Aug. 27, 1935. C. H. AMIDON 2,012,263

CRANK SHAFT GRINDING MACHINE

Filed Sept. 19, 1934 4 Sheets-Sheet 1

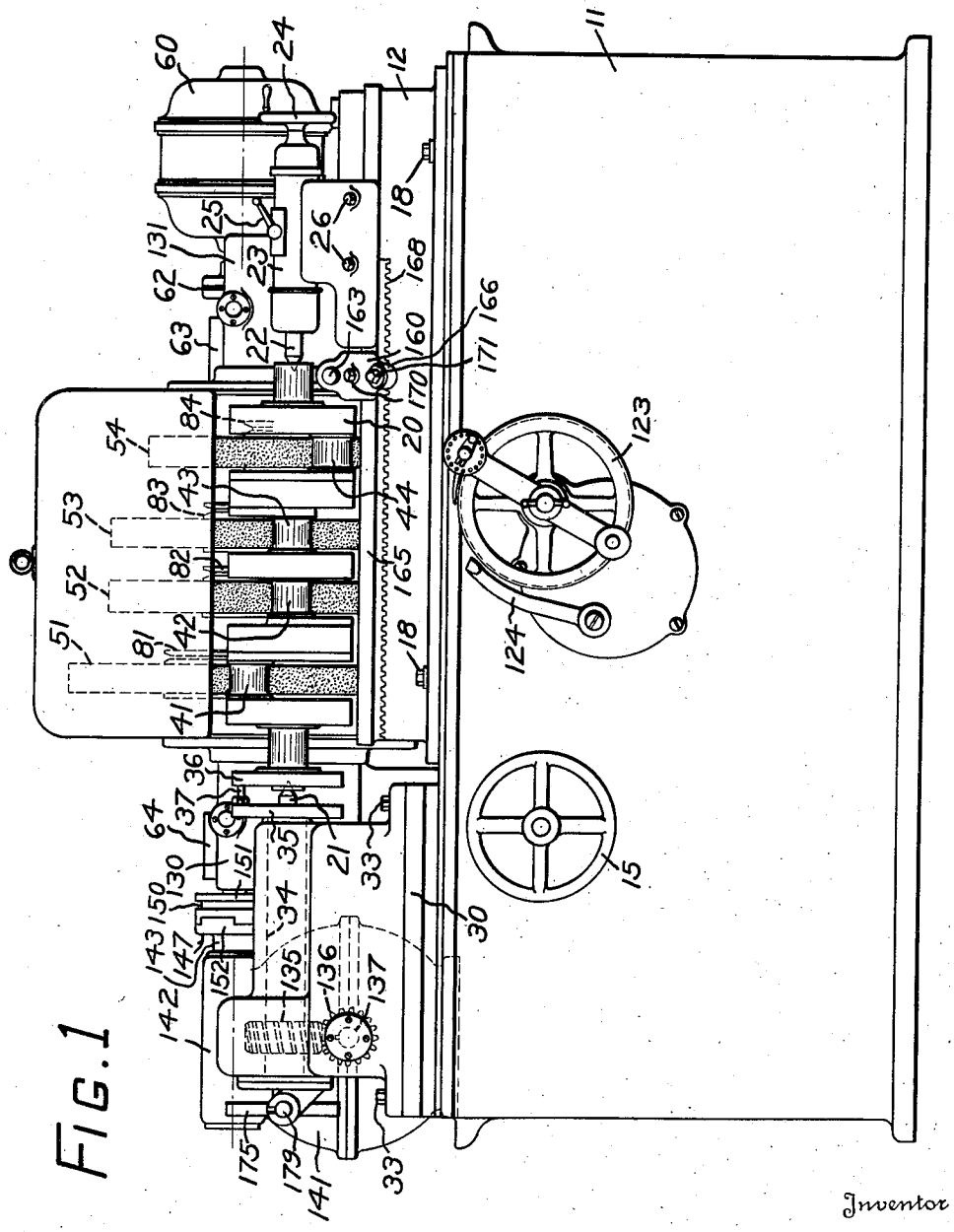


FIG. 1

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CRANK SHAFT GRINDING MACHINE

