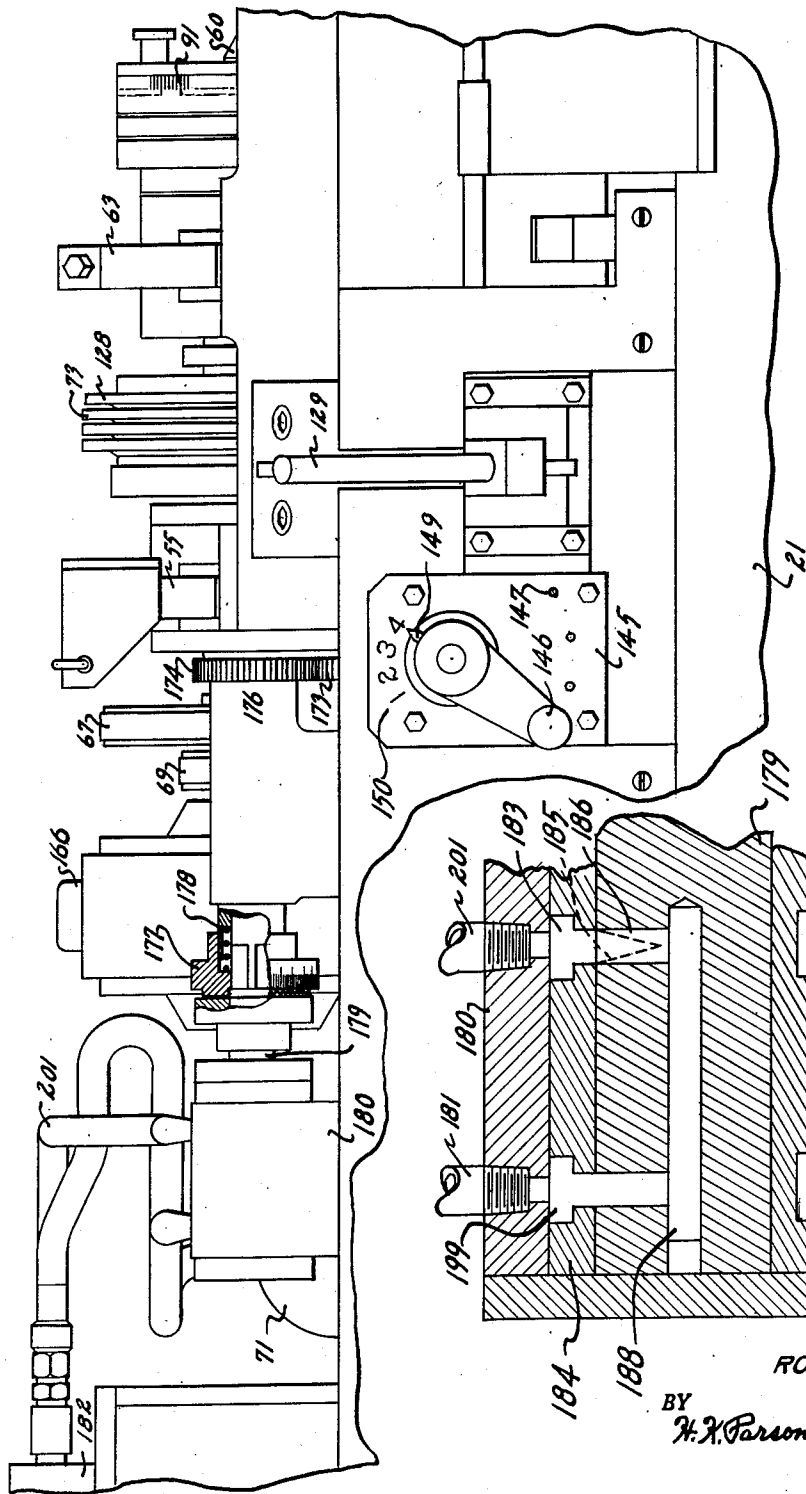


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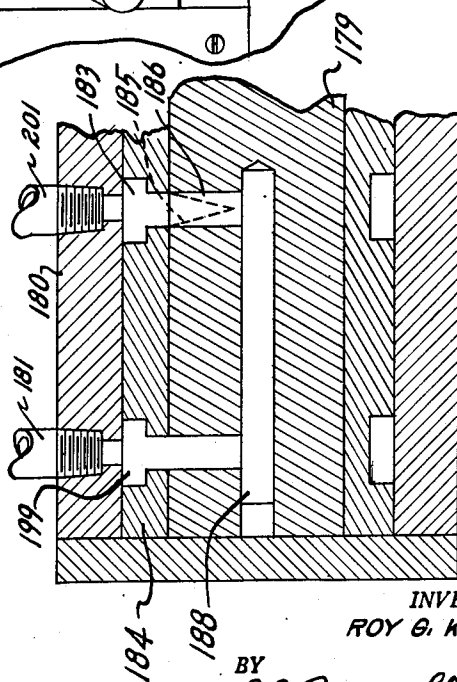


