June 12, 1945. G. A. CARLSON 2,377,991

AUTOMATIC ABRADING MACHINE

Filed Oct. 13, 1943 3 Sheets-Sheet 1

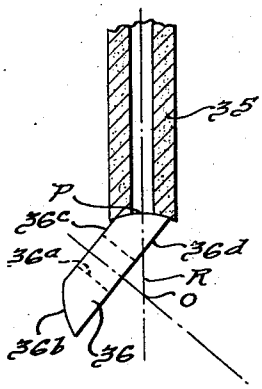


FIG. 2.

FIG. 1.

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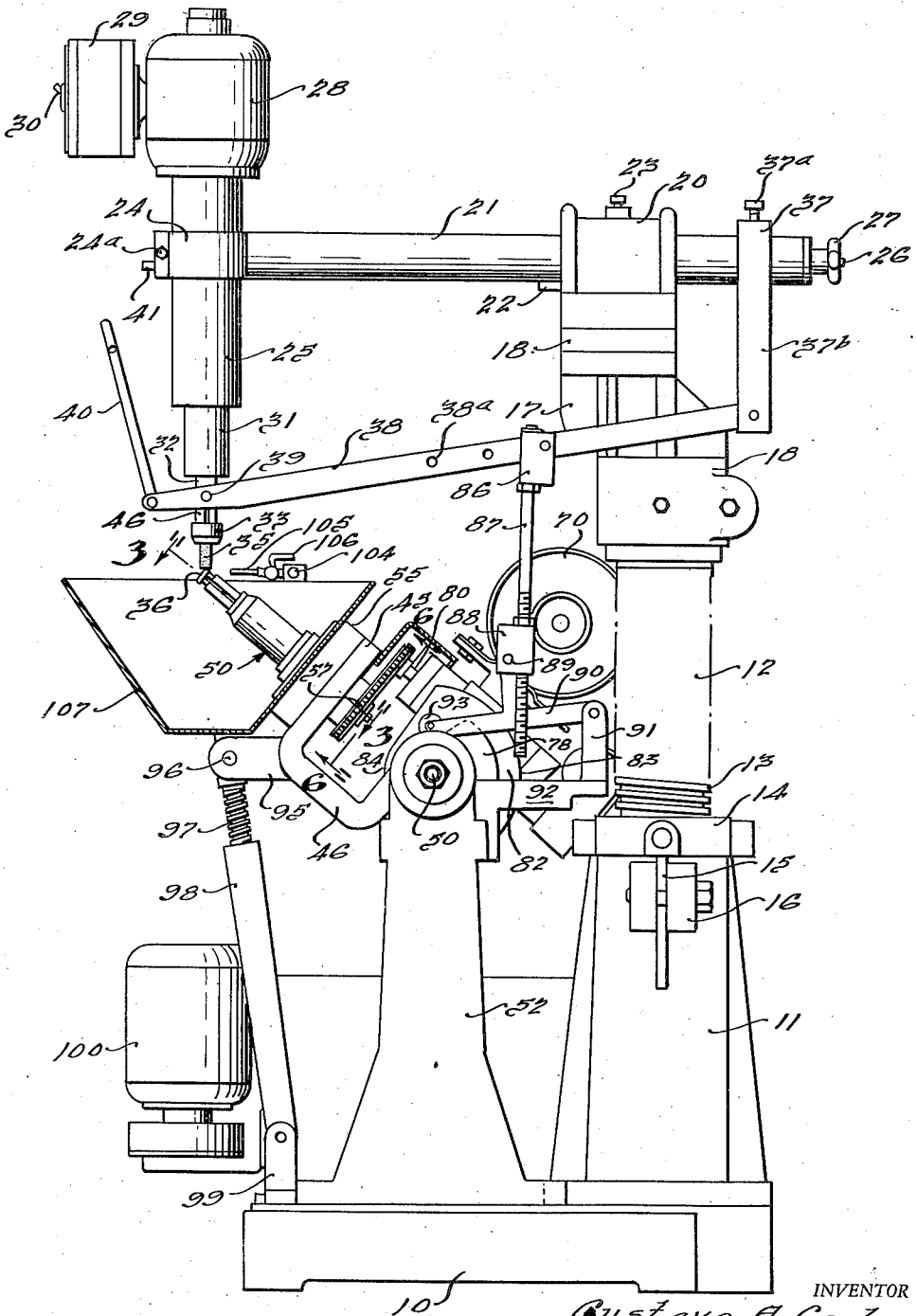


Fig. 2.