Filed Sept. 19, 1934 4 Sheets-Sheet 2

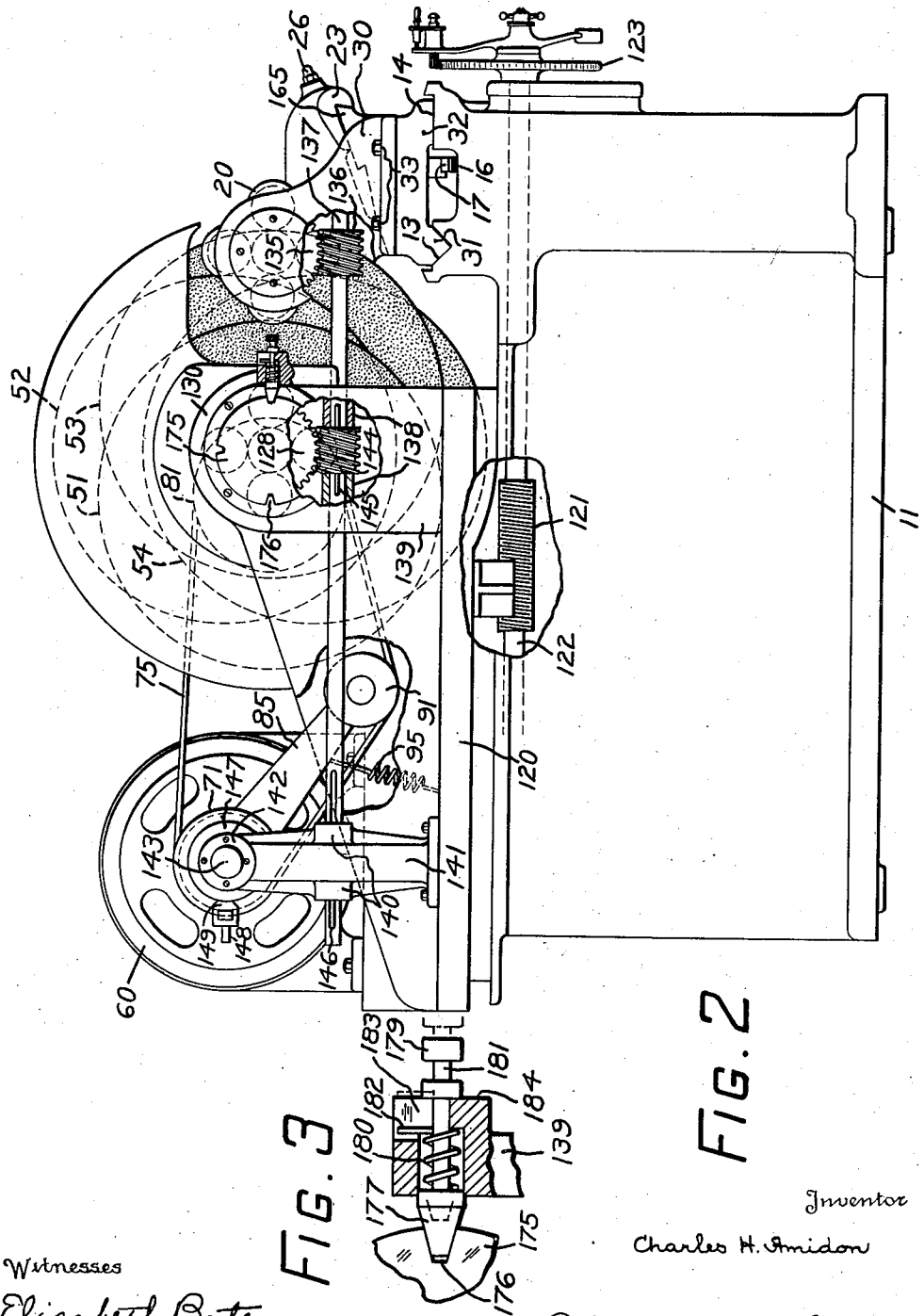


FIG. 3

FIG. 2

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CRANK SHAFT GRINDING MACHINE

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FIG. 5

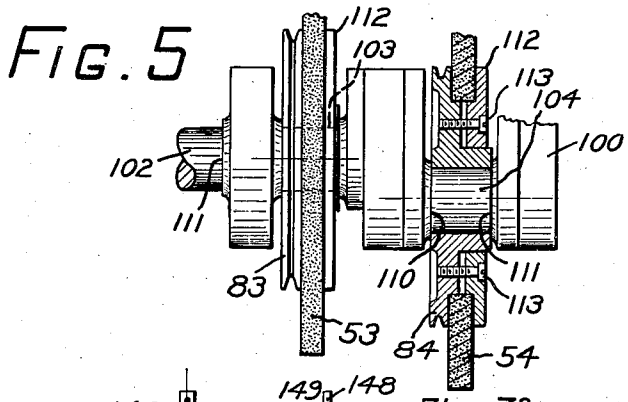
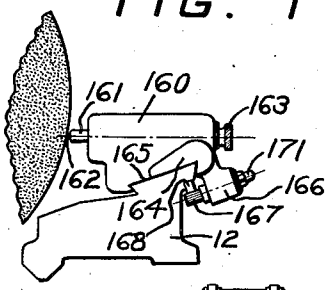