Fig. 15

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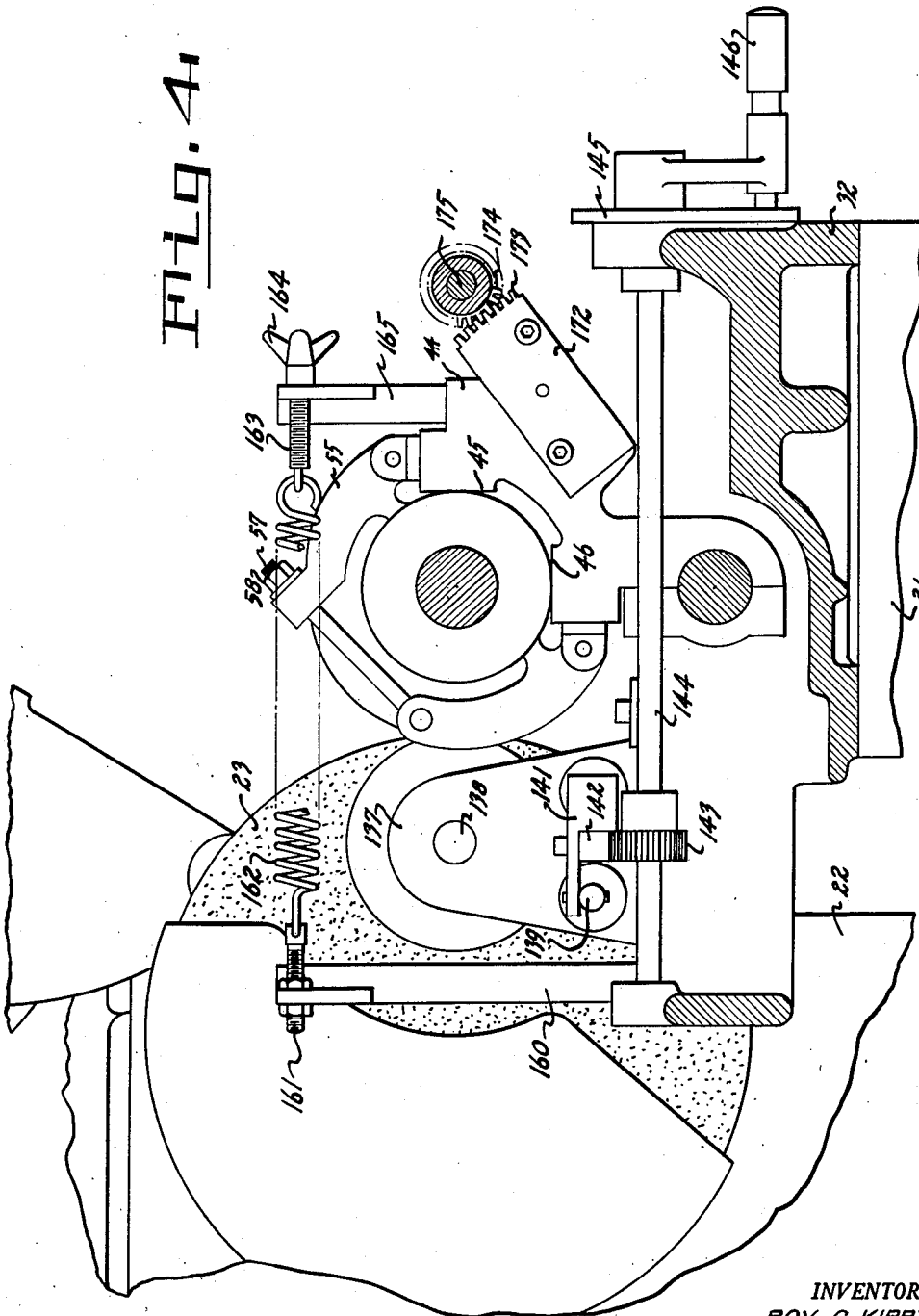
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Fig. 4



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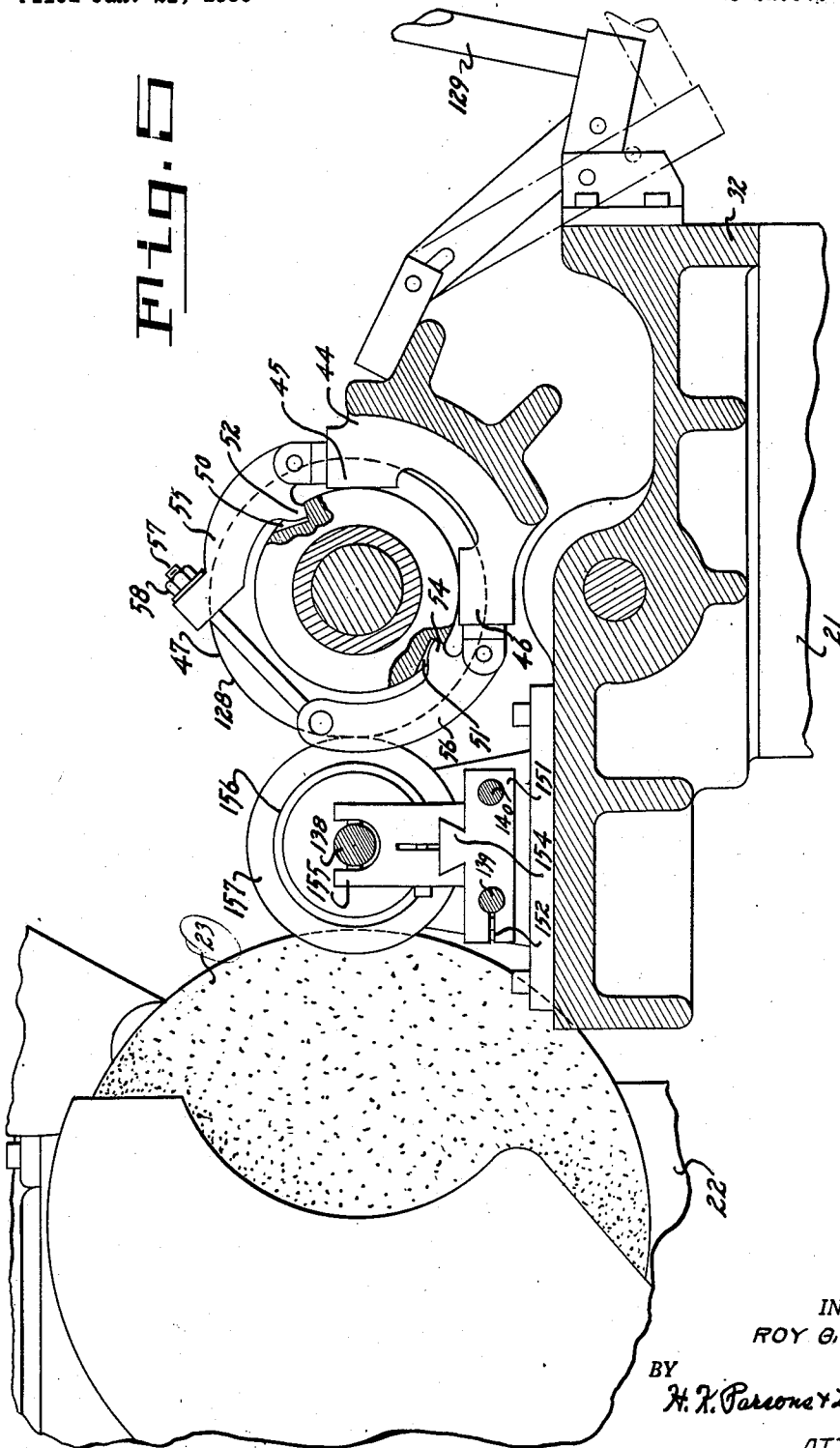
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Fig. 6

