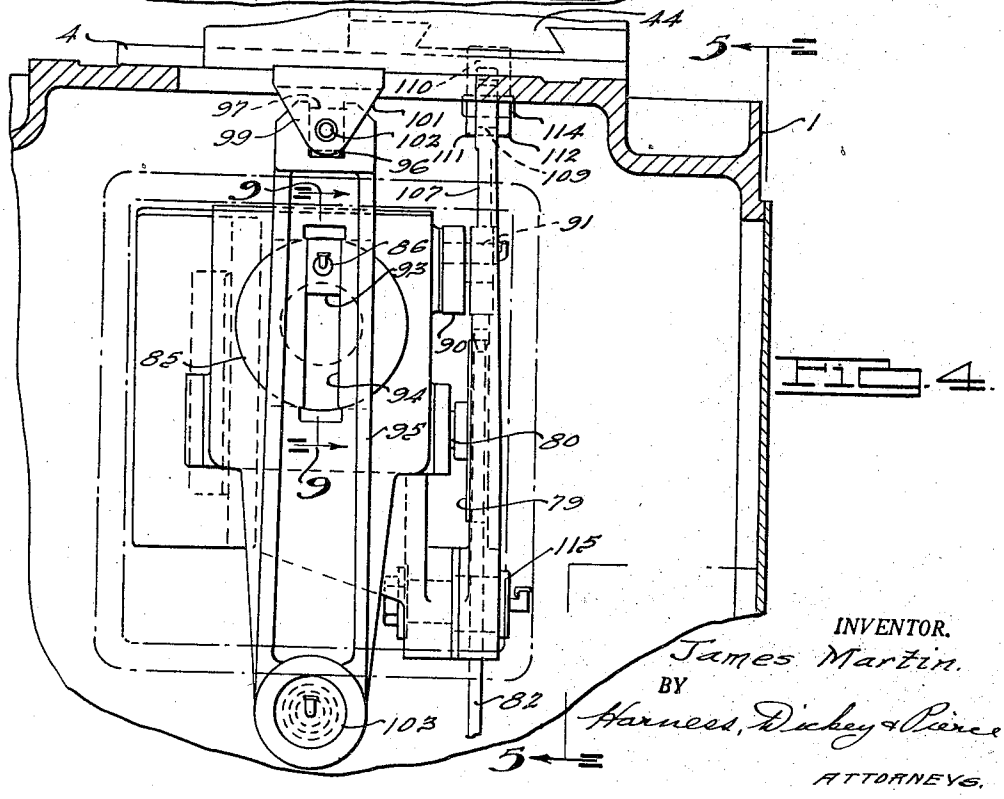


Fig. 4.

