June 3, 1947. R. DAVIES 2,421,548

APPARATUS FOR GRINDING ARTICLES OF IRREGULAR FORM

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FIG. 1.

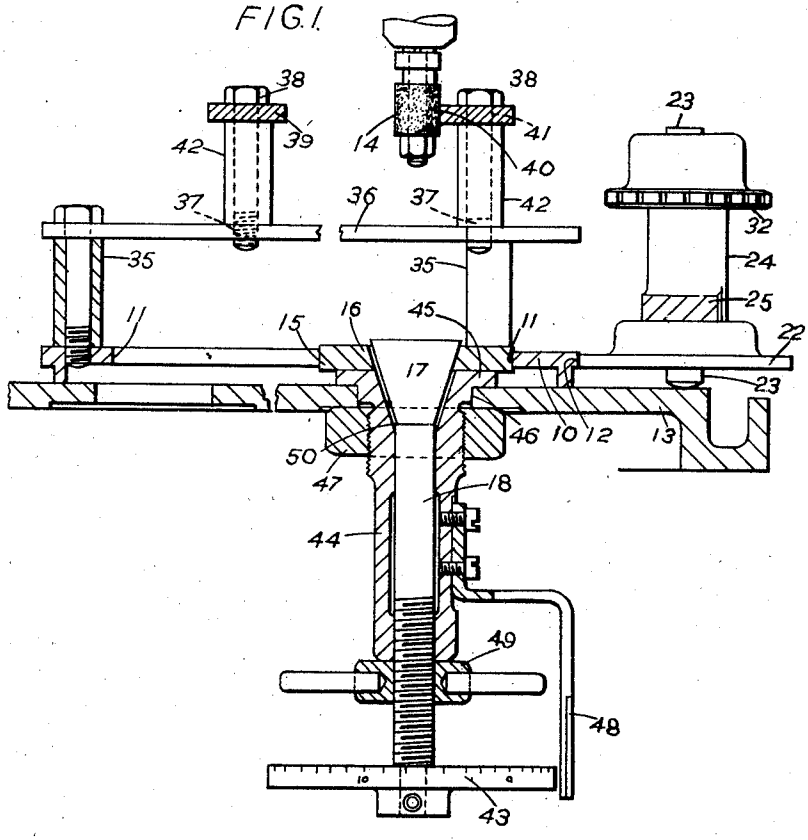
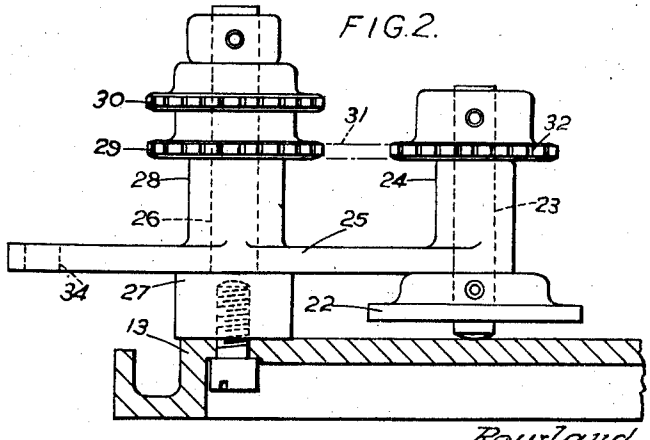


FIG. 2.



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FIG.3.

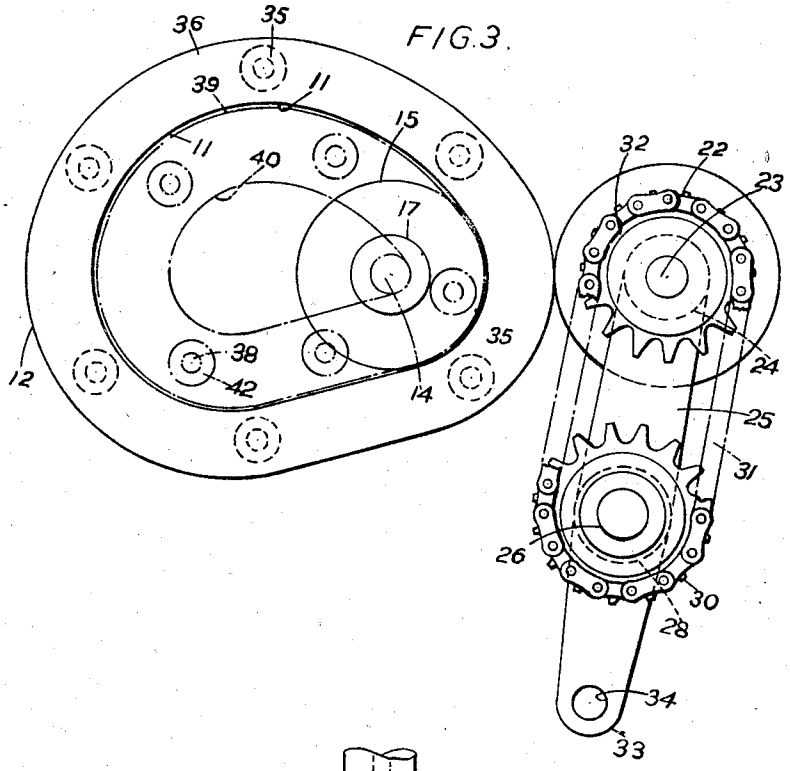
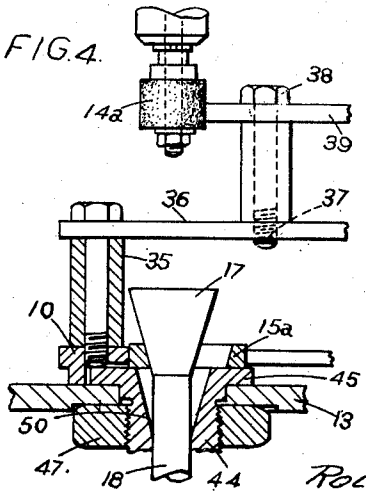