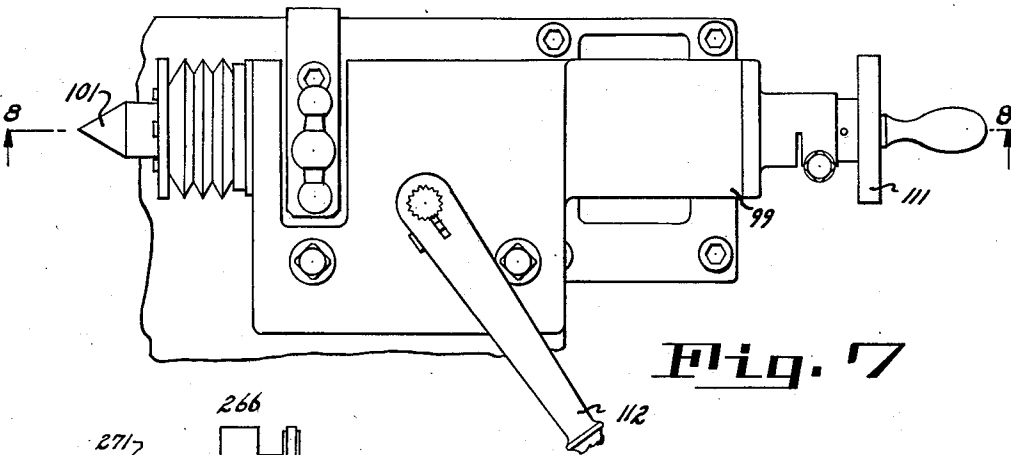
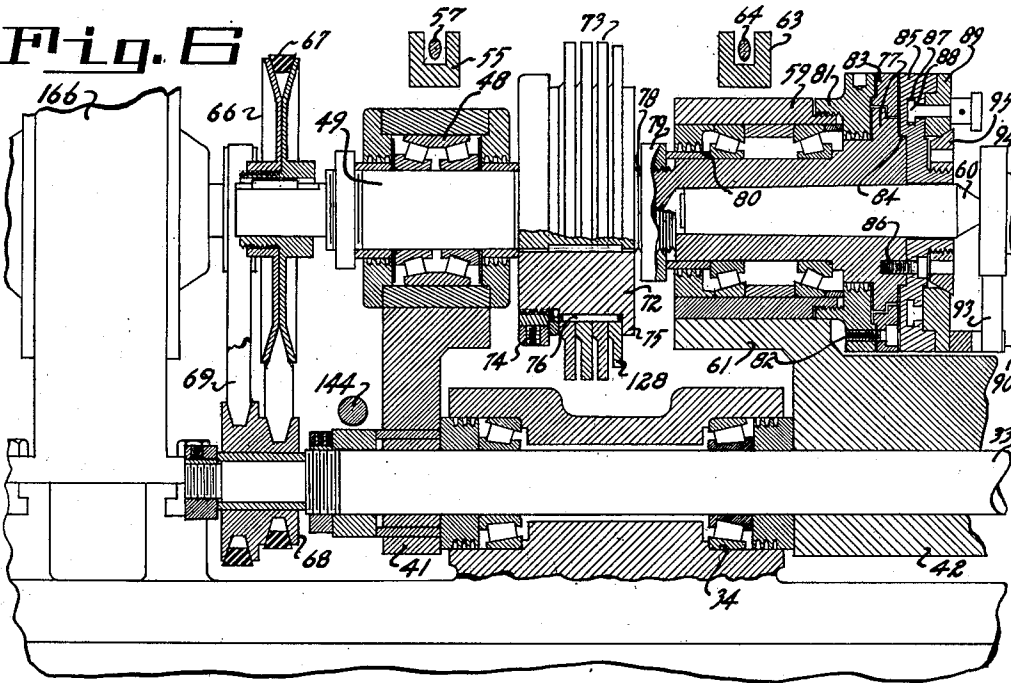


Fig. 7

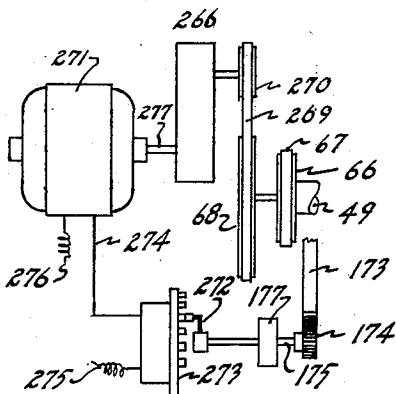


Fig. 16

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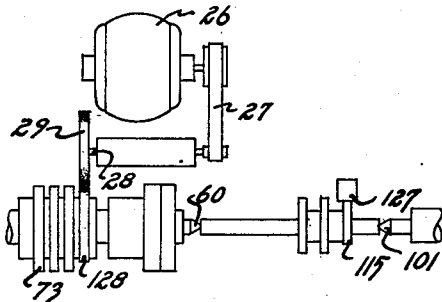