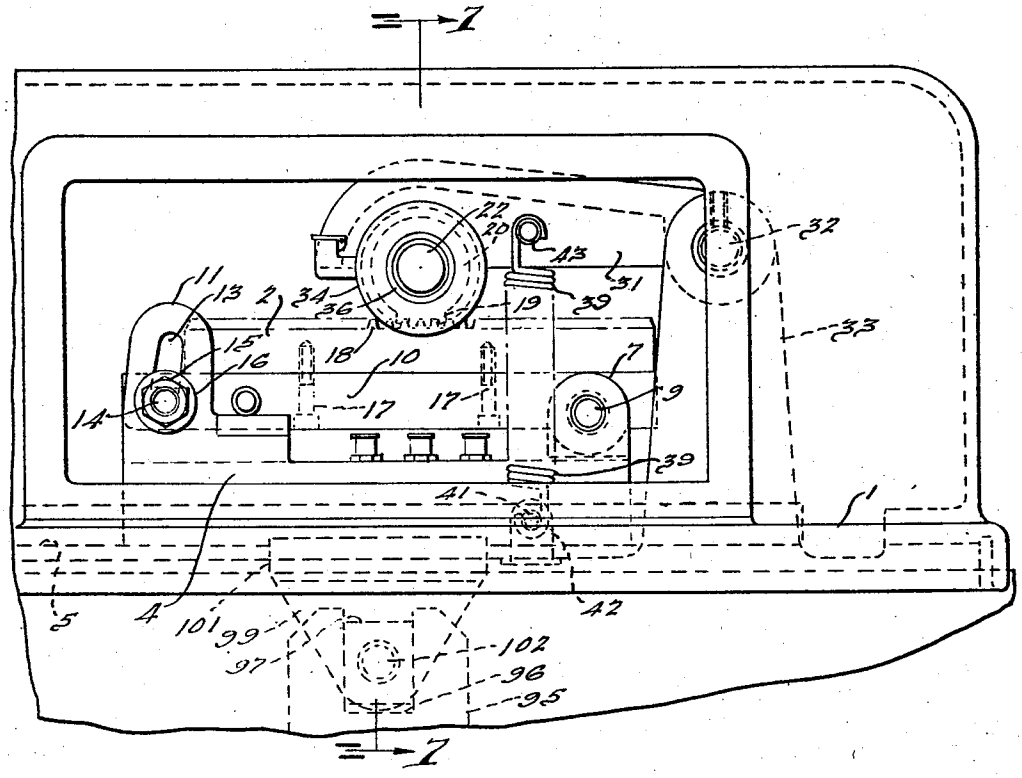
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CAM GRINDING MACHINE

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Fig. 6.



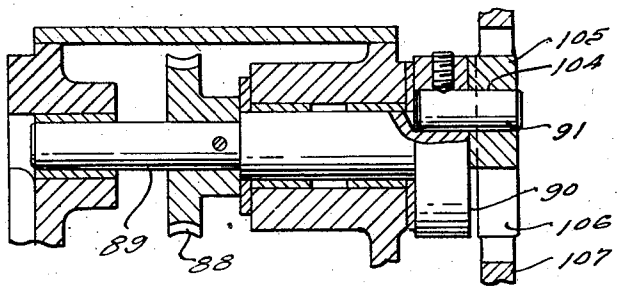


Fig. 8.

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CAM GRINDING MACHINE

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Fig. 7.

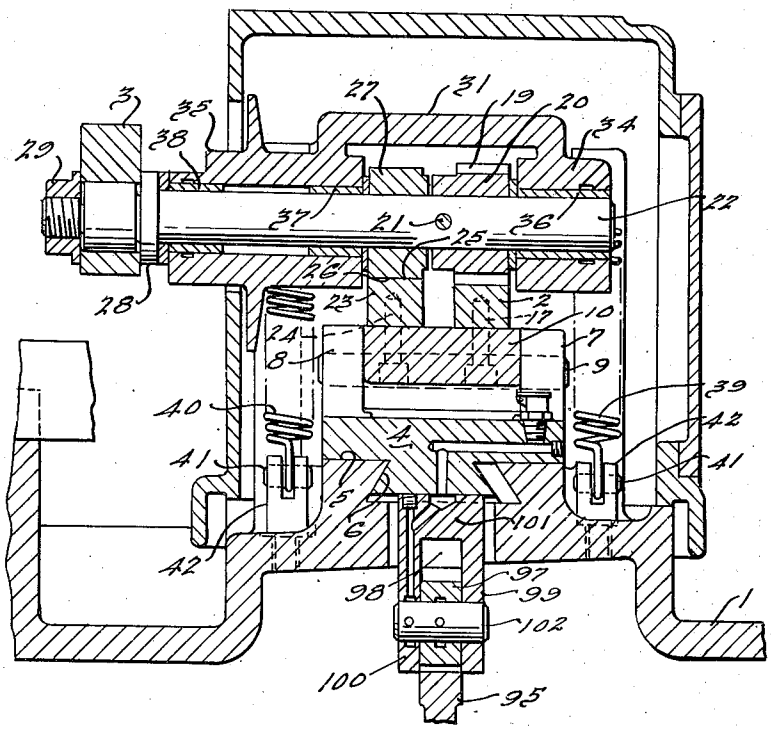
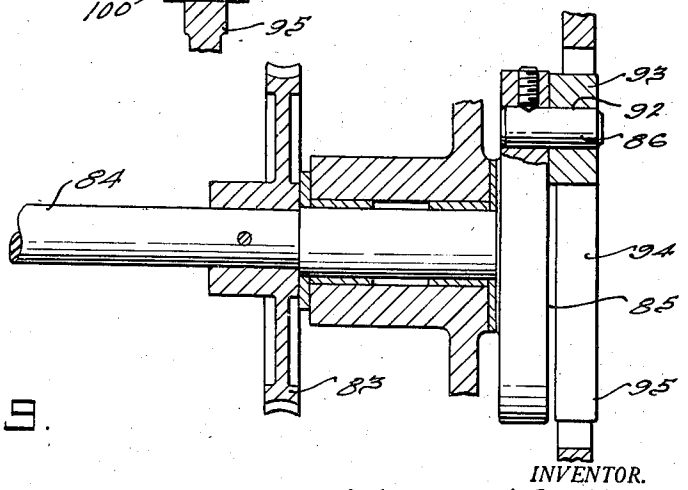