FIG.4.



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FIG.5.

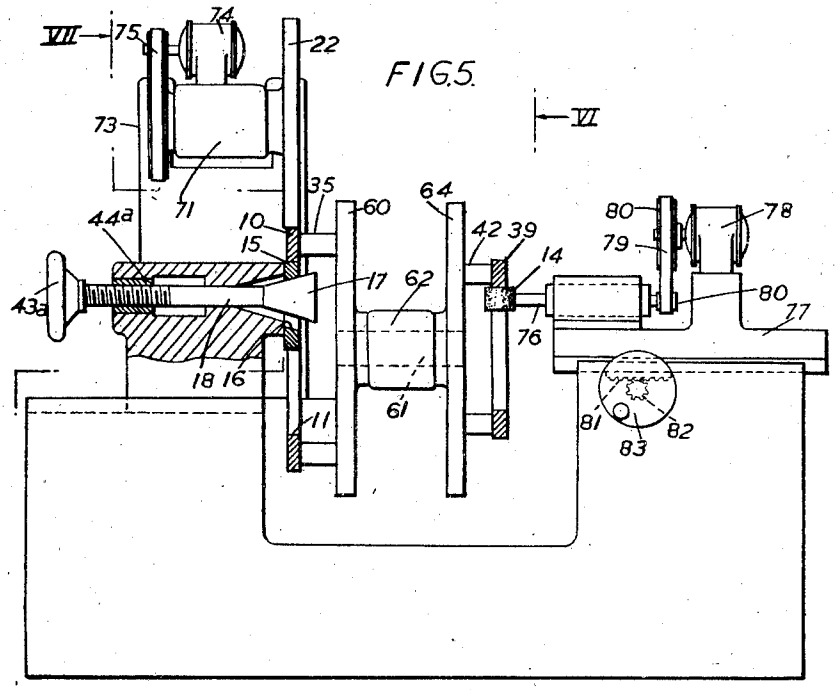
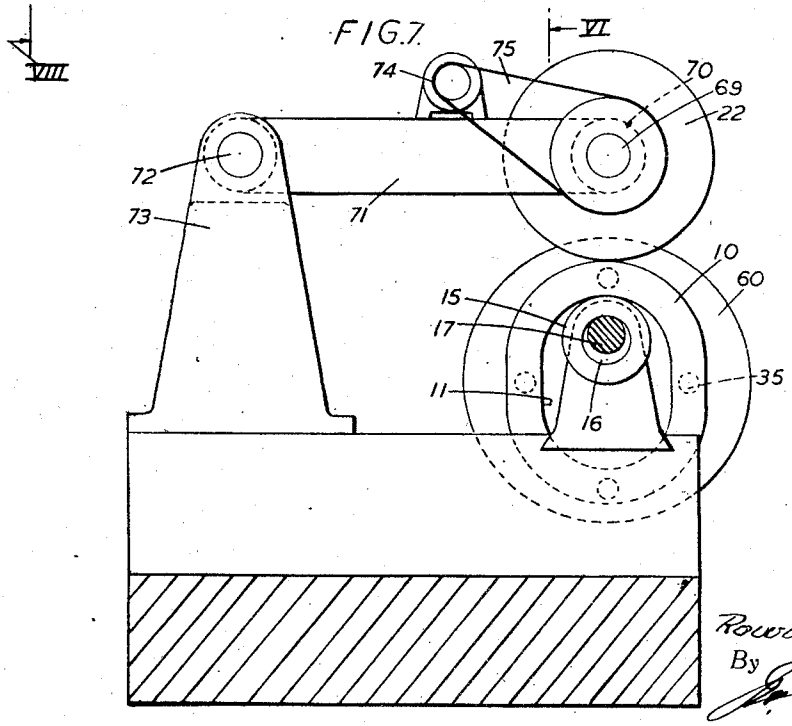


FIG.7.



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FIG. 6.