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AUTOMATIC ABRADING MACHINE

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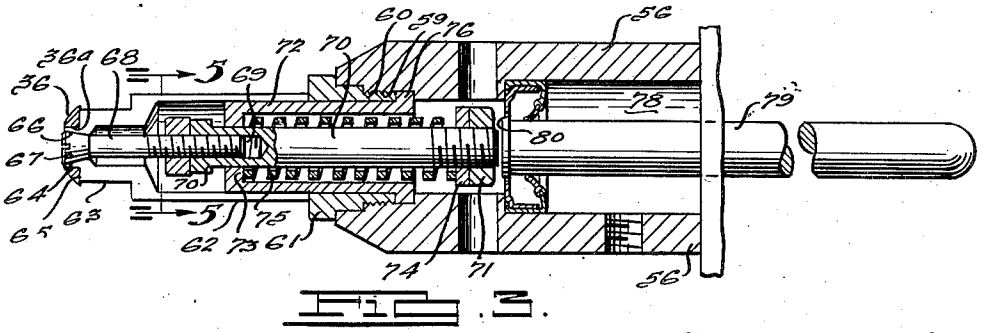


FIG. 3.

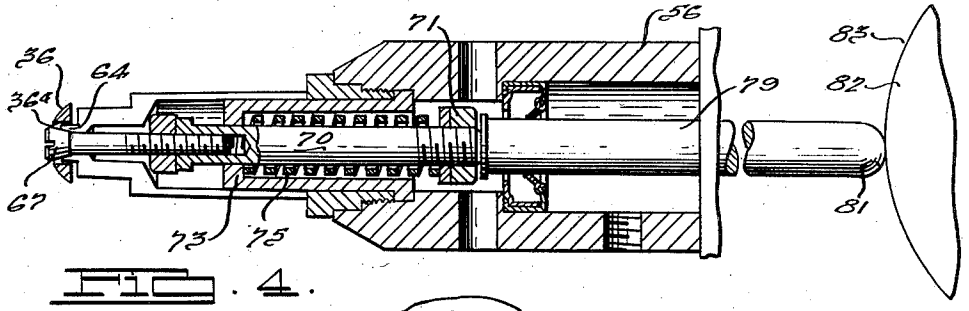


FIG. 4.

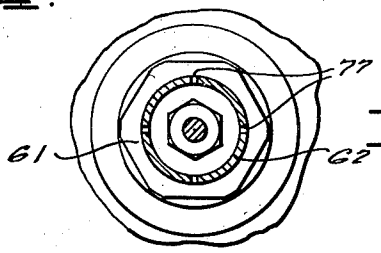


FIG. 5.

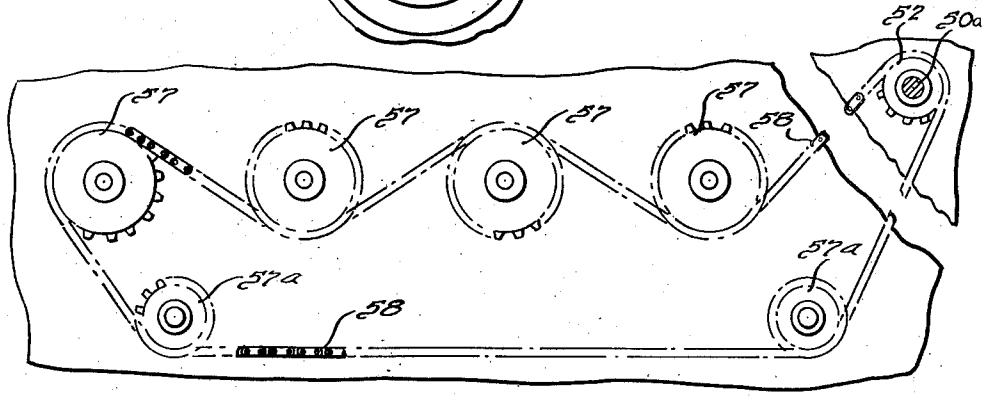


FIG. 6.

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2,377,991

AUTOMATIC ABRADING MACHINE

Gustave A. Carlson, Detroit, Mich.