Fig. 9.



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Patented Feb. 24, 1948

2,436,588

UNITED STATES PATENT OFFICE

2,436,588

CAM GRINDING MACHINE

James Martin, Ferndale, Mich., assignor to Michigan Tool Company, Detroit, Mich., a corporation of Delaware

Application August 2, 1945, Serial No. 608,479

9 Claims. (Cl. 51—45)

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This invention relates generally to grinding machines. More particularly, it relates to a substantially automatic machine for grinding machine elements such as uniform rise cams.

It is well recognized that the precision with which machine elements, such as uniform rise cams, are ground controls the accuracy of the finished product. In order that the cam perform satisfactorily, it is essential that the contour thereof be accurate and the surface be highly polished.

Heretofore, to obtain the accuracy and finish necessary, a fixture was adapted to the carriage of a grinding machine. Inasmuch as the operation was not suited to a grinding machine, considerable set-up and operating time was required, resulting in appreciable costs.

In adaptations of this kind, much depended upon the skill and ability of the operator and it is obvious that only an operator having years of experience could be relied upon to obtain uniformly accurate results.

The primary object of the present invention is to provide an improved machine for automatically and accurately grinding cams having a uniform rise, and to provide a machine which is in no way dependent upon the skill or ability of the operator.

Another object of this invention is to provide a simple, compact, yet at the same time precise, accurate and automatic cam grinding machine which will eliminate the necessity of adapting a fixture to a grinding machine for the production of uniform rise cams.

Another object of the present invention is to provide a novel and improved construction of this type which requires but slight adjustment to produce the desired rise on cams. In order to accomplish this result, the present invention contemplates utilizing an adjustable rack requiring only a change in slope to adapt a machine of this construction to produce such cams.

A further object of this invention is to provide a construction of this type in which the pitch circle of a gear, rotating the cam blank, constantly meshes a reciprocating rack at its pitch line. In order to accomplish this, a roll of the same diameter as the pitch circle of the gear is provided to roll on an adjustable sine bar, reciprocating with the rack, the height of the sine bar being the same as the pitch line of the rack.

A still further object of the present invention is to provide a novel and improved construction

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in which the grinding wheel automatically reciprocates normal to the plane of rotation of the workpiece across the face of the same.

Other objects of this invention will become apparent from the following specification, from the drawings relating thereto, and the claims hereinafter set forth.

In the drawings, in which like numerals are used to indicate like parts wherever indicated:

Figure 1 is a front elevation of a cam grinding machine embodying the improvements of the present invention.

Figure 2 is a diagrammatic sketch of the main driving mechanism suitable for use with a cam grinding machine embodying my invention.