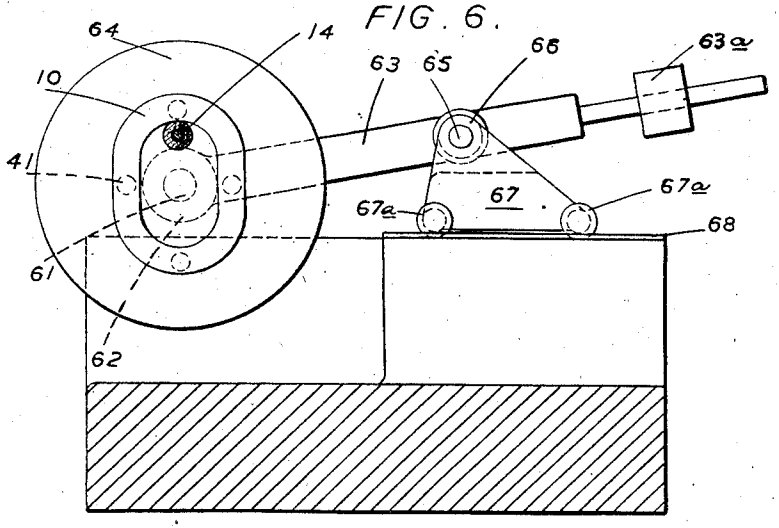
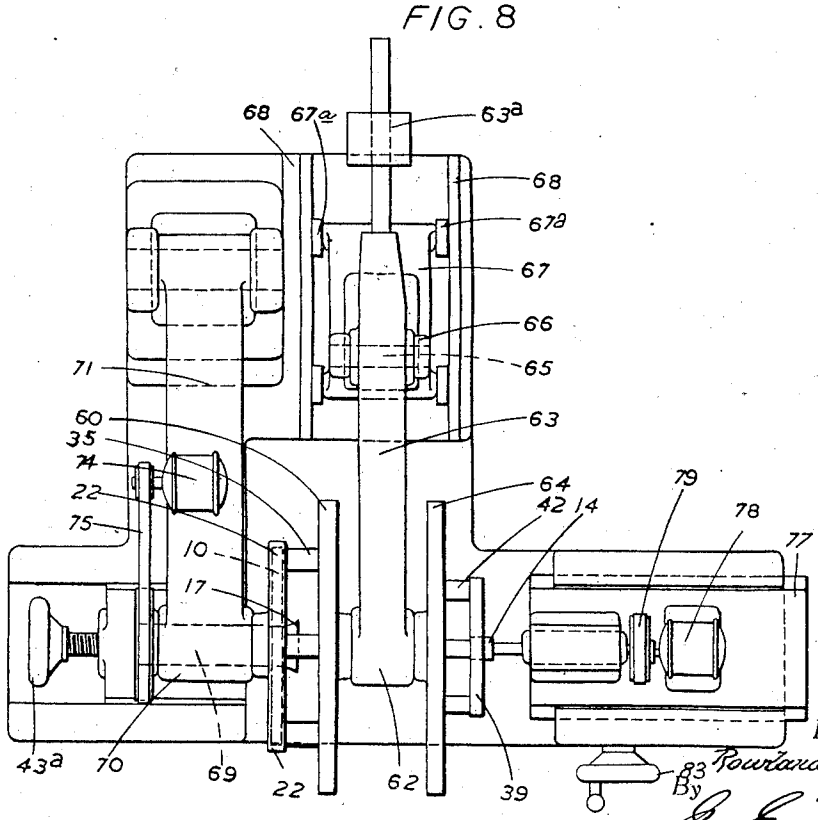