Application October 13, 1943, Serial No. 506,059

13 Claims. (Cl. 51—131)

This invention relates to abrading machines and more particularly to what is termed a special purpose machine designed for use in the mass production of machine parts.

The machine of the present invention is particularly designed and adapted for finishing to exact size and contour a spherical surface and to provide a high surface polish, or finish, on the spherical face of the article being worked upon to insure that the desired spherical contour will be obtained within very narrow precision limits and also at the same time a highly polished smooth surface will result from the finishing operation.

The machine of the present invention is one wherein the article being finished is in the form of a relatively small washer having one face thereof formed as a segment of a sphere for fitting accurately within a correspondingly shaped recess of a cooperating part. The finishing of spherical surfaces within very narrow limits of precision while at the same time obtaining a smooth, highly polished finished surface has heretofore presented a problem of considerable difficulty which the present invention has solved by resort to comparatively simple geometrical principles, the principal object of the present invention being to provide a machine in which a hollow cylindrical grinding element is presented to the work piece while both the grinding element and work piece are rotated upon axes which are inclined to each other and with the grinding element so positioned relative to the work piece that the axis of rotation of the rotatable grinding element will intersect the axis of the rotatable work piece at a point which coincides with the center of the spherical surface to be formed on the work piece.

Another object of the invention is to provide a grinding or finishing machine for the finishing of the spherical face of a work piece and which machine will be automatic in its operation.

A further object is to provide a machine of the character described with a plurality of work holding spindles and cooperating grinding tool spindles together with means for adjusting both the angular relation of the cooperating spindles to each other together with means for enabling the position of the working face of the grinding element relative to the work piece being produced to be varied so that the machine may readily be employed for finishing, not only work pieces of different sizes but also of different contours as well as for also performing other types of grinding operations.

Another object of the present invention is to provide a machine of the character described with new and improved chucking devices for holding the work piece in position during the rotation thereof and for causing the work piece to be automatically clamped and disengaged from the chucking device.

A further object is to so construct the grinding tool and position the same relative to the work that the tool will automatically be worn to the required shape and will automatically maintain such shape in the continued use thereof so that the necessity for frequent dressing operations upon the grinding tool is entirely eliminated.

Other objects of the invention such as providing a machine of compact, simple an inexpensive construction that will be efficient and economical in operation will appear more fully from the following more detailed description and by reference to the accompanying drawings forming a part hereof wherein a constructional example that has proven highly satisfactory in actual commercial operation is shown and wherein

Fig. 1 is a front elevation of a machine constructed in accordance with the principles of the present invention;

Fig. 2 is a side elevation of the machine shown in Fig. 1, parts of the machine being shown in section for the purpose of more clearly illustrating the construction;

Fig. 3 is an enlarged central longitudinal section through one of the work holding chucks taken on the line 3—3 of Fig. 2 and showing the work locked in position for performing the grinding operation;

Fig. 4 is a view similar to Fig. 3 showing the chuck parts automatically released to facilitate the removal of the work piece from the chuck;

Fig. 5 is a transverse section taken on the line 5—5 of Fig. 3;

Fig. 6 is a section taken substantially on the line 6—6 of Fig. 2 and showing the means for driving the rotatable work holding chucks; and

Fig. 7 is an enlarged sectional view showing the relation of the tool to the work.

As shown in the drawings the machine of the present invention comprises a suitable supporting base, or frame 10 which carries an upwardly extending hollow pedestal 11 located intermediate the end of the frame and adjacent to the rear edge thereof. Projecting into the pedestal 11 is an adjustable upright standard 12, the lower end of which is provided with screw threads 13 with which is engaged a nut 14 rotatably mounted on