Figure 3 is an enlarged, side elevational view taken substantially on the line 3—3 of Figure 1, showing the grinding wheel motor and driving means.

Figure 4 is a vertical, sectional view taken on the line 4—4 of Figure 1, showing the stroke carriage linkage.

Figure 5 is a sectional view taken substantially on line 5—5 of Figure 4 showing the feed carriage linkage.

Figure 6 is a vertical, sectional view taken on the line 6—6 of Figure 1, showing the gear and rack for motivating the workpiece.

Figure 7 is a section through the stroke carriage taken on line 7—7 of Figure 6.

Figure 8 is a section on line 8—8 of Figure 5.

Figure 9 is a section taken on line 9—9 of Figure 4.

In the present invention, a construction is provided by which a uniform rise cam is developed as a high-speed grinding wheel automatically reciprocates across the surface of a workpiece, mounted on a spindle for intermittent rotation in one direction and then the reverse. Rotation in this manner is imparted to the blank by means of a gear secured to the spindle, the teeth of said gear engaging those of an automatically reciprocating, sloping rack to give the cam the required rise. As the rack reciprocates, the surface of the workpiece presented to the grinding wheel is ground and polished to the desired contour.

For a more detailed description of the invention, reference may be had to the drawings in which a base is generally indicated at 1. Such base 1 is preferably formed from an integral, hollow casting which serves to provide a rigid support for the cam grinding apparatus, and houses the driving mechanism, both of which are hereinafter described in detail.

It will become apparent from the description which follows that it is necessary to provide for reciprocation and sloping adjustment of a rack 2 in order to accomplish rotation and movement of a workpiece 3 in the plane of rotation. To accomplish this, carriage 4, hereinafter termed a "stroke carriage" is provided. Said stroke carriage 4 is mounted on an upper part of base 1 for reciprocation upon machined surface 5 and slideway 6. Such carriage is provided with upwardly directed projections 7, 8, providing mating holes through which a pin 9 extends to secure arcuately adjustable table 10 thereto. At the opposite extremity, said carriage is further provided with upwardly directed projections 11, 12 with curved slots 13 therein, one of which is shown in Figure 6. Such slots permit bolt 14 to pass through a mating opening of table 10 in such manner that said table may be arcuately moved to, and fixedly held in, a sloping position when nut 15 is tightened to press washer 16 against upwardly directed projection 11.

Rack 2 is secured by means of bolts 17 to said adjustable table for adjustment into a sloping position therewith. Said rack has teeth 18 meshing with teeth 19 of gear 20 pinned at 21 to spindle 22 for rotating the same as rack 2 reciprocates.

In order to prevent binding of the teeth upon reciprocation of rack 2, provision is made to engage such teeth at their respective pitch lines. To accomplish this, a sine bar 23 is mounted adjacent to rack 2 on adjustable table 10 by means of bolts 24. Surface 25 of said sine bar engages peripheral surface 26 of roll 27 which rotates freely on spindle 22. The height of sine bar 23 is equal to the height of the pitch line of rack 2, and the diameter of roll 27 equals that of the pitch circle of gear 20. Thus, it is obvious teeth 18 and 19 must engage at their respective pitch lines.

A workpiece 3 is rigidly secured to an extremity of spindle 22 between shoulder 28 and nut 29 which threadably engages said spindle.

It will be observed that as rack 2 reciprocates with carriage 4, intermittent rotation in one direction and then the reverse will be imparted to workpiece 3 by means of gear 20 and spindle 22. It is pointed out that said rack is made equal in length to the circumference of the pitch circle of gear 20 in order that each stroke of said rack will present the entire peripheral surface of workpiece 3 to grinding wheel 30. It is to be further observed that rack 2 is shown in a neutral or lowered position in Figure 6. In operative position, however, said rack must be sloped to give rise to the cam. This being true, gear 20 will move in the plane of rotation as rack 2 reciprocates, and such movement will be imparted to said spindle and workpiece.