FIG. 8

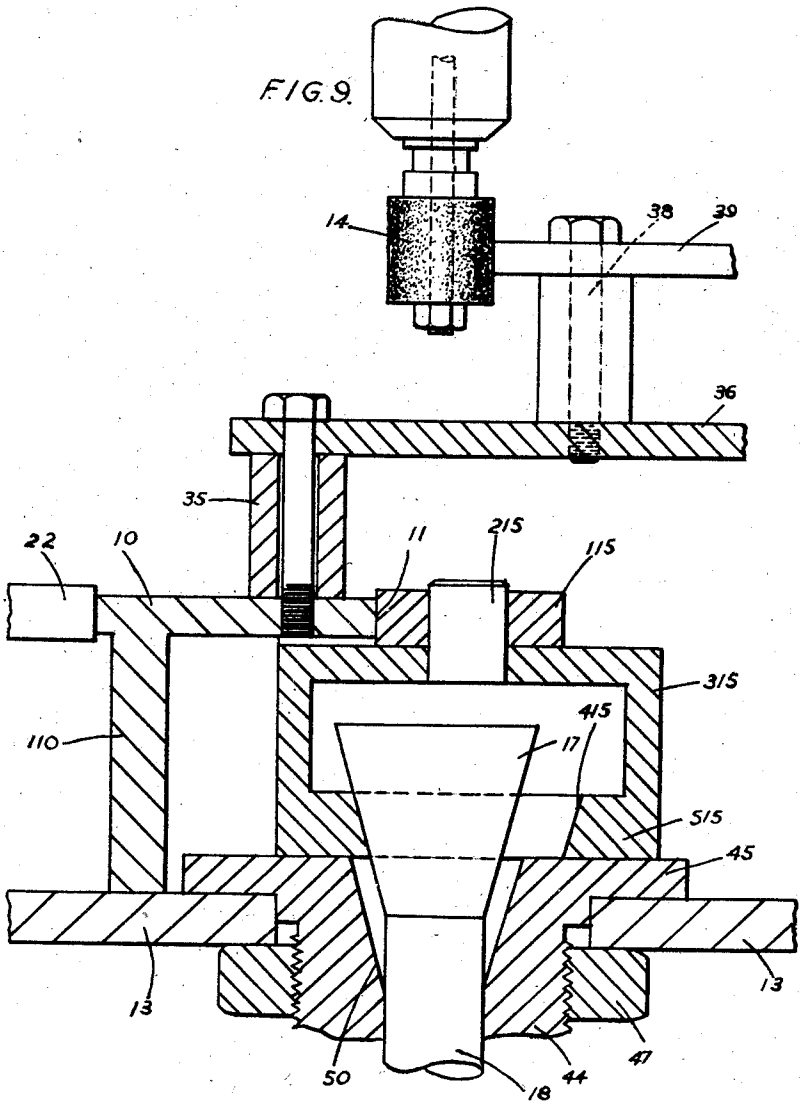


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FIG. 9.



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APPARATUS FOR GRINDING ARTICLES OF IRREGULAR FORM

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Application June 20, 1945, Serial No. 600,458
In Great Britain July 3, 1944

15 Claims. (Cl. 51—101)

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This invention relates to methods of an apparatus for grinding articles of irregular form, such as male and female dies, cams, and other irregularly shaped objects which have to be precision ground to size.

A main object of the invention is to provide a method of grinding articles of irregular form which is simple and convenient to carry out.

A further object of the invention is to provide a method of and apparatus for grinding irregularly shaped objects which will permit adjustment for wear of the grinding wheel to be made during the grinding operation.

Another object of the invention is to provide means by which both male and female work pieces, not necessarily of the same size but of parallel shape, may be ground truly, using only the one master cam, thus insuring perfect correspondence.

In order that the invention may be more completely understood reference is directed to the following description and the accompanying drawings, wherein

Fig. 1 illustrates a set-up for internal profile grinding in which the grinding wheel axis is vertical, the figure being a front elevation, partly in section;

Fig. 2 is a side view of the cam driving mechanism;

Fig. 3 is a plan of the cam and its driving mechanism;

Fig. 4 is a fragmentary view similar to Fig. 1 but showing a set up for external profile grinding;

Fig. 5 illustrates in front elevation a modified form of apparatus in which the grinding wheel axis is horizontal;

Fig. 6 is an end elevation in section on the line VI—VI in Fig. 5, the driving mechanism for the master cam being omitted;

Fig. 7 is an end elevation in section on the line VII—VII in Fig. 5, the driving mechanism for the grinding wheel and the lever supporting the master cam and workpiece being omitted, and Fig. 8 is a plan, and Figure 9 illustrates a further modification.

In the embodiment illustrated by Figs. 1 to 4 inclusive, which is intended for grinding a male or female workpiece by using a master female cam the apparatus comprises a cam plate 10 having parallel faces and formed with an internal cam contour 11 which is parallel to and larger than the workpiece to be ground, the external contour 12 of the cam plate 10 being substantially parallel to the internal contour 11 thereby

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providing an irregularly shaped ring of approximately uniform wall thickness.

The cam plate 10 rests freely on the worktable 13 of the machine and the grinding wheel 14 is mounted above the cam plate 10 on an axis at right angles to the table 13. The grinding wheel head may be made to reciprocate by any known form of mechanism to ensure even wear over the whole face of the wheel. The internal contour 11 of the cam engages a follower roller 15 having a conical bore 16 through which passes the conical head 17 of an adjusting spindle 18 mounted coaxially with the grinding wheel 14, the head 17 of the spindle 18 being of maximum diameter at its upper end and tapering downwardly. The cam 10 is driven by a friction roller 22 engaging the external periphery of the cam and driven in a manner described later. As the cam 10 is caused to gyrate around the roller 15, the point of contact between cam 10 and friction roller 15 is always approximately on a line passing through the axis of the adjusting spindle 18 and the centre of the friction roller 22. Thus the thrust from the cam driving roller 22 passes approximately through the axis of the grinding wheel 14.

If the adjusting spindle 18 is lowered the conical head 17 thereof will displace the roller 15 and the cam 10 horizontally against the pressure exerted by the driving roller 22 which is mounted so that it can move while maintaining contact with the cam 10, and the centre of the follower roller 15 will move along the line joining the axis of the grinding wheel 14 and the point of contact between the cam 10 and roller, whereby the distance between said point of contact and the grinding wheel axis is increased. Conversely, if the adjusting spindle 18 is raised said distance will be reduced.