FIG. 4



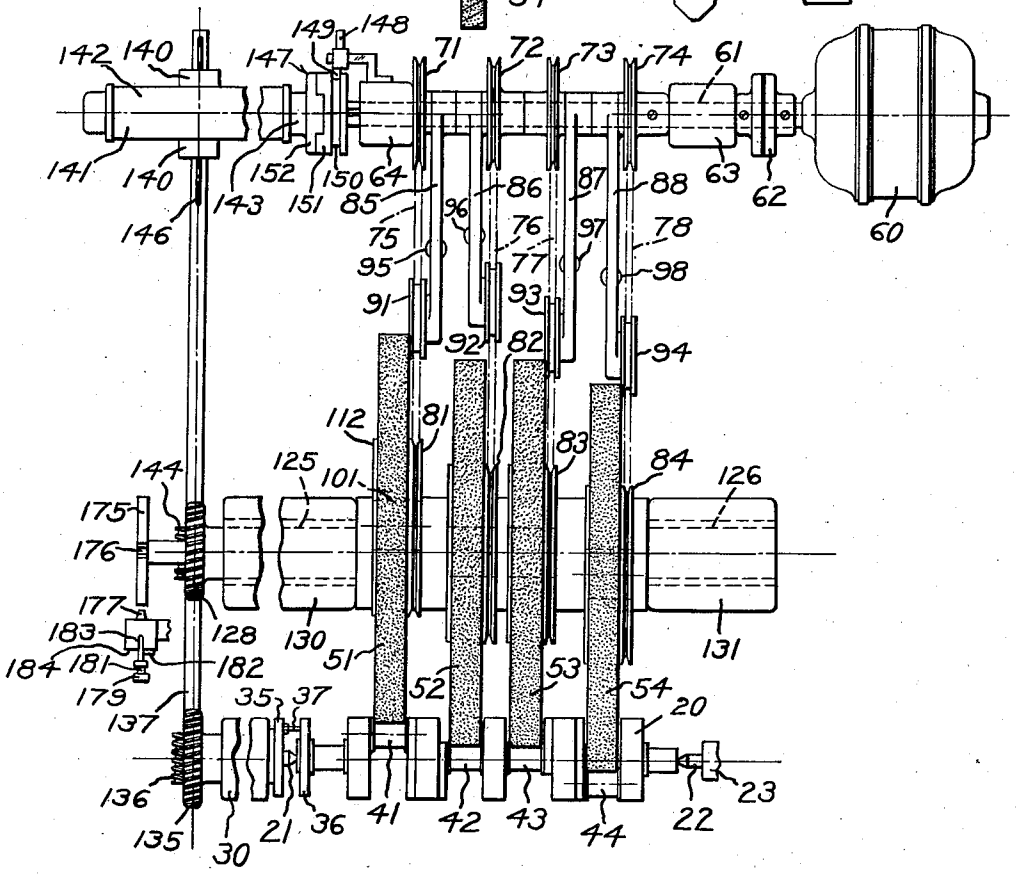


FIG. 6

Witnesses

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CRANK SHAFT GRINDING MACHINE