Spindle 22 is supported by movable arm 31 to provide for said planar movement. Such arm 31 is pinned at 32 to standard 33 upwardly projecting from base 1 and provides bearings 34, 35 for bushings 36, 37, 38 which retain said spindle.

Tension springs 39, 40 prevent gear 20 and rack 2 from disengaging as said rack reciprocates. Said springs, held by pins 41 of clevis bolts 42 secured to base 1, are attached to bosses 43 of arm 31. Such arm 31 thus forcibly urges gear 20 to mate rack 2 continuously, regardless of the sloping disposition of said rack.

Although gear 20 is constrained by spindle 22, the relative movement between the gear and rack, as said rack reciprocates, produces in effect the same result as though said gear were permitted to roll and said rack were stationary. Therefore, as gear 20 in effect rolls on rack 2, it rises uniformly from one extremity to the other thereof, and the surface presented by workpiece 3 to grinding wheel 30, as said wheel reciprocates across said surface, is that of the curve traced by an imaginary point on the pitch circle of gear 20 as it rolls. The slope of rack 2 represents the total rise of the cam and it is apparent that this need only be changed to adapt a machine of my invention to grind cams having different rises. It is also apparent that this adaptation may be made quickly by even an inexperienced operator through use of bolt 14 and nut 15. In this manner, a cam grinding machine of my invention has, by the simple expedient of varying the slope of a rack, made possible the production of uniform rise cams having different rises, and eliminated the necessity of elaborate, expensive adaptations which only a skilled operator could control.

Grinding wheel 30 is mounted upon carriage 44, which is hereinafter termed a feed carriage, to reciprocate therewith. Said carriage is mounted upon base 1 by means of machined surface 45 and keyway 46 for reciprocation in a plane normal to that of stroke carriage 4.

An upper portion of said feed carriage forms grinding head 47, with machined surfaces 48 and slideways 49 adapted to receive slide 50. A lower portion of slide 50 forms at 51 one-half of a housing for bearings 52, 53 which support grinding wheel shaft 54. A cap portion 55 secured to portion 51 by bolt means 56 forms the other half of the housing for said bearings. The generally annular, cylindrical, abrasive grinding wheel 30 is affixed to the extremity of shaft 54 adjacent stroke carriage 4.

To provide for adjusting said grinding wheel into contact with the workpiece, nut 57 is appended to the rear of slide 50 by bolt means 58 to threadably engage portion 59 of feed screw 60. An upper portion of said feed screw 60, secured in suitable bearing means 61, carries bevel gear 62 pinned thereto at 63. Such bevel gear 62 mates bevel gear 64 on shaft 65 which is supported in suitable bearing means 66. A handwheel 67 is mounted on said shaft 65, which when rotated, rotates shaft 65 and bevel gear 64 and in turn bevel gear 62. As bevel gear 62 is turned, it is apparent that slide 50 will move as nut 57 travels along portion 59 of feed screw 60. Thus, by means of handwheel 67, grinding wheel 30 may be positioned with respect to workpiece 3.

Electric motor 68, mounted on feed carriage 44, drives grinding wheel 30 only. It is pointed out that such motor reciprocates with said carriage and is not operatively connected to the driving mechanism to be later described. As motor 68 is energized, motor shaft 69 rotates pulley 70. Pulley 70 drives compound pulley 71 by means of belt 72. Said compound pulley drives pulley 73 mounted on grinding wheel shaft 54 by means of belt 74. It is obvious that pulley sizes may be selected to drive grinding wheel 30 at any speed desired.

To accomplish reciprocation of stroke carriage 4 and feed carriage 44 in timed relationship as described, suitable driving mechanism is provided. A prime mover in the form of an electric motor 75 is mounted at 76 in a lower portion of base 1 which has been previously described. When operation is initiated by starting motor 75, motor shaft 77 rotates pulley 78. Pulley 78 drives

pulley 79, shaft 80 and worm 81 by means of belt 82. Worm 81 drives worm gear 83 and shaft 84 extending therethrough to drive at one extremity crank 85 with crank pin 86 and, at the opposite, worm 87. Worm 87 drives worm gear 88 which in turn drives shaft 89 and crank 90 with crank pin 91.