The cam driving roller 22 is secured to the lower end of an axle pin 23 mounted vertically in a boss 24 formed at one end of a pivoted lever 25, the pivot pin 26 of the lever 25 upstanding from a block 27 secured to the worktable 13 and passing through another boss 28 provided at about the middle of the lever 25. On the upper end of the pivot pin 26 are two sprocket wheels 29, 30 which rotate in unison, the lower wheel 29 being drivingly connected by a chain 31 to another sprocket wheel 32 secured to the upper end of the axle pin 23 of the cam driving roller 22, whilst the upper wheel 30 is driven by chain (not shown) from any available source of rotary motion. The end 33 of the pivoted lever 25 is pierced with a hole 34 for connecting to the lever

a spring or a cable leading to a balance weight whereby the lever 25 is pivoted to maintain the driving roller 22 in frictional engagement with the external contour of the cam 10. The lower end of the axle pin 23 may ride over the face of the worktable 13, as shown, to afford support to the outer end of the lever 25.

The cam plate 10 carries a number of upstanding pillars 35 on the top ends of which is fixed a centre plate 36 which is thus secured to and above the cam plate 10 and in a plane parallel thereto. Conveniently the centre plate 36 is approximately the same shape as the cam plate 10 and of the same size as the outside dimensions thereof. The centre plate 36 is provided with a number of tapped holes 37 in which may be engaged bolts 38 for attaching the workpiece 39 thereto in a plane above and parallel to the centre plate 36. Assuming that the workpiece 39, has an interval contour to be ground in a given position relative to the other dimensions of the workpiece, it will be provided with holes, 41 for the reception of bolts, 38 these holes being arranged so that the workpiece is fixed in this relationship to the already located internal contour, 11 of the cam plate, 10. The bolts 38 pass through spacing collars 42 which support the workpiece 39 a suitable distance above the centre plate 36.

It will thus be seen that, the workpiece 39 being fixed to the centre plate 36, which is in turn fixed to the cam plate 10, the workpiece 39 will execute the same gyratory motion as that of the cam plate 10, the position in which the cam 10 and workpiece 39 gyrate being controlled by the adjusting spindle 18 with the conical head 17.

A suitable choice of cam follower roll and grinding wheel diameters will allow the grinding wheel 14 to pass inside the contour 40 to be ground. By raising the adjusting spindle 18 by turning the handwheel 43 the effective diameter of the cam follower roller 15 is reduced and thus the distance from the axis of the grinding wheel 14 to the internal contour 40 of the workpiece 39 is reduced, whereas by lowering the adjusting spindle 18 said distance is increased. Accordingly by raising or lowering the adjusting spindle 18 the grinding cut can be put on or reduced.

In using the above described apparatus the adjusting spindle 18 is lowered until sufficient clearance is obtained between the grinding wheel 14 and the contour 40 to be ground to permit the wheel to be lowered inside said contour. The cam 10 and workpiece 13 are then caused to gyrate by the driving roller 22 and the grinding wheel 14 is set in motion. The adjusting spindle 18 is then raised until the contour 40 to be ground comes into contact with the rotating grinding wheel 14, the shape ground thereby being parallel to the cam 10 for any given setting of the adjusting spindle 18 and the size of this shape being increased by raising the adjusting spindle 18 to put on the cut.

In order to determine when the workpiece has been ground to a predetermined size it is only necessary to measure one dimension thereof, e. g., the length or a diagonal.

If a male workpiece or the male profile of a ring-like article (as in Fig. 4) is to be ground by the above described apparatus the workpiece 39 is attached to the centre plate 36 in exactly the same manner as before and then the adjusting spindle 18 is raised to push the workpiece 39 away from the grinding wheel 14*a* until sufficient clearance has been obtained to permit the wheel to be lowered outside the contour to be ground; in this case the cut is put on by lowering the adjusting spindle 18.

In general it will be necessary to change the follower roller 15*a* to one of smaller diameter when changing from internal to external grinding.

In order to operate the adjusting spindle 18 the following mechanism may, for example, be provided.

The spindle 18 is mounted in a sleeve 44 having a flange 45 at one end so that the sleeve 44 may be inserted through a hole 46 in the worktable 13 to depend therefrom by its flange 45, the sleeve 44 being provided with an externally screw-threaded portion below the flange 45 to receive a nut 47 for clamping the sleeve 44 to the table 13. At its lower end the sleeve 44 is internally screw-threaded to receive a screw-threaded portion of the adjusting spindle 18 and on the lower end of the spindle 18 is fitted the handwheel 43 graduated on its periphery to indicate the extent of cut put on for a given rotary movement of the handwheel 43, the graduations travelling past a pointer 48 fixed to the sleeve. The externally screw-threaded portion of the spindle is provided with a locking nut or ring 49 for fixing it securely in the adjusted position, and the upper end of the sleeve 44 is coned internally as indicated by reference 50 to clear the conical form of the spindle head 17 when in its lowest position.

In the modification shown in Figs. 5 to 8 the apparatus is constructed to operate with the grinding wheel axis horizontal instead of vertical, the conical headed adjusting spindle being, of course, horizontal and coaxial with the grinding wheel.