Fig. 11

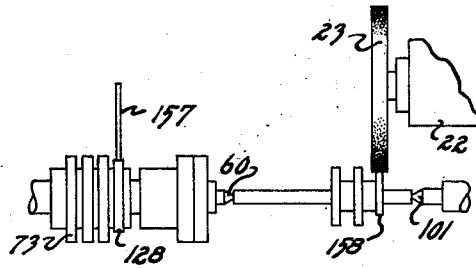


Fig. 12

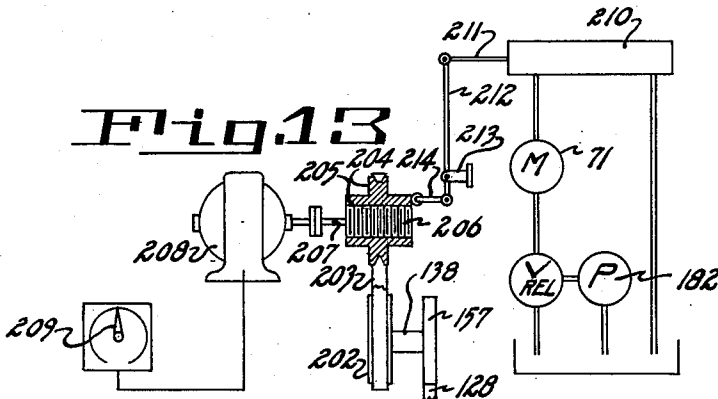


Fig. 13

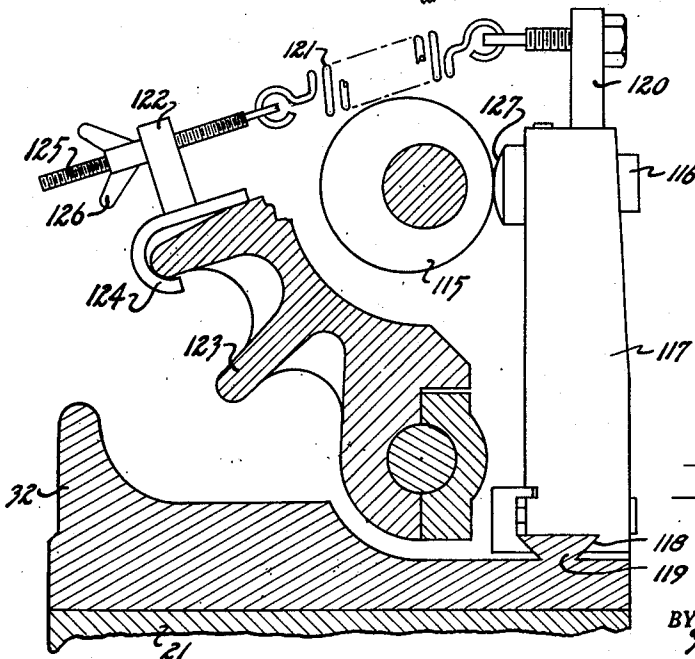


Fig. 14

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UNITED STATES PATENT OFFICE

2,641,874

GRINDING MACHINE

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Application January 21, 1950, Serial No. 139,815

7 Claims. (Cl. 51—101)

1

This invention relates to improvements in grinding machines and has reference to a machine particularly adapted for production by grinding of cam or other surfaces of irregular or non-circular contour.

One of the objects of the present invention is the provision of a machine of this character which will effect a uniform grinding action on surfaces of irregular contour and will eliminate chatter or vibratory effects due to the rise and fall action or relative movement of the work and grinding wheel during generation of the contour.

A further object of the present invention is the provision in connection with a machine of this character of means for effecting an automatic control of the rate of rotation of the work piece in accordance with the variations in its configuration.

An additional object of the invention is the provision of a machine which may be employed both to produce the guiding cam or cams for work piece reproduction from either a prefinished work piece or a simple pattern in which the guide cam or cams so produced may be then utilized without change of position for commercial production of duplicate work pieces and in which multiple angularly related guide cams may be readily produced as a unitary element by utilization of a single pattern element.

It is additionally the purpose of this invention to provide a machine for cam grinding purposes which will permit of ready interchange of various pattern sets, of relative angular adjustment of the work piece and pattern as desired and of supporting means for the machine elements which will be so constructed and related as to minimize the inaccuracies due to unbalance or twisting strains resulting from the grinding action and the controlling action of relative movement of the parts.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof, and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

Figure 1 is a perspective view of a machine embodying one form of the invention.

Figure 2 is a plan view of the headstock portion thereof.

Figure 3 is a front elevation of the portion of the machine as shown in Figure 2.

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Figure 4 is a view partially in elevation and partially in section as on the line 4—4 of Figure 2.

Figure 5 is a view similar to Figure 4 as on the line 5—5 of Figure 2.

5 Figure 6 is a fragmentary longitudinal sectional view as on the line 6—6 of Figure 2.

Figure 7 is a plan view of the tailstock portion of the machine.

10 Figure 8 is a longitudinal section of the tailstock and mounting on the line 8—8 of Figure 7.

Figure 9 is an end view of the swinging carriage and associate parts.

15 Figure 10 is a fragmentary sectional view as on the line 10—10 of Figure 8.

Figure 11 is a diagrammatic view illustrating the utilization of the invention in formation of a master cam.

20 Figure 12 is a similar view illustrating work-piece production by a utilization of the cam as generated in Figure 11.

Figure 13 is a diagrammatic view of a master cam peripheral speed controlling device utilizable in connection with the present invention.

25 Figure 14 is a section of a modified form of carriage control spring mounting.

Figure 15 is a longitudinal section of the rate valve.

Figure 16 is a diagrammatic view of an automatic electrical work speed control.

In the drawings, the numeral 20 designates the bed of a cylindrical grinder which may be of standard commercial type provided with the reciprocating table 21 and the wheelhead carriage 22 which is slidably mounted on the bed for movement in a direction toward and away from the table. This wheelhead, as indicated in Figures 4 and 5, supports the large grinding wheel 23 suitably driven as from motor 24 and is additionally provided with a bracket portion at 25 supporting the supplemental driving motor 26. This latter motor is connected by belt 27 to drive spindle 28 of a second smaller grinding wheel 29. This wheel and its associate parts are supported in bracket 30 hinged as at 31 to the wheelhead so that the parts may be swung downward to bring the grinding wheel 29 into grinding position with respect to a work piece as is indicated in Figure 1. Alternatively, the bracket and grinding wheel may be swung upward toward the motor 24 when out of grinding position so that desired grinding operations may be performed. As has been mentioned, the present invention is particularly adapted for use in the production or generation by grinding of cams or like elements and in the accomplishment of this usually special work holding mechanism is

provided. In its primary form this mechanism includes a heavy bracket or bed plate 32 of appreciable longitudinal extent which is bolted or suitably secured in position on the table 21 of the grinding machine and serves as a support for the work holding, work driving, and work position determining mechanisms which are thus movable or translatable as an entirety with the table and with respect to the position of the grinding wheels. Supported by the bed plate 32 is a longitudinally extending rock shaft or spindle 33 supported at various points intermediate its length as by anti-friction bearings 34, 35, and 36 as indicated in Figures 6 and 9. This shaft is provided with the flats as at 40 providing substantially V-shaped configuration to facilitate ready clamping in position thereon for rotation therewith the oscillating bracket members 41, 42, and 43.