Suitable mechanism is provided to accomplish reciprocation of stroke carriage 4 as crank pin 86 rotates. Said pin passes through opening 92 of slide block 93, positioned to move slidably in I-slot 94 of oscillating lever 95. It is pointed out that crank pin 86 is not tight in opening 92, but is free to rotate.

An upper end of lever 95 provides slot 96, adapted to slidably receive block 97. Said upper end and block 97 are received in channel 98 formed between the downwardly disposed sides 99, 100 of channel block 101 which depends from stroke carriage 4. By means of a pin 102 extending through mating holes in block 97 and said downwardly extending sides, said block is retained therein. Thus, as crank pin 86 rotates, slide block 93 reciprocates in I-slot 94 and lever 95 oscillates about bearing 103, reciprocating carriage 4 by means of block 99 pinned to channel block 101.

Similarly, suitable mechanism is provided to reciprocate feed carriage 44 normal to the plane of reciprocation of stroke carriage 4 as crank pin 91 rotates. Said crank pin extends through opening 104 of slide block 105. An I-slot 106, in lever 107, is provided for said block to slidably reciprocate therein. At the top of lever 107, a slot 108 is provided to receive block 109. Channel block 110 depends from feed carriage 44 and has downwardly disposed sides 111, 112, forming channel 113 in which to receive said upper part of lever 107 and block 109. Said block 109 is retained therein by means of pin 114 passing through mating holes in sides 111, 112 of said block. Lever 107 is mounted to oscillate about bearing 115 at its lower extremity. Inasmuch as the operation is similar to that described for reciprocating stroke carriage 4, it will not be further described.

It will be quite apparent to those skilled in the art that feed carriage 44 must be reciprocated more rapidly than stroke carriage 4 to accomplish the grinding and polishing of an accurate cam contour with reasonable rapidity. It is equally obvious that this result may be readily accomplished by providing in the driving mechanism suitable gear ratios and lever lengths to provide for reciprocation of the grinding wheel many times as the workpiece rotates in either direction. In the machine described herein, the ratio of reciprocation of the feed carriage to that of the stroke carriage is 30 to 1. This, however, may be made any figure consistent with good practice without departing from the described invention.

Formal changes may be made in the specific embodiment of the invention described without departing from the spirit and substance of the invention, the scope of which is commensurate with the appended claims.

What is claimed is:

1. A machine for grinding uniform rise cams comprising a base, a spindle mounted on said base to rotatably support a workpiece, said spindle adapted to permit movement of the workpiece in the plane of rotation, a feed carriage mounted on said base for reciprocation normal to the plane of rotation of said workpiece, said carriage including a generally cylindrical, annular grinding wheel and means for driving the same, a stroke carriage mounted on said base for reciprocation in a plane parallel to the plane of rotation of said workpiece, a gear operatively associated with said spindle for effecting rotation thereof, a rack on said stroke carriage to engage said gear for effecting rotation and movement of said workpiece in its plane of rotation in accordance with said reciprocating movement, the combined rotational and planar movements serving to cause the peripheral surface of the workpiece to progressively contact the surface of the grinding wheel along the contour of a uniform rise cam, and common driving means to reciprocate said feed carriage and said stroke carriage in timed relationship.

2. A machine for grinding uniform rise cams comprising a base, a spindle mounted on said base to rotatably support a workpiece, said spindle adapted to permit movement of the workpiece in the plane of rotation, a feed carriage mounted on said base for reciprocation normal to the plane of rotation of said workpiece, said carriage including a generally cylindrical annular, grinding wheel and means for driving same, a stroke carriage mounted on said base for reciprocation in a plane parallel to the plane of rotation of said workpiece, said stroke carriage including an adjustable rack and means for adjusting the same to a sloping position, a gear secured to said spindle for effecting rotation thereof, said sloping rack on said stroke carriage engaging said gear for effecting rotation in accordance with said reciprocating movement, the combined rotational and planar movements serving to contact the surface of the grinding wheel along the contour of a uniform rise cam, and common driving means to reciprocate said feed carriage and said stroke carriage in timed relationship.