In this construction the female cam 10 is fixed by bolts (not shown), having distance pieces 35, to a face plate 60 fixed to one end of a spindle 61 rotatably mounted in the end 62 of a lever 63, the centre plate 64 to which the workpiece 39 can be attached, by bolts having distance pieces 42, being secured to the other end of the spindle 61, and the spindle being prevented from axial movement by the two plates 60 and 64. At its other end the lever 63 is freely pivoted on a spindle 65 carried in bearings 66 mounted on a carriage 67 having wheels 67*a* running between fixed guide rails 68 at right angles to the axis of the grinding wheel 14 in the horizontal plane and so that the end of the lever 63 carrying the cam 10 is completely free to follow the movement of the cam. The lever 63 is balanced about the pivot 65 by means of an adjustable weight 63*a*.

The cam 10 is, as before, rotated by a friction roller 22 secured to a spindle 69 mounted in a bearing 70 formed in one end of an arm 71 pivoted at 72 to a fixed support 73, whereby the roller 22 yieldably engages the external periphery of the cam 10. Mounted on arm 71 is a motor 74 which drives the roller 22 through a belt 75.

With the internal contour 11 of the cam 10 engages the follower roller 15 through the conical bore 16 of which passes the conical head 17 of the adjusting spindle 18, which, as in the construction shown in Figs. 1 to 4, is mounted coaxially with the grinding wheel 14, and is therefore, in the construction of Figs. 5 to 8, mounted horizontally.

If the adjusting spindle 18 is moved to the

left in Fig. 5 the conical head 17 thereof will displace the roller 15 and the cam 10 vertically upwards against the pressure exerted by the weight of lever 71 acting through the driving roller 22, the lever 71 rising in Fig. 7. Accordingly the centre of the follower roller 15 will, as in the construction shown in Figs. 1 to 4, move along the line joining the axis of the grinding wheel 14 and the point of contact between the cam 10 and the roller 15, whereby the distance between said point of contact and the grinding wheel axis is increased.

Conversely if the adjusting spindle 18 is moved to the right in Fig. 5 the weight of lever 71, acting through the roller 22 will push the cam 10 vertically downwards, maintaining the follower roller 15 in contact with the conical head 17. Accordingly the distance between the grinding wheel axis and the point of contact between cam 10 and roller 15 will be reduced.

In order to move the spindle 18 in and out the outer end thereof is screw-threaded and engages a fixed nut 44*a*, the spindle being provided with a hand wheel 43*a*, and a locking nut (not shown) similar to the locking nut 49.

The grinding wheel 14 is secured to a drive spindle 76 mounted on a slide 77 which also carries the motor 78 which drives the wheel 14 through a belt 79 and pulleys 80. The slide 77 may be moved in and out in the usual manner by means of a rack 81 and pinion 82 operated by a hand wheel 83.

With the vertical and horizontal forms of apparatus just described the distance between the inner and outer walls of the follower roller is the important dimension rather than the actual outside diameter and this fact renders it possible to use rollers with the same outside diameter for both internal and external grinding so that any slight errors in the cam are reproduced in both contours to the same extent. It is here pointed out that a small roller will clearly be more sensitive to slight irregularities in the cam than a roller of larger diameter.

Figure 9 illustrates a further embodiment of the invention in which instead of employing an internally conical roller, a roller 115 having a cylindrical bore is provided. The roller 115 runs on a pin 215 fixed to and concentric with a hollow support 315 freely disposed over the conical head 17 of the adjusting spindle 18, said head 17 extending through a conical bore 415 formed in the base 515 of the support 315 which rests freely on the flange 45.

The cam plate 10 has a depending annular rib 110 whereby it is freely supported on the worktable 13 with its internal contour 11 maintained in engagement with the roller 115, by the friction roller 22 which is driven by the means already described with reference to the construction shown in Figures 1 to 4.

The grinding wheel 14 is mounted coaxially with the adjusting spindle 18 and the latter is raised and lowered by the mechanism shown in Figure 1. Lowering of the spindle 18 displaces the hollow support 315, roller 115 and cam 10 horizontally against the pressure exerted by the driving roller 22, the centre of the latter moving along the line joining the axis of the grinding wheel 14 and the point of contact between the cam 10 and the roller, whereby the distance between said point of contact and the grinding wheel axis is increased. Conversely, if the adjusting spindle 18 is raised said distance will be reduced.

As in the construction shown in Figures 1 to 4, the workpiece 39 is secured by bolts 38 to a centre plate 36 which is secured to and above the cam plate 10 and in a plane parallel thereto by means of pillars 35 upstanding from the plate 10. Such a construction has the advantage that the roller is more free to rotate and is cheaper to manufacture, while the change from one roller to another of different size is more easily effected, since it is necessary to change the outside diameter of the cylindrical rollers only.

The method of grinding according to the invention has the advantage that by adjusting the effective diameter of the roller, grinding wheel wear is compensated for and the actual diameter of the wheel becomes unimportant within wide limits, while the same adjustment also affords a means of putting on the cut. At all times during grinding operation, so long as the face being ground has cleaned up and the cut is allowed to run out, the form of the workpiece will be parallel to that of the cam therefore the grinding operation is continued until by measurement of any convenient dimension, it is ascertained that the workpiece is of the size required.

From the foregoing it will be understood that a single master cam having an internal contour can be used to grind both male and female workpieces such as dies of irregular form, and that also the master cam for a particular job, internal, or external can be ground on the same machine using a female template of the actual job required as the controlling cam. Such irregular dies when ground on a machine according to the invention will have the same accuracy as dies of circular form.