The member 41 has a seat or socket portion as at 44 providing lugs 45 and 46 to receive a unitary bearing assembly, designated as an entirety by the numeral 47, having interior anti-friction bearing 48 supporting the rotary shaft or spindle 49. Exteriorly, the bearing is provided with recesses as at 50 and 51 to receive lugs 52 and 54 of the clamp arms 55 and 56 which are pivoted to the member 44 and extend in arcuate embracing relation to the bearing unit, these members being connected at their outer ends by the swivel blocking rod 57 which may be put under tension by tightening of screw 58, drawing the clamping arms angularly inward so that the lugs 52 and 54 will exert suitable retaining pressure against the bearing holding it in position on the lugs 45 and 46.

Similar structure is provided in connection with the bracket 42 in which the bearing unit 59 for the headstock spindle 60 is seated against the portion 61 of the bracket arm, use being made of the clamps 62 and 63 connecting clamp rod 64 and nut 65.

It will be evident that by loosening of the nuts 58 and 65, the rods 57 and 64 may be swung outwardly into disengaging relation to the clamp arms which may then be opened, releasing the bearings and the unit assembly readily removed.

The shaft 49 carries on its outer or left hand end as particularly illustrated in Figure 6 the driving pulley or sheave 66 rotatable by belt 67 of the table pulley 68 rotatably supported by the rock shaft 33. This pulley is, in turn, driven through belt 69 and pulley 70 on the shaft of the rotary head-stock operating hydraulic motor 71 which thus supplies power for rotation of the work. Carried by the shaft 49 is the rotary head 72 which is of larger diameter than the bearing unit 47. The outer face of the head 72 therefore forms a seat to receive the cam cluster or like member 73 which may constitute either the work piece to be ground or the guiding form to control the work-piece produced during different phases of operation of the machine. In any event, the member 73 has an internal bore of size to slip over the bearing unit and closely interfit with the member 72 where it is retained between the clamp nut element 74 and the flange 75. A key or spline as indicated at 76 perfectly locks the parts for synchronous rotation.

Integral with the spindle 49 is the bushing 77 having a tapered recess to receive the headstock center 60, while intermediate the flange 72 and the portion 77 the spindle 49 is threaded as at 78 to receive clamp nut 79 tightening the bearing clamping collar 80.

A bearing clamping collar 81 circumscribes the inner portion of member 77 for securing the outer elements of the double taper roller bearing in position within the bearing sleeve or support 59.

Secured to the face of the member 81 as by the clamp bolts 82 is the retaining collar 83 interengaged with the shoulder on the member 77 for locking it in position against endwise movement with respect to the bearing assembly. The member 77 terminates in a reduced shoulder portion at 84 centralizing the collar 85 retained on the inner face of 77 by bolts such as 86. This collar has an arcuately extending T slot as at 87 receiving T bolt 88, permitting limited oscillatory movement of disc 89 carrying the headstock drive bracket 90. The member 85 is provided with graduations as at 91 for cooperation with the indicator or pointer 92 on member 89 minutely to indicate the exact angular relative adjustment of said parts and thus the phase relationship between the position of the member 73 as determined by key 76 and the position of the drive bracket 90. It will be understood the drive bracket 90 by engagement with driving dog 93 on the work piece 94, thus definitely determines and establishes the phase angle relationship between the work piece and the member 73. This relationship having been established, tightening of clamp nut 95 rigidly locks the parts 85 and 89 in their desired angular or phase adjusted position.

For support of the opposite end of the work piece 94, there is provided a tailstock mechanism particularly illustrated in Figures 7 and 9, which mechanism is carried by the bracket 43 supported by the rock shaft 33. The bracket 43 is provided with ways as at 96 and 97 for the tailstock unit 98 which includes sleeve 99 within which is slidably mounted the telescoping sleeve or bushing 100 tapered to receive the tailstock center 101. A pin 102 engaged in the groove 103 of bushing 100 guides same for longitudinal movement. The projection of the tailstock center is effected by spring 104 bearing against the collar 105 interiorly pinned to the sleeve 100 and which, in turn, guides the adjusting screw 106 engaging nut 107 keyed at 108 to the sleeve 100. This nut serves to vary the compression of spring 109 which bears against washer 110 seated in the sleeve 100. Rotation of the screw is effectable by the hand wheel 111. For ordinary retraction of the tailstock center 101 to release the work, use is made of the customary control handle 112 pivoted to member 98.

In the utilization of the present invention for the production of master control cam units or the like, a pattern, model, or work piece 114 is clamped in position between the headstock and tailstock centers as indicated in Figure 1. The swinging bracket 22 carrying the grinding wheel 29 is lowered in the position indicated in Figure 1 and one of the cam or contour surfaces 115 of the work to be reproduced is engaged with the abutment lug 116 carried by a standard 117 which has a dovetail guideway at 118 interfitting with the dovetail guide 119 upstanding from the rear portion of the member 32. This mounting of the standard is such that it might be readily aligned with any one of the several cam or eccentric elements 115 on the member 114. To retain the parts in suitable interengaging relation while allowing of oscillation of the shaft 33 and parts supported thereby during grinding, the standard preferably supports a bracket 120 to which is secured spring 121 having its outward end extending forwardly and supported from the member 122 carried by the upper portion of the oscillating carriage or

frame 123. In Figure 1 the structure shown is particularly adapted for short work in that the member 122 is indicated as rigidly mounted on 123 while in Figure 14 it has been shown as carried by a hook clamp or attachment 124, permitting of its sliding along the frame to insure a most direct line pull of the spring between the support elements 120 and 122. An attaching screw 125 and adjusting nut 126 in either event permits proper determination of the acting spring forces which, as will be most evident by reference to Figure 14, causes an upward and inward clockwise oscillatory urge of the frame and pattern member.