3. A machine for grinding uniform rise cams comprising a base, a spindle mounted on said base to rotatably support a workpiece, said spindle so mounted as to permit movement of the workpiece in the plane of rotation, a feed carriage mounted on said base for reciprocation normal to the plane of rotation of said workpiece, said carriage including a generally cylindrical, annular grinding wheel and means for driving the same, oscillatory means to effect reciprocation of said carriage, a stroke carriage mounted on said base for reciprocation in the plane parallel to the plane of rotation of said workpiece, said carriage including an adjustable rack and means for adjusting the same to a sloping position, oscillatory means to effect reciprocation of said stroke carriage, a gear operatively associated with said spindle for effecting rotation thereof, said sloping rack on said stroke carriage engaging said gear for effecting rotation and movement of said workpiece in its plane of rotation in accordance with said reciprocating movement, the combined rotational and planar movements serving to cause the peripheral surface of the workpiece to progressively contact the surface of the grinding wheel along the contour of a uniform rise cam, and common driving means to cause said oscillatory means to reciprocate said feed carriage and said stroke carriage in timed relationship.

4. A machine for grinding uniform rise cams comprising a base, a spindle mounted on said base to rotatably support a workpiece, said spindle so mounted as to permit movement of the workpiece in the plane of rotation, a feed car-

riage mounted on said base for reciprocation normal to the plane of rotation of said workpiece, said carriage including a generally cylindrical, annular grinding wheel and means for driving the same, a crank operated oscillating lever to reciprocate said feed carriage, a stroke carriage mounted on said base for reciprocation in a plane parallel to the plane of rotation of said workpiece, said carriage including an adjustable rack and means for adjusting same to a sloping position, a crank operated oscillating lever to effect reciprocation of said stroke carriage, a gear operatively associated with said spindle for effecting rotation thereof, said sloping rack on said stroke carriage engaging said gear for effecting rotation and movement of said workpiece in its plane of rotation in accordance with said reciprocating movement, the combined rotational and planar movements serving to cause the peripheral surface of the workpiece to progressively contact the surface of the grinding wheel along the contour of a uniform rise cam, and common driving means to drive said crank pins in such manner the oscillating levers will effect reciprocation of said carriages in timed relationship.

5. A machine for grinding uniform rise cams comprising a base, a spindle mounted on said base to rotatably support a workpiece, said spindle mounted in such manner as to permit movement of the workpiece in the plane of rotation, a feed carriage mounted on said base for reciprocation normal to the plane of rotation of said workpiece, said carriage including a generally cylindrical annular, grinding wheel, means for driving the same, and means for adjusting the grinding wheel into contact with the workpiece; an oscillating lever for reciprocating said feed carriage, a stroke carriage mounted on said base for reciprocation in a plane parallel to the plane of rotation of said workpiece, said carriage including an adjustable rack and means for adjusting the same to a sloping position, an oscillating lever to effect reciprocation of said stroke carriage, a gear secured to said spindle for effecting rotation thereof, said sloping rack on said stroke carriage engaging said gear for effecting rotation and movement of said workpiece in its plane of rotation in accordance with said reciprocating movement, the combined rotational and planar movements serving to cause the peripheral surface of the workpiece to progressively contact the surface of the grinding wheel along the contour of a uniform rise cam, and common driving means to oscillate said levers in such manner as to effect reciprocation of the carriages in timed relationship.