In the construction described above both the master cam and the workpiece although rigidly connected together are floating as a unit in relation to the grinding wheel and the follower roller. If desired however the master cam and workpiece could be mounted to rotate about a fixed bearing while the grinding wheel head and the adjusting spindle with its follower roller could be rigidly connected together and movable as a unit relatively to the work.

Constructions according to the invention are particularly suitable for grinding dies of irregular shape such as those employed in the manufacture of sardine tin bodies and ends. Further any number of such dies all alike within the limits usual for dies of circular form may be ground by means of apparatus according to the invention. By the employment of formed grinding wheels radii could be put on parts which require them, such as punch bores and die centre blocks.

The invention may also be used to grind cams of any contour whether internal or external, and re-entrant curves may also be ground within limits depending on the practical size of the grinding wheel.

The invention also includes articles of irregular form, such as dies employed in the manufacture of sardine tin bodies and ends, ground in accordance with the method hereinbefore set forth.

I claim:

1. Apparatus for grinding articles of irregular form, comprising in combination, a grinding wheel, a cam for supporting the article and having a contour parallel to the contour to be ground, means for causing the cam to gyrate in a plane perpendicular to the grinding wheel axis and an adjustable abutment consisting of an element axially aligned with the grinding wheel axis and

a second element with which the cam contacts as it gyrates and which is movable for adjustment relative to the first element.

2. Apparatus for grinding articles of irregular form comprising in combination a grinding wheel, a cam for supporting the article and having a contour parallel to the contour to be ground, means for causing the cam to gyrate in a plane perpendicular to the grinding wheel axis, a follower roller disposable to co-operate with said cam, means for varying the effective diameter of said roller while its effective centre remains coincident with the grinding wheel axis, and means for maintaining the gyrating cam in contact with said follower roller.

3. Apparatus for grinding articles of irregular form comprising in combination a grinding wheel, a cam for supporting the article and having a contour parallel to the contour to be ground, means for causing the cam to gyrate in a plane perpendicular to the grinding wheel axis, an adjustable abutment device comprising two elements having mutually engaging inclined planes, a parallel sided roller mounted on one of said elements to contact the gyrating cam, and means for moving the other of said elements relatively to the roller-carrying element to vary the position of the roller relatively to the grinding wheel axis.

4. Apparatus for grinding irregular male and female profiles from a single master, comprising in combination, a grinding wheel, a cam ring with one of its profiles having a contour parallel to the male and female profiles to be ground, means for supporting the male or the female workpiece on the cam ring, in fixed relation thereto, a rolling abutment, means for maintaining the cam profile which is parallel to the profile to be ground in contact with a point on said abutment while the effective centre of said abutment remains coincident with the grinding wheel axis, means for moving the abutment to adjust the position of said point in relation to the axis of the grinding wheel, and means co-operating with the other profile of the cam to effect gyration of said cam.

5. Apparatus for grinding articles of irregular form comprising in combination a grinding wheel, a cam, means for freely supporting said cam in a plane through which the grinding wheel axis passes at right angles, means for attaching a workpiece to said cam in a plane parallel to that of the cam, an axially displaceable conical member coaxial with the grinding wheel, an internally conical follower roller rotatable about said conical member, means for restraining said follower against axial movement, means for pressing the cam against said follower roller, means for rotating the cam while pressed against said follower roller, and means for displacing the conical member axially, whereby the follower roller is displaced in its own plane, thereby varying its effective radius, that is, the distance between the grinding wheel axis and the point of contact between cam and roller.

6. Apparatus for grinding irregular male and female profiles of complementary form from a single master, comprising in combination a grinding wheel, a cam ring having one of its profiles with a contour parallel to the male and female profiles to be ground, means for supporting the male or the female workpiece above and parallel to the cam in fixed relation thereto, two members disposed in the same plane, one within the other, the inner one of said members having a conical external surface and the outer one of

said members having a conical internal surface coacting with said conical external surface of said inner member, resilient means for maintaining the cam profile which is parallel to the profile to be ground in contact with the outer one of said members, means for displacing the inner one of said members axially, whereby the outer member is displaced to positions of varying eccentricity relative to the inner member as the latter is displaced axially, and means co-operating with the other profile of the cam ring to impart a driving movement thereto to cause gyrating of the cam and the workpiece supported thereon.

7. Apparatus according to claim 1 characterised in that the cam is freely slidable during its gyratory movement upon the flat top of a work-table situated at right angles to the axis of the grinding wheel.

8. Apparatus for grinding articles of irregular form comprising in combination a grinding wheel, an adjustable abutment having its effective centre coincident with the grinding wheel axis, means for adjusting the abutment face of said abutment during grinding to vary the distance of said face from the effective centre of the abutment, a cam ring for supporting the article to be ground and having one of its profiles parallel to the profile to be ground, means for maintaining said cam ring with said parallel profile in contact with the abutment face during a gyratory movement of the cam and a rotary driven member yieldably mounted in frictional engagement with the other cam profile to effect gyration of the cam and the attached workpiece.