With the parts thus positioned, the unit indicated at 73 comprises the workpiece, and an element thereon to be formed is properly aligned with the grinding wheel 29 which preferably has a surface corresponding in arcuate dimension to the rounded contacts 127 on the abutment 116.

Rotation of spindle 49 will revolve a selected section, such as 128 of the work piece, to present all portions of the periphery thereof to the active surface of the grinding wheel 29. At the same time, the synchronized rotation of member 114 by contact of 115 with the fixed abutment 116—127 will cause an in and out oscillation of the entire oscillatory carriage, such that the contour of the portion 115 will be reproduced with extreme accuracy on the member 128.

If it is desired to produce a series of master cams, such as 128, on the element designated as an entirety by the reference character 73 but in angularly phased relation, as for example, the relationship existing between the various cams on an automobile cam, this result may be effected, if desired, by utilization of a single pattern element and without adjustment of the position of the spring supports 117 and 124.

In accomplishment of this result, after the first member 128 has been completed, nut 95 may be loosened and collar 89 may be given an angular rotation of desired amount as easily determinable by relationship of scale 91 and pointer 92 according to the relative out of phase or angle between corresponding configurations desired of the cams to be produced, the parts located, and the grinding wheel 29 aligned with the portion of member 73 on which the next cam surface is to be generated or produced and this operation continued until all such cams have been formed from the single pattern and in desired angular relationship one to the other.

As an alternative, of course, and as particularly indicated in connection with Figure 1, a complete pattern or a sample work piece may be inserted at 114, in which event it is unnecessary between grindings of the elements 128 to make any change in phase relationship between pattern and work but each element of the work being ground will be a direct reproduction of the particular pattern.

At the completion of such a work piece forming operation, downward oscillation of the control handle 129 will rock and lock the oscillating carriage in a retracted position as indicated by the dotted lines in Figure 5. When so positioned, the table is preferably translated to move the parts out of alignment with the main grinding wheel head, after which the bracket 22 is swung into its upward or retracted position when the machine is conditioned for operation of the main grinding wheel 23.

The base of the unit 32 is provided with a guide portion or ways at 131 to receive a bed

plate 132 adjustably retained in position by bolts 133 engaged in the slots 134 permitting of a forward and back adjustment of the position of the bed plate 132 as determinable by the scale 133' and index 134'. A screw 135 swiveled to the base 32 and engaging the bracket nut 136 on the plate 132 may be utilized, if desired, for accurately effecting this adjustment.

The plate 132 has rising therefrom the pair of brackets or standards 137 mounting at their upper portion the shaft 138 and near their bases the rods 139 and 140. Rod 139 extends to the left of the unit, as viewed in Figure 2, and has secured to its projecting end the block 141 carrying rack 142 meshing with pinion 143 for effecting longitudinal sliding of the rod. The pinion 143 is mentioned on the shaft 144 extending forwardly through plate 145 carried by the base plate 32 and is provided with the actuating handle means 146. The plate itself is formed with sockets 147 with which the locking pin 148 of the handle may be selectively engaged to lock the handle and thus the pinion and rack in desired adjusted position. A pointer 149 movable with the handle cooperates with indicia 150 on plate 145 to denote the particular adjustment effected by movement of the handle.

While the rod 140 may also be movable with the block, it is preferably fixed in position with the standards and therefore forms a guide both for the sliding movement of the block with the plate 151 which is likewise mounted on rod 139. Member 151 is split, as at 152, the furcations thus provided spanning the rod 139 and may be clamped in adjusted position along the rod by screw 153. Member 151 is provided with dovetail rib 154 extending parallel to the rods 139 and 140 and adjustably mounting the uprights 155 which have yoke portions spanning the shaft 138. Mounted on the shaft 138 is the hub 156 carrying a guide roller 157 which is thus supported for rotation on the shaft 138 and for translation with rod 139 as it is reciprocated. By reference particularly to Figure 2, it will be noted that this guide roller 157 is adapted to be positioned for peripheral running engagement with the discs or cam elements 128 and that by outward rocking of the oscillatory carriage, as by actuation of lever 129 retracting the members 128 from interengagement with the member 152 and suitable actuation of handle 146 the member 152 may be brought into alignment with any selected member 128. The spacing of the sockets 147 on plate 145 may be so positioned that each movement of the handle from one socket to the next will effect the exact accurate translatory adjustment of the member 152, it being understood that if a different series of positionings due to different spacing of members 128 is desired that a new plate 145 may be substituted or that a sufficient number of sockets may be provided to take care of the desired incremental shifting movements.

In the diagrammatic view, Figure 11, the oscillation of the swinging carriage is shown as controlled by interengagement of the pattern element 115 with the abutment 127, parts being urged toward each other by the spring 121. At this time, the small grinding wheel 29 is being employed to generate the master cam elements such as 128. When, however, the master cam has been generated and is then being utilized for production of the work piece 158 or a series of similar work pieces, the wheel 29 is no longer employed but in its stead the large grinding wheel

23, as diagrammatically illustrated in Figure 12. Under these conditions the oscillatory control is by interengagement of the rotating disc or roller 157 and the appropriate previously generated cam element 128. In order that the oscillatory movement in this work piece production may be identical with the oscillation imparted by the pattern during generation of the cam, it is preferable that this guide wheel 157 be identical in diameter with the diameter of the wheel 29 employed for the generating operation.

During this phase of utilization of the machine, the spring 121 and its supporting bracket 117 are removed so that the table may be transmitted to bring the grinding wheel 23 in proper engagement with the portion of the work piece to be ground and without interference from the bracket 17. As it is still desired that the carriage oscillation be controlled by spring again, the bed plate 32 is provided with a standard 160 which is connected by bolt 161, the actuating spring 162 definitely connected by screw 163 and adjusting nut 164 with a second standard or bracket 165 mounted on the oscillating carriage unit. The spring thus continuously urges and holds the pattern element 128 being employed in yielding contact with guide disc 157 to permit the necessary in and out swinging of the carriage while maintaining sufficient pressure properly and adequately to maintain the work in engagement with the grinding wheel.