Filed Sept. 19, 1934 4 Sheets-Sheet 4

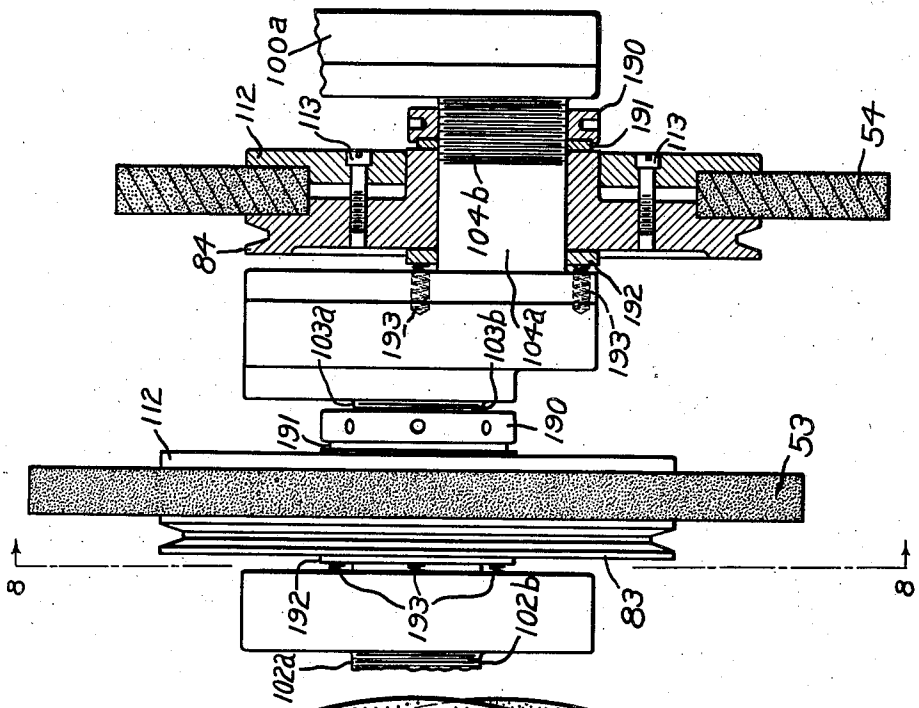


FIG. 7

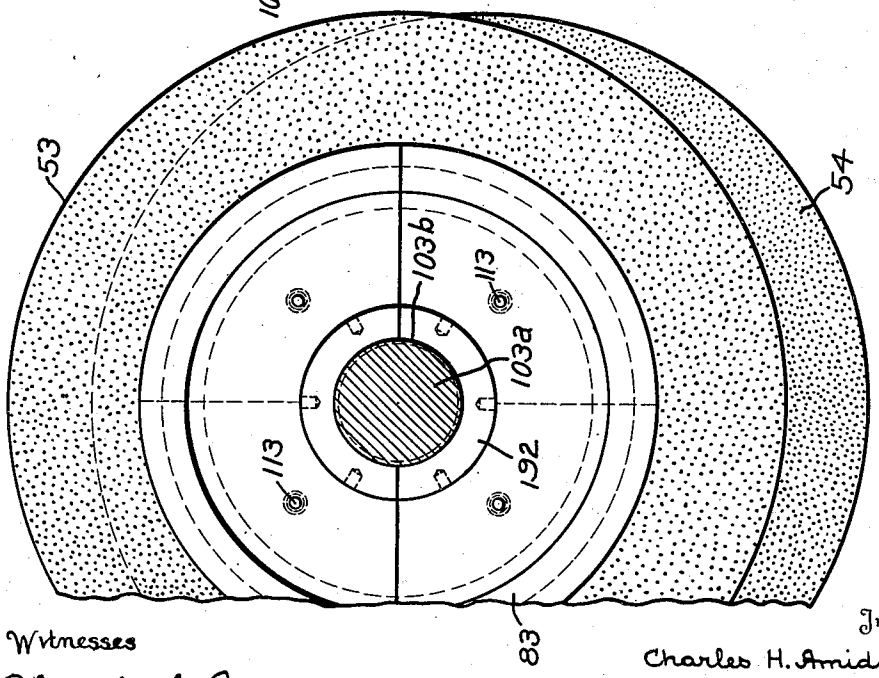


FIG. 8

Witnesses

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Patented Aug. 27, 1935 2,012,263

UNITED STATES PATENT OFFICE

2,012,263

CRANK SHAFT GRINDING MACHINE

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Application September 19, 1934, Serial No. 744,709

13 Claims. (Cl. 51—90)

The invention relates to grinding machines, and with regard to its more specific features to a grinding machine for grinding crank shafts.

One object of the invention is to provide a grinding machine capable of grinding irregular bodies at a high rate of production. Another object of the invention is to provide a grinding machine capable of grinding all throws of a crankshaft at a single operation. Another object of the invention is to provide a grinding machine adapted to grinding cranks and similar articles to a high degree of precision. Another object of the invention is to provide a highly efficient grinding machine. Another object of the invention is to provide a grinding apparatus adapted to produce precision results without the use of work-rests, thus simplifying the grinding operation. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts as will be exemplified in the structure to be hereinafter described and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, illustrative of one of various possible embodiments of the mechanical features of this invention,

Figure 1 is a front elevation;

Figure 2 is an end elevation, the machine being viewed as from the left-hand side of Figure 1, certain machine parts being shown as broken away to show other mechanism;

Figure 3 is a view on an enlarged scale of a device for holding the axis of each grinding wheel at any one of a plurality of points in its orbital path for use when it is desired to true one or more of the grinding wheels;

Figure 4 is a fragmentary view showing the wheel truing or dressing device;

Figure 5 is a detailed view showing a pair of grinding wheels and their mountings, one wheel and its support being illustrated in section;

Figure 6 is a diagrammatic view illustrating the grinding of a crankshaft and the driving trains for wheel rotation, wheel orbital movement, and workpiece rotation;

Figure 7 is an enlarged view, similar to Figure 5, showing a modified form of wheel mounting whereby the planes of rotation of the several wheels may be adjusted relative to each other by a small amount;

Figure 8 is a sectional view taken on the line 8—8 of Figure 7.

As conducive to a clearer understanding of the present invention, I note that the regular practice in grinding crankshafts has involved the grinding of the several pins or throws successively. Machines which have heretofore been provided for grinding crankshafts according to such method have included mechanisms for successively positioning the same wheel against different throws and for supporting the work-piece. With the very best arranged and organized of such machines the setting up for grinding of successive crank-throws has nevertheless involved a substantial amount of time. The present invention succeeds in performing at a single operation successfully that which, according to the usual prior practice required a plurality of operations.

Referring now to Figures 1 and 2, I provide a machine base 11 upon which is mounted a table or carriage 12 by means of suitable ways on the under side of the table, not shown, and cooperating ways 13, 14 formed in the machine base 11. The table or carriage 12 may be moved longitudinally of the machine base 11 by means of a hand wheel 15 which is connected, through suitable gearing not shown, to a driving gear 16 that meshes with a rack 17 fastened to the under side of the table or carriage 12. Although, so far as certain features of the invention are concerned, I may employ a relative traversing movement, in the present embodiment of this invention there is no occasion to give the wheel and work-piece large relative traversing movements; it is preferred to hold the work-carrying table in a fixed position on the machine base 11 during the grinding operation, and accordingly once the desired position of adjustment is achieved, the table 12 may be locked to the machine base 11 as by means of bolts 18.

Now referring to Figure 1, the work-piece 20, which is here shown as an automobile crankshaft, is carried by centers 21 and 22, the latter being mounted in the usual adjustable tail-stock 23 having a hand wheel 24 to move the center 22 towards and away from the work-piece, together with locking device 25 to lock the center 22 in adjusted position. This tail-stock 23 is in turn adjustably mounted for movement parallel to the axis of rotation of the work-piece on the table 12, and may be secured in adjusted position by means of clamping bolts 26.