9. Apparatus for grinding articles of irregular form comprising in combination a grinding wheel, a cam ring for supporting a workpiece to be profile ground, said cam ring having one of its profiles parallel to the workpiece profile when in its finished form, a sleeve disposed in axial alignment with the grinding wheel axis, a spindle within said sleeve, said spindle having a conical head, a roller having a bore of a conical form complementary to that of the spindle head, said roller being disposed about said head, means maintaining the cam profile which is parallel to the profile to be ground in contact with said roller while driving the cam by its other profile, and means for displacing said spindle axially within the sleeve whereby displacement of the cam-contacted roller at right angles to said spindle is effected.

10. Apparatus for grinding articles of irregular form comprising in combination a grinding wheel having its axis horizontal, a lever, a support to which said lever is pivoted at one end with its axis parallel to the grinding wheel axis, a mounting for said support, said mounting permiting free reciprocation of said support but constraining the reciprocation of a direction at right angles to the grinding wheel axis, a spindle parallel to the grinding wheel axis, and carried by the other end of said lever, a cam ring having one of its profiles parallel to the profile to be ground, said cam ring being mounted on said spindle, means for mounting the workpiece in fixed relation to said cam, a follower roller, means for varying the effective diameter of said follower roller while maintaining its effective centre coincident with the grinding wheel axis, and means for maintaining the cam profile which is parallel to the profile to be ground in contact with said roller, while driving the cam by its other profile.

11. Apparatus for grinding irregular male and female profiles from a single master, comprising in combination a grinding wheel having its axis horizontal, a carriage freely movable horizontally at right angles to said grinding wheel axis, a substantially horizontal lever pivoted at one end to said carriage, a horizontal spindle parallel to the grinding wheel axis and freely rotatable in the other end of said lever, a cam ring with one of its profiles having a contour parallel to the male and female profiles to be ground, means securing said cam ring to one end of said spindle, means for fixing the article to be ground to the other end of said spindle, a rolling abutment, means for maintaining the cam profile which is parallel to the profile to be ground in contact with a point on said abutment, means for moving the abutment to adjust the position of said point in relation to the axis of the grinding wheel, and means co-operating with the other profile of the cam to effect gyration of said cam while maintained in contact with said point.

12. Apparatus for grinding irregular male and female profiles from a single master, comprising in combination a grinding wheel having its axis horizontal, a carriage freely movable horizontally at right angles to said grinding wheel axis, a substantially horizontal lever pivoted at one end to said carriage, a horizontal spindle parallel to the grinding wheel axis and freely rotatable in the other end of said lever, a cam ring with a profile having a contour parallel to the male and female profiles to be ground, means securing said cam ring to one end of said spindle, means for fixing the article to be ground to the other end of said spindle, an axially displaceable conical member coaxial with the grinding wheel, an internally conical follower roller rotatable about said conical member, means for restraining said follower roller against axial movement, means for pressing the cam against said follower roller, means for rotating the cam while pressed against said follower roller, and means for displacing the conical member axially, whereby the follower roller is displaced in its own plane, thereby varying its effective radius, that is, the distance between the grinding wheel axis and the point of contact between cam and roller.

13. Apparatus for grinding articles of irregular form comprising in combination a grinding wheel, a cam ring for supporting a workpiece to be profile ground, said cam ring having one of its profiles parallel to the workpiece profile when in its finished form, an interally screw threaded sleeve disposed in axial alignment with the grinding wheel axis, a spindle disposed within said sleeve, and having a screw thread cooperating with the internal screw thread thereof, said spindle having a conical head, a roller having a

bore of conical form complementary to that of the spindle head, said roller being disposed about said head, means for maintaining the cam profile which is parallel to the profile to be ground in contact with said roller while driving the cam by its other profile, a hand control member, and an operative connection between said control member and said spindle to rotate the spindle on operation of the control member whereby the spindle is axially displaced within the sleeve with consequent displacement of the cam-contacted roller at right angles to said spindle.

14. Apparatus for grinding articles of irregular form comprising in combination a grinding wheel, a cam ring having one of its profiles with a contour parallel to the male and female profiles to be ground, means for separating the male or the female workpiece in fixed relation and parallel to the cam ring, an axially displaceable conical member coaxial with the grinding wheel axis, a support having an internal conical bore disposed over said conical member, a cylindrical pin mounted on said support, a roller having a cylindrical bore rotatably mounted on said pin, means for maintaining the cam profile which is parallel to the profile to be ground in contact with said roller while driving the cam by its other profile and means for displacing said conical member axially during a grinding operation.

15. Apparatus for grinding articles of irregular form comprising in combination a grinding wheel, a cam ring having one of its profiles with a contour parallel to the male and female profiles to be ground, means for supporting the male or female workpiece in fixed relation and parallel to the cam ring, a support, an externally conical roller axially displaceable and rotatably mounted on said support with its centre coincident with the grinding wheel axis, means for maintaining the cam profile which is parallel to the profile to be ground in contact with said roller while driving the cam by its other profile, and means for displacing said roller axially during a grinding operation.

ROWLAND DAVIES.

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