the top face of the pedestal 11 and provided with a suitable locking lever 15 adapted to be engaged in a slot provided in the face of a bracket 16 secured to, and projecting laterally from, the side face of said pedestal 11. Carried by the upper end of the standard 12 is a bracket 17 the lower end of which is provided with a split boss, or collar 18 by means of which the bracket 17 may be securely fastened to the pedestal 12. At its upper end the bracket 17 is provided with a cross beam section 19 to which is suitably secured at spaced intervals a plurality of pillar blocks 20. In the particular constructional example illustrated the bracket 17 is provided with four of such pillar blocks one for each of the grinding tools hereinafter to be more fully described. Mounted for slidable, but non-rotatable movement within each pillar block is a hollow horizontally extending post 21, preferably secured against rotation within its respective pillar block 20 by a key 22, a set screw 23 also being provided for locking the post 21 against longitudinal movement relative to the block. At its outer end each post 21 is provided with a split collar 24 in which is adapted to be secured as by a clamping bolt 24*a*, a vertically extending spindle 25 of a grinding tool fixture. The split collar 24 is suitably secured to one end of an adjusting screw 26 which extends longitudinally through the post 21 and projects rearwardly from the rear end of the post, the projecting rear end of the screw 26 being threaded to receive an adjusting nut 27 by means of which the position of the collar 24 and the tool spindle 25 may be adjusted laterally with respect to the work piece. The tool holding spindle 25 is hollow and carries at its upper end a driving motor 28 which may be of any suitable construction but which is shown as an electric motor which has preferably mounted upon the front face thereof a switch box 29 which carries a switch of any suitable construction and which is shown as being provided with a suitable pivoted tumbler switch handle 30 that projects from the front face of said switch box. Slidably mounted for vertical movement within the spindle 25 is a tool holding sleeve 31 having a suitable socket in its lower end to receive the spindle 32 of a tool holding chuck 33 which may be constructed in accordance with the usual construction of devices of this character and in which is adapted to be secured a suitable tool 35; suitable connections being provided between the motor 28 and sleeve 31 to rotate the latter and the tool 35 carried thereby.

Means are provided for automatically raising and lowering the tool 35 to and from the work piece which is indicated by the reference character 36 and which will be hereinafter more fully described. Such means consists of a bracket 37 carried by the post 21 adjacent to the rear end of the latter, the bracket 37 being held in fixed position upon the post by means of a set screw 37*a*. The bracket 37 is provided with a depending lower portion 37*b* to the lower end of which is pivotally secured a rod 38 which, adjacent to its forward end, is provided with a pin 39 that projects laterally from the side face of said rod to engage under the lower face of the tool carrying sleeve 31. At its forward end the rod 38 has pivotally secured thereto the lower end of a handle 40 which at its upper end is formed to provide a hook 40*a* adapted to be engaged over a pin 41 that projects forwardly from the front face of the collar 24. The rod 38 and pin 39 are employed for either raising the tool 35 from the work manually by means of the handle 40 or automatically by means hereinafter to be more fully described.

Each of the tool holding spindles 25 with the grinding tool 35 carried thereby is adapted to perform a grinding operation upon the work piece 36 the work piece being carried in suitable rotatable chucks, four of which are provided, as clearly shown in Fig. 1 of the drawings. The tool holding chucks are carried in a swinging bracket 45 (see Fig. 2) which extends across the front part of the machine, and is provided at each end thereof with depending U-shaped arms 46 which terminate at their lower ends in bearing bosses 47, 48. These bearing bosses 47, 48 serve to mount the bracket 45 pivotally upon a camshaft 50 which is rotatably mounted on a pair of pedestals or standards 51, 52 supported upon the base 10 of the machine. The shaft 50 extends through the pedestal 51 shown in the left hand side of Fig. 1 of the drawings, and has secured to its end a suitable gear or sprocket (not shown) which is preferably driven by a silent chain drive from a similar sprocket mounted on the driving shaft of the motor 53, said sprockets and chain being encased within the housing 54. Suitable gearing connections enclosed within the gear housing 55 are employed to impart drive from the camshaft 50 to a shaft 50*a* (see Fig. 6) which carries at its upper end a sprocket wheel 52 and which serves to drive the work holding spindles presently to be described. The swinging bracket 45 is provided with a plurality of bosses 55, in the present structural example four of such bosses being provided, these bosses serving as bearings for the rotatable work spindles 56 (see Fig. 2). Each of said work spindles, as shown in Fig. 2, extends through its respective boss 55 and the lower end of each spindle has secured to it a sprocket wheel 57, there being four of such sprockets one for each of the respective work spindles.