In order that this machine may be to a large extent universal and to facilitate removal of the machine parts from the base when desired, and for simplicity in setting up the machine, I prefer to mount the head center 21 in a head-stock 30 which is independent of the table 12 but which

rests upon the same ways 13 and 14 that the table 12 rests upon and which head-stock has cooperating ways formed therein and designated by the numerals 31 and 32 on Figure 2. By reason of this construction various driving mechanisms hereinafter referred to may be lined up to perform their function without undue friction, and once the desired position of the head-stock 30 is achieved it may be bolted in place by means of holding bolts 33.

Still referring to Figure 1, the center 21 is, as in lathe practice, removably positioned in a work-spindle 34, to the outer end of which is secured a driving plate 35. The spindle 34 is suitably journaled for rotation in the head-stock 30 and is rotated as will hereinafter be described.

The majority of modern automobile crankshafts have integrally forged therewith at one end a driving plate 36, to be secured ultimately to the automobile flywheel, and this driving plate 36 has one or more holes therein and usually one hole at least is located to precision limits a fixed radial distance from the crankshaft center, and I find such crankshafts may readily be driven by locating a driving pin 37 removably secured to the driving plate 35 in such hole in the driving plate 36, but for other types of crankshafts, or for this type if desired, the usual lathe dog may be employed.

Assuming now that the spindle 34 is rotated, the table 12 and the head-stock 30 having been fixed in position and the centers 21 and 22 engaging the crankshaft 20, and the driving pin 37 fixed in position as described, with the locking device 25 in locking position, the crankshaft 20 will be rotated, and successive crank-throws 41, 42, 43 and 44 will partake of circular orbital movements, with diurnal motion equal in angular velocity to the angular velocity of their orbital motion respectively. I have illustrated herein a crankshaft with successive throws angularly displaced 90 deg. from the preceding throw in the orbital path, but the much used four-throw crankshaft with all throws in a plane, may be ground on the present machine, and so also may any type of six- or twelve-cylinder crankshaft such as the familiar type of crankshaft employing the one hundred and twenty degree angle of displacement.

For the grinding of the crankshaft 20 or any other work-piece according to the present invention, I provide a plurality of grinding wheels 51, 52, 53 and 54 (see now Figure 6) which I cause to rotate diurnally and also to move orbitally in a circular motion complementary to that of the several throws 41, 42, 43 and 44, that is with the orbital movement of each grinding wheel always in phase with the orbital movement of the throw it is grinding, and having the same radius and angular velocity. I further provide means collectively to displace all the orbits of the grinding wheels towards the orbits of the crank-throws to produce a cutting in-feed.

Still referring to Figure 6, I provide an electric motor 60 to which is coupled a shaft 61 by means of a coupling 62, the shaft 61 being mounted in suitable bearings 63 and 64, and the shaft 61 having affixed to it four pulleys 71, 72, 73 and 74 which are connected by belts 75, 76, 77 and 78 to pulleys 81, 82, 83 and 84 attached to the several grinding wheels 51, 52, 53 and 54. Likewise mounted on the shaft 61, but not fastened thereto, are arms 85, 86, 87 and 88 which mount idler pulleys 91, 92, 93 and 94 that serve to tension the belts 75, 76, 77 and 78, springs 95, 96, 97 and 98 providing the required tension.

Referring now to Figure 5, I provide for the machine a number of crankshafts 100, each one of which is the counterpart of a crankshaft to be ground, so far as angular position of crank-throws or pins and radius of throw thereof and longitudinal spacing of throws are concerned. Each crankshaft 100 is preferably an integral forging, and has pins 101, 102, 103 and 104 upon which are mounted the pulleys 81, 82, 83 and 84 respectively, these pulleys being each split pulleys, that is formed of a pair of similar halves for assembly purposes (this type of construction being illustrated with respect to the modification, in Figure 8). Pulleys 81, 82, 83 and 84 fit nicely between shoulders 110 and 111 on the respective throws 101—104, and these pulleys constitute mountings for the respective grinding wheels 51—54, which are thereby freely rotatable on the several pins 101—104. The mounting for each wheel includes likewise an additional removable split clamping plate 112, each one secured to its corresponding combined pulley and mounting 81—84 by means of bolts 113, and when it is desired to replace a worn grinding wheel with a new one, the two halves of the plate 112 are first removed, whereupon the grinding wheel may be moved sideways off the shoulder on its pulley mounting, which frees the latter, the grinding wheels having holes therein sufficiently large to pass over the throws of the crankshaft 100.