Reference has been made to the fact that the cam and work piece assembly are rotated as by the hydraulic motor 71 through suitable belting and the speed reducer 166. If the amount of irregularity of the cam or eccentric surfaces being produced is but slight it is possible to perform the grinding operation by continuous speed rotation of the parts. For best grinding results, however, as to finish and accuracy the present invention contemplates automatic modification of the rate of drive of the work pieces in accordance with variations in configuration so that there is a substantially uniform relative surface speed between the operative phase of the grinding wheel and the work piece and a suitable slowing down of the rate of rotation of the work piece in accordance with increase in radius and a corresponding relative speeding up of rotation as the work piece radius decreases.

One mechanism for accomplishment of this result is particularly illustrated in connection with Figures 3 and 4 of the drawings. Secured to the oscillating carriage at the left hand end thereof is a plate 172 having an arcuate rack portion 173 concentric with the shaft 33 about which the carriage oscillates. This rack meshes with pinion 174 carried by spindle 175 journaled in the bearing 176 carried by the bed plate 32 and has splined thereon the sliding clutch 177 outwardly urged by spring 178. Axially aligned with the spindle 175 is the valve stem 179 journaled in the valve block or casing 180. Connected into the casing 180 is exhaust conduit 181 leading from the hydraulic headstock drive motor 71, this motor also being coupled to a pump unit by conduit 200 or source of actuating medium as at 182.

The pressure medium from the motor discharges by way of the annular groove 183 of the bushing 184 in the valve block and conduit 201 to the pump unit 182 for reutilization. The bushing is provided with a throttle aperture, preferably of the V-type, at 185 variably con-

trolled by the relative positioning with respect thereto of the slot 186 in the valve stem. The stem itself is provided with a longitudinally extending bore 188 communicating with groove 199 which is, in turn, coupled by conduit 181 with the discharge side of the hydraulic motor 71. It will be evident that depending upon the rotary adjustment given to valve stem 179 a variable amount of actuating fluid will be allowed to exhaust from the driving pump 71 and thus the rate of actuating of the headstock spindle 49 by way of the speed reducer 166 and the belts 67, 69 is accurately controlled. Due to the clutch connection between the members 177 and 179 the valve stem may be independently rotated with respect to pinion 174 for selection of any desired rate of headstock actuation for a particular positioning of the pinion. During grinding operations, whether for production of the cam elements 128 through use of the grinding wheel 29 or for production of the eccentrics or cams such as 115 through use of the wheel 23, there will be a corresponding in and out oscillatory movement of the work supporting carriage. This movement will be transmitted through rack 173 to the pinion 174 and thus to the valve. As the carriage swings inward or toward the grinding wheel, shortening the work radius, the pinion will be rotated in a clockwise direction to open up the effective control porting in the valve chamber, proportionally increasing the rate of rotation imparted to the work and control cams. However, as the carriage is oscillated outwardly or in a clockwise direction, the pinion will thereby be rotated in a counterclockwise manner, closing down the throttling action and slowing up rotation of the work. It has been found by utilization of this mechanism that a much better and more accurate finish with the absence of chatter effects can be produced as, for example, on the high points of automobile camshafts, and it is possible with uniform rotation irrespective of the particular radius of the work being presented in opposition to the grinding wheel.

An alternative form of control for accomplishment of this result has been indicated in Figure 13. In this view the disc or roller 157 which engages the members 128 has been indicated as keyed or rigidly mounted on the shaft 138, which projects outwardly from the shaft support and is provided with the pulley 202 connected by belt 203 with a second pulley 204 on the sleeve nut 205. This nut is supported on the threaded portion 206 with shaft 207 which is driven by the variable speed motor 208 provided with a suitable controller 209 for determining the speed of operation of the motor. As in the form of the invention previously described, the headstock is basically driven by the hydraulic motor 71 supplied with actuating fluid from a pump or hydraulic unit 182 while the discharge from the motor leads into the valve block 210 containing a valve corresponding in function and operation to the valve mechanism contained within valve block 180. The position of this valve is determined by rod 211 pivoted to one end of lever 212 intermediately pivoted supported at 213 and terminally pivotally connected by the link 214 to the sleeve nut 205. In operation, controller 209 is set to select a proper non-chatter producing speed of rotation for the headstock and the headstock motor is put in operation through activation of the pump or unit 182. The frictional engagement between the elements 128 and 157 will effect rotation of the member 157 at a sur-

face speed corresponding to the surface speed effected by rotary movement of member 128. It will, therefore, be evident that as the radius of curvature of member 128 increases it will tend to speed up the rate of rotation of 157, 202, which action will advance the nut along the screw 206, thus transmitting motion to valve rod 211 moving the valve to a throttle or slow down the motor until the rate of advance of the work surface has been reduced to the preselected rate of operation determined by motor 208 so that the nut and screw rotate in synchronism without relative longitudinal movement. Correspondingly, a reduction in radius will cause offset direction of relative movement of the screw and nut, speeding up the work rotation until the prescribed surface speed is reached and maintained. It will thus be noted that in both of the forms of the invention here chosen for purposes of illustration, means have been provided for automatically varying the rate of rotation imparted to the work during grinding in accordance with the variations in configuration of the work so that proper control of surface speed to insure an accurate chatter-free finish on the work is insured. Preferably, the adjustment is such as to maintain a constant relative speed of movement of the surface of the work and the operative surface of the grinding wheel for the attainment of highest accuracy and uniformity of surface finish and prevention of production of marked or irregular surfaces due to differences in this relative surface speed as occur in normal uniform work piece rotation grinding operations.