Trained about the sprockets 57 and the driving sprocket 52 and a pair of idler sprockets 57*a* is a driving sprocket chain 58 (see Fig. 6) by means of which all of the work holding spindles are rotated. The construction of the work spindles and chucks carried thereby is fully shown in Figs. 3 to 5 inclusive of the drawings. As shown in Figs. 3 and 4 the work spindles 56 are provided with a screw threaded counterbore 59 adjacent their outer ends, in which is adapted to be received a reduced screw threaded inner end 60 of a chuck sleeve which is provided with a shouldered flange 61 of hexagonal shape upon which a wrench may be placed to screw the chuck sleeve securely in position within the spindle 56. Projecting outwardly from the flange 61 is a relatively thin sleeve portion 62 having a reduced head 63 at the outer end thereof. The head 63 terminates in a small cylindrical boss 64, which serves with the adjacent shoulder 65 formed on the reduced head 63, as a seat for the work piece 36.

The interior of the boss 64 is provided with a frustro-conical bore 66 in which is adapted to seat a similarly shaped frustro-conical head 67 of a bolt 68, the inner end of which is threaded into a tapped hole 69 formed in one end of a spring retaining bolt 70; the other end of the spring retaining bolt 70 having secured to it a nut 71. The bolt 70 passes through a spring retaining plug 72 having at one end an inwardly projecting annular flange 73 between which and the washer 74 seated against the inner face of the nut 71 is confined a coiled compression spring 75. At its inner end the spring retainer 72 is provided with an outwardly projecting flange 76

which is seated within the counterbore of the spindle 56 and is held in place therein by means of the chuck sleeve. The chuck sleeve is provided with a plurality of slots 77 which extend longitudinally of said sleeve from the outer extremity thereof to the flanged hexagonal head 61 of said sleeve.

As shown in Figs. 3 and 4 the inner end of the spindle 56 is provided with a bore 78 through which passes a cam actuated rod 79 having at its inner end an enlarged head 80 adapted to engage the end of the bolt 70 to operate the chuck. At its outer end the cam rod is provided with a rounded end 81 adapted to engage with the periphery of a cam 82. As shown in Fig. 1 of the drawings, there are four of these cams 82 mounted upon the camshaft 50, one for each of the work spindles 56, said cams having a throw portion 83 and a reduced portion 84. As the camshaft 50 is rotated the cams 82 engage the cam rods 79 and actuate the work holding chuck, as will presently be more fully described. Mounted on the camshaft 50 immediately adjacent to the cams 82, are cams 85 which serve to automatically raise and lower the tool carrying spindles 25. For this purpose the rod 38 has mounted upon it a clevis 86 from the lower end of which depends a screw threaded rod 87 upon the lower screw threaded portion of which is adjustably secured a block 88 to which is pivotally secured, as by the pin 89, a three armed lever 90 one end of which is pivotally mounted upon a clevis post 91 that projects upwardly from a bracket 92 secured to and projecting rearwardly from the standards 51 and 52. The front arm of the lever 90 carries a cam roller 93 which engages with the periphery of the cam 85.

Means for adjusting the bracket 45 and the angle of the work carrying spindles 56 carried thereby relative to the grinding tool 35 are provided, and such means consists of an arm 95 that projects laterally and forwardly from the bracket 45; the front end of said arm being pivotally secured by the pin 96 to an adjusting screw 97 screwed into the top end of a connecting rod, or link, 98 and the lower end of which is pivotally mounted in a clevis bracket 99 secured to the base or frame 10 of the machine. Secured to the upper end of the adjusting screw 97 is a hand wheel 100 by means of which the screw 94 may be rotated to swing the bracket 45 and the parts carried thereby upon the axis of the camshaft 50 to change the angular relation of the spindles 56 and the work piece 36 carried thereby relative to the axis of rotation of the work carrying spindle 25.

Means are provided for supplying a coolant to the work during the grinding operation and such means consists of a pump 101 driven by a motor 102, the outlet or delivery side of said pump having connected thereto a conduit 103 which leads upwardly and is connected to a branch 104 which extends horizontally across the machine at substantially the same vertical height as the points of contact between the abrading tools 35 and the work pieces 36, the branch 104 being provided with discharge nozzles 105 one for each work station from which coolant liquid may be discharged directly upon the work and abrading tool under the control of a valve 106. The liquid discharged from the noozzle 105 is collected in a pan, or trough 107 which in turn is connected by the conduit 108 to the intake side of the pump 101.