Referring now to Figure 2, I provide a cross-slide or table 120 such as has been heretofore provided in grinding machines, and mounted on ways, not shown, provided therein and on the base 11 for movement perpendicular to the movement of the carriage 12 on ways 13 and 14. It is by movement of the cross-slide 120 that the cutting action is secured, and the cutting feed which may be continuous, if desired, is achieved in any usual or desired manner, such as by means of a cross-feed screw 121 mounted, integrally formed on, or secured to a shaft 122, which is mounted in suitable journals or bearings, not shown, provided in the machine base 11, and which is actuated by means of a hand wheel 123 (see also Figure 1) and associated mechanism including interposed gearing and shields, stop devices 124 and the like, all of which may be of any usual or desired form, for example such as shown in U. S. Letters Patent No. 762,838 granted to Charles H. Norton. By such a mechanism a graduated and controlled, and if desired a continuous cross-feed of the cross-slide 120 may be secured, and such movement is a precision one, and relatively speaking a slow one or one composed of minute successive increments. As shown in Figure 2, the motor 60 is mounted on cross-slide 120; likewise mounted thereon are the bearings 63 and 64 of the shaft 61. Each crank 100 provided for the machine, in addition to the two, four, six or any other number of crank-throws or pins provided, has a pair of end trunnions 125 and 126. Referring to Figure 2, to the trunnion 125 is attached a worm wheel 128. The trunnion 125 is removably mounted in a journal 130 which is a two-part journal for removal of the crankshaft 100; the other trunnion 126 is removably mounted in a two-part journal 131. The bottom half of each of the journals 130 and 131 is fastened to the cross-slide 120, a fixed distance from the axis of the shaft 61, although, adjustably on the axis of the crankshaft 100.

Thus all of the grinding wheels and the driving mechanism therefor are carried on the cross-slide 120 so that they may be caused to approach and recede from the work-piece collectively at will.

Referring now to Figures 2 and 6, I provide mechanism for rotating the work-piece crankshaft 20 and the grinding wheel supporting crankshaft 100 synchronously, that is at the same angular velocity, and I further provide means for synchronizing their phases. The work-spindle 34 has rigidly secured to it a worm wheel 135, and with this worm wheel meshes a worm 136 which is affixed to a shaft 137 that is journaled in a bearing, not shown, in the work-head 30. The shaft 137 extends through a pair of bearings 138 carried by a standard 139 projecting upwardly from the cross-slide 120, and the shaft 137 likewise passes through a couple of bearings 140 carried by a casing 141 also secured to the cross-slide 120, which casing 141 likewise supports a bearing 142 for a shaft 143 that is in line with and adapted to be coupled to the shaft 61, by means of a clutch to be described. Meshing with the worm wheel 128 is a worm 144 which is held in a fixed position so far as translation is concerned with respect to the cross-slide 120 by the bearings 138. The worm 144 is splined and a long key 145 on the shaft 137, or any similar device to transmit angular motion without transmitting rectilinear motion, causes the shaft 137 to drive the worm 144 and therefore the worm wheel 128.

The casing 141 contains a large worm wheel (not shown) which is restrained from movement relative to the casing by the bearings 140, 140, the shaft 137 having a long key 146 cooperating with a spline in said worm wheel, the purpose of this construction for transmitting power being the same as with respect to the worm 144. Fastened to the shaft 143 is a worm, not shown, which meshes with the aforesaid worm wheel to drive the same. The shaft 143 is normally connected by a positive dog clutch 147 to the shaft 61, but may be disconnected therefrom by means of a lever 148 having a pin 149 fitting in a groove 150 formed in movable part 151 of the clutch 147. The movable part 151 is splined to the shaft 61 while the abutting part 152 of the clutch 147 is fixed to its shaft 143.

When the clutch 147 is engaged and the motor 60 is running, power is transmitted along the shaft 61, through the clutch 147, and to the shaft 137, thus to drive both cranks 20 and 100, and as the worms 136 and 144 are of the same size and pitch, and likewise the worm wheels 135 and 128 are of the same size and pitch, the crankshafts are rotated at the same angular velocity, and since the worm wheels are so located on their respective shafts as to maintain corresponding crank-throws in the same phase relationship, and the two cranks are similar as heretofore pointed out, and their throws have the same radius, it follows that the orbital movement of each grinding wheel traces a circle similar to the orbital movement of each throw of the crank 20 and in the same phase relationship. By reason of the gear ratio which will be sufficiently apparent from the accompanying drawings, the diurnal motion of each grinding wheel is very much greater than its orbital velocity, and further by reason of the large diameter of the grinding wheels as compared with diameter of crank-throws to be ground, a high peripheral grinding speed is achieved. Assuming a constant diurnal velocity of the grinding wheels and a constant angular velocity of the crankshaft 20, there would be a constant surface speed of each wheel with respect to the work surface. By reason of the orbital motion, however, there is a tendency to change the velocity of each grinding wheel as the grinding wheel pulleys 81, 82, 83 and 84 approach and recede from the driving pulleys 71, 72, 73 and 74. By using a non-positive drive for the wheels 51, 52, 53 and 54 I find that their inertia of rotation checks this tendency, at least sufficiently so that no harmful effects result.