6. A machine for grinding uniform rise cams comprising a base, a movable spindle mounted on said base to rotatably support a workpiece, said spindle permitting movement of the workpiece in the plane of rotation, a feed carriage mounted on said base for reciprocation normal to the plane of rotation of said workpiece, said carriage including a generally cylindrical, annular grinding wheel and means for driving same, a stroke carriage mounted on said base for reciprocation in a plane parallel to the plane of rotation of said workpiece, said carriage including a table pivotally mounted for adjustment into a sloping position and means for rigidly securing the same in adjusted position, a rack mounted on said table, a sine bar of the same height as the pitch line of said rack adjacently mounted on said table, a gear secured to said spindle for effecting

rotation thereof, a roll of the same diameter as the pitch circle of said gear mounted to revolve freely on said spindle, said rack engaging said gear for effecting rotation and movement of said workpiece in its plane of rotation in accordance with the reciprocation of said stroke carriage, said sine bar contacting the periphery of said roll to prevent binding between rack and gear, the combined rotational and planar movements serving to cause the peripheral surface of the workpiece to progressively contact the annular surface of the grinding wheel along the contour of the uniform rise cam traced by a point on the pitch circle of said gear, and common driving means to effect reciprocation of said carriages in timed relationship.

7. A machine for grinding uniform rise cams comprising a base, a spindle mounted on said base to rotatably support a workpiece, said spindle permitting movement of the workpiece in the plane of rotation, a feed carriage mounted on said base for reciprocation normal to the plane of rotation of said workpiece, said carriage including a generally cylindrical, annular grinding wheel and means for driving same, a stroke carriage mounted on said base for reciprocation in a plane parallel to the plane of rotation of said workpiece, a gear operatively associated with said spindle for effecting rotation thereof, a sloping rack on said stroke carriage of a length equal to the circumference of the pitch circle of said gear to engage said gear for effecting rotation and movement of said workpiece in the plane of rotation in accordance with said reciprocating movement, said workpiece rotating 360° as the rack reciprocates in one direction and being similarly reversibly rotated as said rack reciprocates in an opposite direction, said planar movement being sufficient to produce the desired rise on the cam, the combined rotational and planar movements serving to cause the peripheral surface of the workpiece to progressively contact the annular surface of the grinding wheel along the contour of a uniform rise cam, and common driving means to reciprocate said carriages in time relationship.

8. A machine for grinding uniform rise cams comprising a base, a spindle mounted on said base to rotatably support a workpiece, said spindle permitting movement of the workpiece in the plane of rotation, a feed carriage mounted on said base for reciprocation normal to the plane of rotation of said workpiece, said carriage including a generally cylindrical, annular grinding wheel and means for driving same, a stroke carriage mounted on said base for reciprocation in a plane parallel to the plane of rotation of said workpiece, a gear operatively associated with said spindle for effecting rotation thereof, a sloping rack on said stroke carriage to engage said gear for effecting rotation and movement of said workpiece in the plane of rotation in accordance with said reciprocating movement, means operatively associated with said spindle to continuously urge said gear into engagement with said rack as the peripheral surface of said workpiece progressively contacts the annular surface of said grinding wheel along the contour of a uniform rise cam, and common driving means to reciprocate said carriages in timed relationship.

9. A machine for grinding uniform rise cams comprising a base, a spindle mounted on said base to rotatably support a workpiece, said spindle permitting movement of the workpiece in the plane of rotation, a feed carriage mounted

on said base for reciprocation normal to the plane of rotation of said workpiece, said carriage including a generally cylindrical annular grinding wheel and means for driving the same, a stroke carriage mounted on said base for reciprocation in a plane parallel to the plane of rotation of said workpiece, a gear secured to said spindle for effecting rotation thereof, a sloping rack on said stroke carriage to engage said gear for effecting rotation and movement of said workpiece in the plane of rotation in accordance with said reciprocating movement, a tension spring operatively associated with said spindle to continuously urge said gear into engagement with said rack as the peripheral surface of said workpiece progressively contacts the annular surface of said grinding wheel along the contour of a uniform rise cam, and common driving means to reciprocate said carriages in timed relationship.

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