The manner in which the machine operates is as follows: the motor 53 being set in operation drives the camshaft 50 through the gearing connections containing the housing 54 and drive is also simultaneously imparted to each of the work spindles 56 by means of the gearing connections in gear housing 55 to the driving sprocket 52 and driving chain 58 to the sprocket 57 secured to each of the work spindles 36. In the meantime each of the motors 28 have been energized by the actuation of their respective switches 30 to rotate the tool carrying spindles 25 and the tools 35 carried thereby. As the camshaft 50 rotates, when the rollers 93 ride downwardly upon the low portions of the cams 78 the forward end of the rods 38 will move downwardly lowering the pins 39 and permitting the tool carrying spindles 31 to descend by their own weight to force the grinding tools 35 against the spherical surface of the work 36 and when the cam roller 93 rides up upon the high portion of the cam 78 the rod 38 will be raised and the engagement of the pins 39 with the lower face of the tool carrying sleeve 31 will raise the tools 35 upwardly out of contact with the work piece as shown by the position of the tool 35 and associated parts at the right hand side of Fig. 1. As the throw of cam 78 raises the tool from the work, the throw of cam 83 causes the cam rod 79 to be forced upwardly and inwardly into the tool holding spindle 56 to engage the right hand end of the bolt 70 thus pushing the bolt to the left and causing the conical head 67 of the screw 68 to be raised off the seat 66 of the work chuck, the longitudinally extending slots 77 of said chuck permitting the boss 64 to spring inwardly and out of engagement with the bore 36*a* of the work piece or washer 36. It will of course be understood that the boss 64 is originally machined to an outer diameter less than that of the diameter of the bore 36*a* of the washer. The operator then may lift the work piece 36 clear of the chuck and replace it with a new part to be ground. As the low portion 84 of the cam comes around to engage with the cam rod 79 so as to permit the head 80 of the rod to move out of engagement with the end of the bolt 70, the spring 75 pushes the bolt 70 to the right and forces the conical head of the screw 68 into engagement with the conical bore 66 of the chuck sleeve and forces the split ends of the sleeve which form the boss 64 tightly into engagement with the bore 36*a*, all as will be more readily understood and as clearly illustrated in Fig. 3 of the drawings.

As heretofore described the work piece 36 is in the form of a washer having one face thereof of spherical contour as indicated at 36*b* in Fig. 7 of the drawings. This spherical surface represents a segment of a sphere having a radius of curvature such as indicated by the line R in Fig. 7 and having its center located at the point O. The work spindles 56 are set at such an angle to the axis of rotation of the abrading tools 35 and the latter are adjusted laterally relative to the work piece so that the axis of rotation of the abrading tools coincides with the radius R indicated in Fig. 7 of the drawings that passes substantially through the mid-point P of the spherical surface 36*b* desired to be produced upon the work piece. As a result of the geometrical principles resulting from this arrangement and the rotation of the work piece upon its axis of rotation at an angle to the axis of rotation of the abrading tool such that the latter passes through the center of the spherical surface, the abrading tool, which as shown in Fig. 7, is in the form of a hollow tubular member, automatically and inevitably produces with great facility and accuracy a true spherical contour on the face 36*b* of the

washer as long as the diameter of the abrading tool is large enough so that the tool will completely span the curved surface **36***b* of the work-piece. As the abrading tool **35** is rotated upon its axis at the correct angle relative to the axis of rotation of the work piece, the lower working surface of the abrading tool cuts itself by its engagement with the sharp lower and upper edges of the flat faces **36***c* and **36***d* of the washer, or work piece, so as to generate or form a recess in the lower end of the tool **35** having a true spherical contour the radius of curvature of which is exactly equal to the radius R of the sphere having its center at the point O. Consequently, the correct contour is at all times maintained upon the working face of the abrading tool as it is worn away and consequently no dressing of the tool is required.

From the foregoing description it will be seen that the machine is entirely automatic in its operation, the work holding chucks being automatically released after a predetermined period of operation so that the operator may manually remove the finished work pieces from one of the work holding chucks and replace a work piece to be finished upon the same during the time that the parts of the chuck are in the position shown in Fig. 4 of the drawings, each time the respective tool **35** for each respective chuck is raised to the upper inoperative position shown in the right of Fig. 1.

It will of course be understood that the cams **82** are arranged in staggered relation upon the camshaft **50** at 90 degree intervals about said shaft when the machine, as shown in the drawings, is provided with four sets of chucks and tools, the chucks being released and the tools raised during a 90 degree interval of the camshaft rotation, the rate of rotation of which is such that ample time is provided by such 90 degree interval to permit the removal of one work piece and its replacement by another.