A crank 100 having been chosen which has throws the same as those of a crankshaft to be ground, as stated, and grinding wheels having been mounted on such crank 100 as shown and described, the work-piece crank 20 is mounted in place between the centers 21, 22 and the driving pin 37 is inserted in the hole in the plate 36. Assuming that the center 21 is of a length to dispose several throws 41, 42, 43 and 44 opposite the grinding wheels, the work-piece crank 20 may then be ground to finished size by starting the motor 60 and then advancing the cross-slide 120 by turning the hand wheel 123. On account of the fact that the orbital movement of the grinding wheels is the same as that of the crank-throws to be ground, the planes of tangency between the several grinding wheels and the several crank throws will be parallel. The lines of tangency in such planes bear a fixed relation to the orbits of the several grinding wheels respectively, and consequently generate cylinders whose radius is the radius of the several throws of the crankshaft, and these imaginary cylinders are contacted successively by all portions of the respective throws on account of their diurnal motion. Thus by advancing the grinding wheels to contact with the several throws, all of them may be ground by an equal amount and to a given diameter. If desired, a continuous in-feed of the grinding wheels may be employed, in connection with a dwell at the end of such feed to continue the grinding until the effect of pressure in the several machine parts is removed. This is called "grinding out the spark". An intermittent feed may also be employed, if desired. In order to avoid, as much as possible, grinding lines in the work-piece, the grinding wheels should be of an even texture and have a relatively hard surface.

After the machine is once set up, similar cranks may be introduced into the machine merely by running back the tail center 22 with the hand wheel 24. After a certain number of grinding operations the grinding wheels lose their regular or their even texture, and to put them back into condition for continuing the grinding to precision limits, they should be trued. I provide truing mechanism to true the wheels 51—54 without removing them from the machine.

Referring now to Figures 1 and 4, a truing holder 160 has therein a rod 161 having screw threads, not shown, cooperating with internal threads in the holder 160. The rod 161 has a diamond 162 in one end thereof, and on the other end a knob 163 by the angular adjustment of which the position of the diamond 162 may be adjusted to within precision limits. The holder 160 has ways 164 fitting ways 165 provided on the table 12. An integral bracket 166 carries a pinion gear 167 cooperating with a rack 168 affixed to the table 12 as shown in Figures 1 and 4 which serves as an adjusting means for positioning the holder relative to the table 12. Referring to Figure 1, the holder 160 is held in adjusted position on the table

12 by means of a binder bolt 170, and by tightening this bolt the holder 160 may be rigidly secured to the table 12. Prior to such rigid clamping of the parts together, however, the diamond 162 may be adjusted to exactly the desired position relative to the table 12 in a longitudinal direction by turning the bolt-headed stud 171 upon which the pinion 167 is mounted.

In connection with the truing of the wheels, I provide means to restrain the orbital movement thereof while permitting their diurnal motion. Referring to Figure 1, an index plate 175 is secured to the end of crankshaft 100, this index plate 175 having a number of index notches 176 equal to the number of throws of the crank to be ground and positioned angularly on said index plate by angles corresponding to the displacement of the several throws. When it is desired to true the grinding wheels and to insure the grinding of each throw 41, 42, 43 and 44 to the same diameter, clutch 147 is first released, and then the shaft 100 is turned (by manually turning the shaft 143, for example) until one of the notches is engaged by a detent 177 mounted, as shown in Figures 2 and 3, in a portion of the bracket 139. This restrains orbital movement of the grinding wheels, and one or more of them are in a forward position. The dressing holder 160 having been secured in position as described, the motor 60 may be started, and then by turning the hand wheel 15, the diamond 162 may be traversed with whatever wheel is at that time farthest forward. It is noted that the crank 20 will preferably not be located in the machine at this time, and it is further observed that coarse longitudinal adjustments of the diamond holder may be made by positioning it in the desired place on the table 12, while the traversing action of the diamond is better achieved by moving the table after the dressing device is locked in position. To insure contact between wheel and diamond, screw 163 may be turned.

Having trued one of the four (more or less) wheels, the detent 177 is withdrawn as by pulling a knob 179 thus withdrawing said detent against the action of a spring 180, and the shaft 100 rotated until the next notch 176 comes under the detent 177. The spring 180 causes the detent to engage the notch and it is noted that the detent is preferably of wedge shape, as shown, to cooperate with the wedge-shaped notch to determine accurately the position of the several grinding wheels in their orbits.

A second wheel having been positioned forward, it is now trued by traversing the table 12 through the medium of the hand wheel 15. In some cases this may be done without readjusting the bracket 160 on the table 12, and in other cases such readjustment will be effected, but the position of the diamond 162 with respect to the cylinder containing all of the orbits should remain the same, which will be the case if the adjustment of the knob 163 is undisturbed.

If the several wheels are successively trued as indicated, both by reason of the fact that their orbits all lie in the same cylinder, and by reason further of the fact that the table 12 moves in a line parallel to the axis of that cylinder, and therefore parallel to all of the elements thereof, the several grinding wheels will be dressed and trued to the same diameter which, under the conditions and with the machine as described, will insure, in succeeding grinding actions, the production of ground crank-throws all of the same diameter.

Subsequent to the truing operations the detent 177 should be withdrawn by pulling out the knob 179, and the detent may be held in withdrawn position by giving the knob 179 a partial turn. The knob 179 and the detent 177 are connected by a shaft 181 projecting laterally from which is a pin 182 slidably in a slot 183. Pin 182 and slot 183 serve to align the detent 177 in its operative position, and upon withdrawal of the detent the pin 182 moves out of the slot 183 and after the parts are given a partial turn the pin 182 engages the front face of a bearing portion 184 thus to hold the detent withdrawn. The machine is then ready for the introduction of a crankshaft 20 to be ground, and orbital movement of the crankshafts 20 and 100 is resumed upon engagement of the clutch 147.