In Figure 16 there has been diagrammatically illustrated an automatically controlled electrical drive in place of hydraulic for the headstock and cam members. In this view the numeral 271 designates a variable speed member which, through the speed reduction element 266, operates pulley 270 and, in turn, through belt 269 drives the regular pulley 68 of the machine and thus by belt 67, the sheave or pulley 66 on the headstock spindle 49, these latter parts being shown in detail, for example, in Figure 6 of the drawings. As in the form previously described, the oscillation of the headstock carried through rack 173 rotates pinion 174 carried by spindle 175. In the present instance, however, in place of the spindle being coupled by the adjustable clutch device 177 with the valve 180 the coupling is to the rotary arm 272 of the rheostat or like variable resistance member 273. This member is coupled by line 274 with the motor 271 and additionally with power line, such as 275 at the opposite power circuit line 276, being coupled with the motor 271 in conventional manner.

With this form of construction any oscillatory or partial rotary movement imparted to the pinion 174 by carriage effected movement of the rack 173 will vary the position of the control arm 272 automatically to vary the rate of rotation of the shaft 277 of motor 271 and thus the rate of drive of the headstock. In this instance also we have, as before, means controlled by the guide cam for effecting automatic variation in the rate of rotation of the cam and work piece in accordance with the variations in the effective radius or contour of the cam.

What is claimed is:

1. The process of producing cam contours consisting in axially mounting a pattern and a control cam blank, controlling relative movement of the said blank with respect to a grinding wheel by rotating the blank and pattern with the pat-

tern in engagement with a shoe having a large radius, grinding the control cam with by a generating wheel of lesser radius than that of the shoe, supporting the ground control cam in engagement with a shoe of substantially the same radius, grinding the control cam with a generating a work piece for the original pattern in corresponding axial relationship to the control cam, and grinding the work piece to a cam contour determined by interengagement of the control cam and said shoe.

2. A cam grinding attachment for grinding machines which embody a base, a work table, a grinding wheel support and means for effecting relative translatable and feeding movements of the work table and grinding wheel support with respect to the base, said attachment including a base plate adapted to be mounted on the table, a carriage supported by the base plate for oscillation with respect thereto, a headstock unit mounted on the carriage, variable speed driving means for effecting rotation of the headstock unit, and control means effective during oscillation of the carriage to vary the rate of rotation imparted to the headstock by said driving means, said means including a rotary controller and connections between the carriage and controller actuatable by oscillatory movement of the carriage for effecting speed varying rotation thereof upon oscillating movement of the carriage.

3. A cam grinding machine including a support, a carriage mounted thereon for oscillation with respect thereto, a work driving headstock supported on the carriage for oscillation therewith, said headstock having a pattern cam receiving portion adapted to receive a pattern cam having axially spaced control cam portions, guides mounted on the support, a slide carried by said guides, bracket means rising from the slides, a contact shoe rotatably supported by the brackets and shiftable by the slide selectively to engage different effective portions of a pattern cam on the headstock for peripheral frictional engagement therewith, driving means for rotating the headstock, a rate controller for said driving means, and operating connections between said shoe and rate controller variably to determine the rate of drive of the headstock in accordance with the peripheral speed frictionally imparted by the headstock driven cam to the rotatable contact shoe.

4. A cam grinding machine including a support, a carriage mounted thereon for oscillation with respect thereto, a work driving headstock supported on the carriage for oscillation therewith, said headstock having a pattern cam receiving portion adapted to receive a pattern cam, a contact member carried by the support for operative engagement with the contact cam, means for resiliently oscillating the carriage in a direction to maintain a pattern cam in engagement with said contact member, driving means for rotating said headstock, a hydraulic rate controller for said driving means including an adjustable rate valve carried by the support, and means connecting the rate valve and the oscillatable carriage for varying the setting of the valve in accordance with the oscillatory positioning of the carriage.

5. A cam grinding machine including a support, a carriage mounted thereon for oscillation with respect thereto, a work driving headstock supported on the carriage for oscillation therewith, said headstock having a pattern cam receiving portion adapted to receive a pattern cam, a contact member carried by the support for op-

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erative engagement with the contact cam, means for resiliently oscillating the carriage in a direction to maintain a pattern cam in engagement with said contact member, driving means for rotating said headstock, a hydraulic rate controller for said driving means including an adjustable rate valve carried by the support, means connecting the rate valve and the oscillatable carriage for varying the setting of the valve in accordance with the oscillatory positioning of the carriage, and additional means to preselect the range of rate variations effectable by oscillatory movement of the carriage.

6. In a cam reproducing mechanism, the combination with a support, of a carriage pivotally mounted thereon for oscillation relative thereto, said carriage having bearing receiving seats formed thereon, a headstock unit having bearing cartridges for engagement with the seats, means for removably securing said cartridges on the seats, said headstock mechanism having a pair of spaced axially aligned seating portions for selective mounting of work piece and pattern elements, said seating portions each having means for determining the rotative position of the element to be mounted thereon, and means intervening said position determining elements for varying their angularly phased relationship.

7. In a cam grinding machine, the combination with a base, of a carriage pivotally mounted on the base for oscillation with respect thereto, means for effecting oscillatory movements of the carriage in accordance with the peripheral contour of the cam to be ground, means for supporting the cam to be ground on said oscillatory carriage, and means for determination of the rate of

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presentation of the surface of the cam to be ground to a grinding member, said means including a hydraulic driver for effecting a rotation of the work holding means, a rotatable throttling valve connected variably to determine the rate of operation of said hydraulic motor, a control element having a clutch portion engageable with the valve, a pinion carried by said control member, and an arcuate rack mounted on the carriage and meshing with the pinion whereby oscillation of the carriage will operate through the pinion and controller to vary the position of the rate valve and thus the rate of actuation of the work holder by said motor.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,716,115	Clark et al.	June 4, 1929
1,938,439	Remington	Dec. 5, 1933
2,018,847	Fraser	Oct. 29, 1935
2,060,437	Harley	Nov. 10, 1936
2,334,938	Lang	Nov. 23, 1943
2,352,608	Archer	July 4, 1944
2,414,126	Sevin	Jan. 14, 1947
2,415,801	Armitage et al.	Feb. 11, 1947
2,422,681	Johnson	June 24, 1947
2,508,998	Green	May 23, 1950
2,557,043	Wright et al.	June 12, 1951

FOREIGN PATENTS

Number	Country	Date
12,235	Great Britain	May 26, 1913