The manually actuated handles **40** are provided so that the tool holding sleeves **31** may be raised and held in their upper inoperative position by the engagement of the hooked end **40***a* of the handle **40** over the pins **41** so as to enable the tools **35** to be changed whenever necessary.

Although the machine has been described in connection with the production of a specific work piece it will of course be understood that the various adjustments in the machine render it capable of use for the production of many different types of work. For example, the vertical position of the tools **35** or any similar tools which may be mounted in the machine may be readily changed by raising or lowering the pedestal **12** thereby changing the position of all of the tool carrying heads simultaneously. Likewise the tool carrying heads may be individually adjusted in a vertical direction by unloosening the split collar **24** by which each tool is carried. Lateral adjustment of the tools can be effected by loosening the set screw **23** and moving the posts **21** bodily and longitudinally within the pillar blocks **20**, finer adjustments of the tools laterally or horizontally being effected by means of the adjusting nuts **27**.

Ample adjustment for the pins **39** with respect to the tool carrying sleeves **31** to compensate for any adjustments of the tools **35** and work chucks is provided by means of a plurality of holes **38***a* provided in the rod **38** and also by adjustment of the block **88** upon the depending screw threaded rod **87**. Likewise ample adjustment is also provided by means of the adjusting screw **97** for changing the angular position of the spindles **56** with respect to the tool.

Due to the fact that the bracket **55** is rotated upon the axis of the camshaft **50** and that all of the working parts carried by the camshaft together with the gearing connections therefor are grouped about the camshaft **50** in proper radial relation thereto, angular adjustments of the bracket **45** and parts carried thereby can be made without disturbing any of the driving connections or affecting their proper relationship, as will be readily understood.

While I have shown a constructional example that has proven highly satisfactory in actual commercial use, it will of course be understood that many changes, variations and modifications of the constructional details may be resorted to without departing from the principles of the invention as set forth in the claims hereunto appended.

I claim:

1. In a machine of the character described a supporting base, an upright vertically adjustable pedestal mounted on said base, a bracket carried by said pedestal having a plurality of spaced bosses, a supporting post mounted in each of said bosses and projecting laterally from said bracket, a plurality of individually operated motors mounted one on each of said pedestals, a rotatable abrading tool driven by each of said motors, a plurality of rotatable work supporting chucks one for each of said abrading tools, a single bracket by which all of said work chucks are carried, means for rotatably supporting said work chucks from said supporting base and means for adjusting said work chuck bracket to present the work pieces carried thereby to said abrading tools in various predetermined angular positions.

2. A device of the character set forth in claim 1 in which means are provided for adjusting said individual motors and the abrading tools carried thereby both vertically and horizontally relative to said work pieces.

3. In a machine of the character described a supporting base, a plurality of individual motors carried thereby, means for adjusting said individual motors in unison to and from said supporting base, means for independently adjusting said individual motors both horizontally and vertically, a plurality of rotatable abrading tools one for each of said motors and driven thereby, a plurality of rotatable work chucks one for each of said abrading tools, means for mounting said rotatable work chucks upon said base, a single bracket in which all of said work chucks are mounted, means for pivotally mounting said bracket upon said base and means for adjusting said bracket about its pivot to vary the angular relation of said work chucks and the work pieces carried thereby relative to said abrading tools.

4. In a machine of the character described a supporting base, a plurality of individual independently operated motors and means to support the same from said base for lateral and vertical adjustment relative thereto, a rotatable abrading tool carried by each of said motors, a plurality of rotatable work chucks located below said abrading tools, cam means for raising each of said tools to an inoperative position away from the work piece carried by its respective chuck after a predetermined interval and cam means for automatically releasing said chuck from said work piece when said abrading tool is raised to an inoperative position.