Figures 7 and 8 illustrate a modification in the wheel mounting mechanism. A wheel mounting crankshaft 100*a* is provided whose throws or pins represented by pins 102*a*, 103*a* and 104*a* have threaded portions 102*b*, 103*b* and 104*b* upon which are mounted spanner nuts 190 engaging washers 191 which engage the pulley mountings 81, 82, 83 and 84 respectively, the other side of said pulley wheel mountings being engaged by washers 192 that are backed up by springs 193 located in the crank-arms as shown in Figures 7 and 8. By turning the spanner nuts 190 one way or the other the longitudinal position of each wheel may be adjusted sufficiently to cause each wheel to be located accurately with respect to the fillets on the crank-throws 41, 42, 43 and 44 which were produced in the previous operation, either a lathe operation or a forging operation or otherwise.

One adjustment laterally of all the grinding wheels 51, 52, 53 and 54 will probably suffice for the grinding of any given lot of crankshafts in actual production practice. It should be noted that this means of adjusting the position of the several grinding wheels permits the wheels to "split the spark" on all throws thus achieving economy so far as wear of the grinding wheels is concerned.

It will thus be seen that there has been provided by this invention an apparatus in which the various objects hereinabove set forth, together with many thoroughly practical advantages, are successfully achieved.

As various possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth, or shown in the accompanying drawings, is to be interpreted as illustrative and not in a limiting sense.

I claim:—

1. A grinding machine comprising, in combination, a crankshaft with a plurality of throws, a plurality of grinding wheels one on each of several of said throws, a rotatable mounting for a work-piece, means to rotate the said mounting, means synchronized with said last-named means to rotate said crankshaft, and flexible means to rotate each of said grinding wheels.

2. A grinding machine comprising, in combination, a plurality of grinding wheels, individual mounting means for each of said grinding wheels movable through predetermined paths, a rotatable mounting for a work-piece, means to rotate said last-named mounting, means to rotate each of said individual mountings for said wheels through their predetermined paths and synchronously with said mounting for said work-piece, and

means to rotate each of said wheels on its mounting.

3. A grinding machine comprising, in combination, a grinding wheel, means to rotate orbitally said grinding wheel, means to rotate diurnally said grinding wheel, means to rotate a work-piece on an axis entirely outside the orbit of said grinding wheel, and means to cause said work-piece to approach said orbit by grinding increments.

4. A grinding machine comprising, in combination, a plurality of grinding wheels, a mounting for each grinding wheel, means to move the axis of each grinding wheel through predetermined courses at equal angular velocities, means to rotate each grinding wheel on its axis, means to arrest any grinding wheel at a predetermined angular position in its course which is the same for all said wheels, means to locate a dressing device at such position, and means to traverse said wheel with said dressing device.

5. A grinding machine comprising, in combination, a grinding wheel, means to rotate said grinding wheel orbitally, means to rotate said grinding wheel diurnally at a velocity greatly in excess of the velocity of its orbital motion, means to rotate a work-piece orbitally, and means to rotate said work-piece diurnally at the same angular velocity as the orbital motion.

6. A grinding machine comprising, in combination, a plurality of grinding wheels, means to rotate all of said grinding wheels in the same orbital path maintaining their ascensions different and their relative hour angles the same, and means to rotate each wheel diurnally at substantially a constant angular velocity.

7. In a grinding machine as claimed in claim 6, the combination with the parts therein specified, of precision means to true each wheel to the same diameter.

8. In a grinding machine as claimed in claim 6, the combination with the parts therein specified, of means for arresting any of the said grinding wheels at a given and at the same hour angle while maintaining its diurnal motion, a dressing device, means to traverse said dressing device relative to the grinding wheel and in a line perpendicular to the plane of any orbit, and means to adjust the position of said dressing device.

9. In a grinding machine, a drive shaft, a plurality of pulleys on said drive shaft, a pair of separated journals in a line parallel to said shaft, a member having a plurality of axis pins mounted in said journals for rotation, a grinding wheel mounted for rotation on each pin, a pulley affixed to each grinding wheel, each of said first-named pulleys being in line with a pulley for a grinding wheel, flexible driving means connecting the several sets of pulleys, and means driven from said shaft for rotating said member.

10. In a grinding machine as claimed in claim 9, the combination with the parts therein specified, of a work-piece spindle parallel to said journals, and means to drive said spindle at the same angular velocity as and in the same phase relation as said member.

11. In a grinding machine as claimed in claim 9, the combination with the parts therein specified, of a work-piece spindle parallel to said journals, means to drive said spindle at the same angular velocity and in the same phase relation as said member, a dressing device, a mounting for said dressing device to move it parallel to the axis of said journals, and means to arrest said shaft at any one of a plurality of positions.

12. A mounting for a plurality of grinding wheels comprising a pair of trunnions mounted in line, a plurality of pairs of crank-arms, a plurality of pins each pin detachably mounted between a pair of crank-arms, and a plurality of wheel mounting members each journaled on a pin.

13. In a mounting as claimed in claim 12, the combination with the parts therein specified, of means for adjusting axially on its pin one or more wheel mounting members.

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