5. In a device of the character described a supporting base, a vertically adjustable upright pedestal mounted thereon, a bracket carried by said pedestal provided with a plurality of spaced bearing bosses, a plurality of tool posts slidably but non-rotatably mounted in each of said bosses, an individual independent motor mounted for vertical and horizontal adjustment in the end of each of said tool posts, a rotatable abrading tool driven by each of said motors, a pair of spaced standards carried by said supporting base, a camshaft rotatably mounted in said standards, a work chuck carrying bracket mounted for pivotal movement upon said camshaft, a plurality of rotatable work chucks one for each of said abrading tools carried by said bracket, a common driving means for all of said work chucks driven by said camshaft, a first cam means carried by said camshaft and connections therefrom to each of said abrading tools to cause the latter to be moved to and from operative positions relative to their respective work piece and a second cam means carried by said camshaft for automatically releasing the work piece carried by each of said chucks when said abrading tool is raised to an inoperative position with respect to said work piece.

6. A device as set forth in claim 5 having means for adjustably securing said work chuck carrying bracket and the work pieces carried thereby in predetermined adjusted relationship with respect to said abrading tools.

7. A device as set forth in claim 5 having means for adjustably securing said work chuck carrying bracket and the work pieces carried thereby in predetermined adjusted relationshp with respect to said abrading tools and a driving motor and gear connections between said motor and camshaft, said gearing connections being carried by said work chuck bracket for rotation therewith about the axis of said camshaft whereby the driving relationship of said gearing between said motor and camshaft will be maintained for all angularly adjusted positions of said work chucks.

8. In a machine of the character described a plurality of spaced individual independently operated motors, a rotatable tool driven by each of said motors, a plurality of work chucks one for each of said tools arranged in predetermined angular relationship to said tools, cam means and connections therefrom to raise said tools after a predetermined period of operation of said tool to an inoperative position away from a work piece carried by its respective work chuck and manually operated means associated with said connections to raise said tool and hold it away from said work piece independently of said cam means.

9. In a machine of the character described a plurality of spaced individual independently operated motors, a rotatable tool driven by each of said motors, a plurality of work chucks one for each of said tools arranged in predetermined angular relationship to said tools, cam means and connections therefrom to raise said tools after a predetermined period of operation of said tool to an inoperative position away from a work piece carried by its respective work chuck and manually operated means associated with said connections to raise said tool and hold it away from said work piece independently of said cam means, and a second cam means for automatically releasing and effecting engagement of said work chuck with a work piece adapted to be carried thereby in predetermined timed relationship with the movement of said tool by said first cam means to an inoperative position with respect to said work piece.

10. In a machine for finishing a work piece of segmentary spherical contour and provided with a central aperture, a work chuck having an expansible sleeve adapted to be engaged in said aperture, a member for expanding said sleeve into tight engagement with the walls of said aperture, a hollow tubular abrading tool for engaging the spherical surface of said work piece, means for rotating said chuck upon an axis passing through the center of said aperture and the center of the arc of curvature of said spherical surface and means for rotating said tool on an axis inclined to said first named axis passing through said center of curvature and substantially midway of said spherical surface, a camshaft and cam means actuated thereby for causing said sleeve to be engaged and disengaged with said object and a second cam means for moving said abrading tool in timed relationship with said first cam means to cause said tool to be moved to an inoperative position out of engagement with said work piece when said sleeve is disengaged therefrom.

11. In a machine of the character described a plurality of individual independently operated motors, a rotatable tool driven by each of said motors, a rotatable camshaft, motor and gearing connections therefrom to said camshaft, a swinging bracket pivotally mounted upon said camshaft, a plurality of rotatable work chucks one for each of said tools carried by said bracket, each of said work chucks having a driving sprocket connected thereto, a single driving chain trained about all of said sprockets to drive said work chucks in unison, means for driving said chain from said camshaft and means for adjusting said bracket and work chucks and holding them in different predetermined angular positions relative to said tools.

12. A machine as set forth in claim 11 in which the gear connections between said motor and camshaft are carried by said swinging bracket for movement about the axis of rotation of said camshaft so that the driving connections between said motor and camshaft will be maintained in all angular adjusted positions of said bracket and work chucks.

13. In a machine of the character described a plurality of spaced rotatable tool spindles, an abrading tool carried by each of said spindles, a plurality of work chucks one for each of said tools, means for holding said chucks in predetermined angular adjusted positions relative to said tools, each of said work chucks being provided with releasable work retaining means, cam means for causing engagement and disengagement of said work retaining means and a second cam means operating in timed relationship with said first cam means to move each tool out of engagement with a work piece carried by its respective chuck when said chuck has been actuated to disengage said work piece and to move said tool into engagement with said work piece when said chuck has been actuated to clamping engagement with said work piece.

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