APPARATUS FOR FINISHING OVAL WORKPIECES

Filed Nov. 17, 1964 4 Sheets-Sheet 1

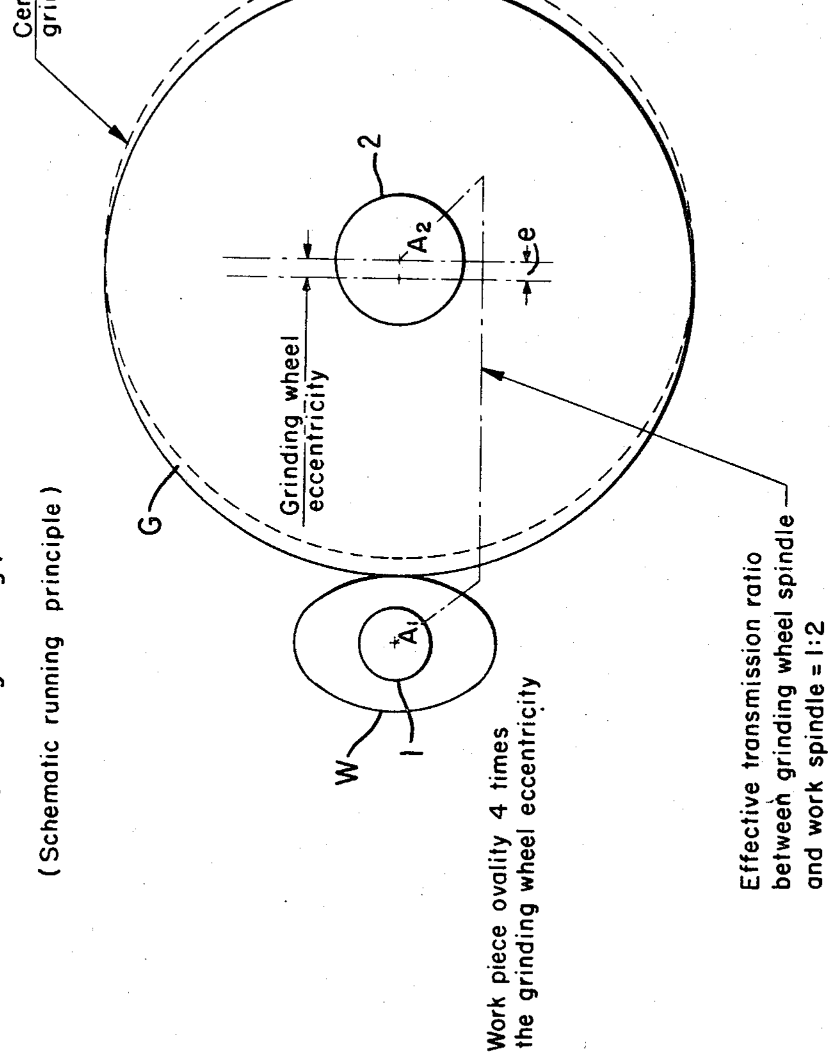

FIG. 1

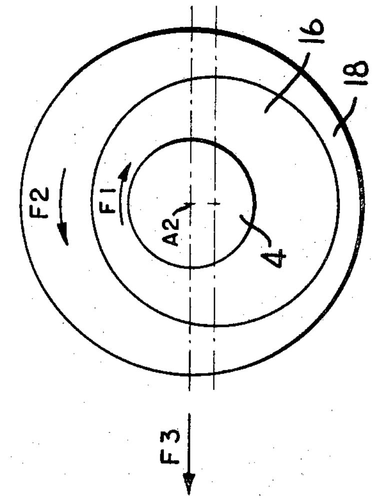

FIG. 4

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FIG. 3

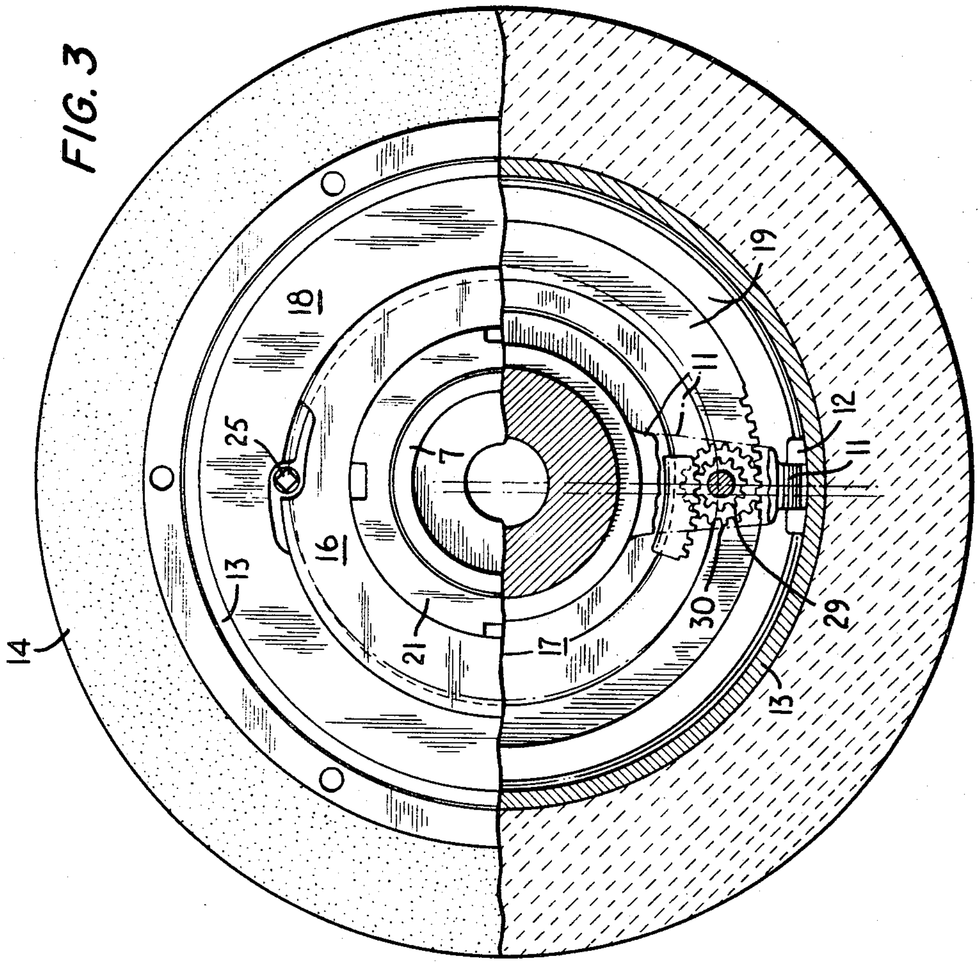
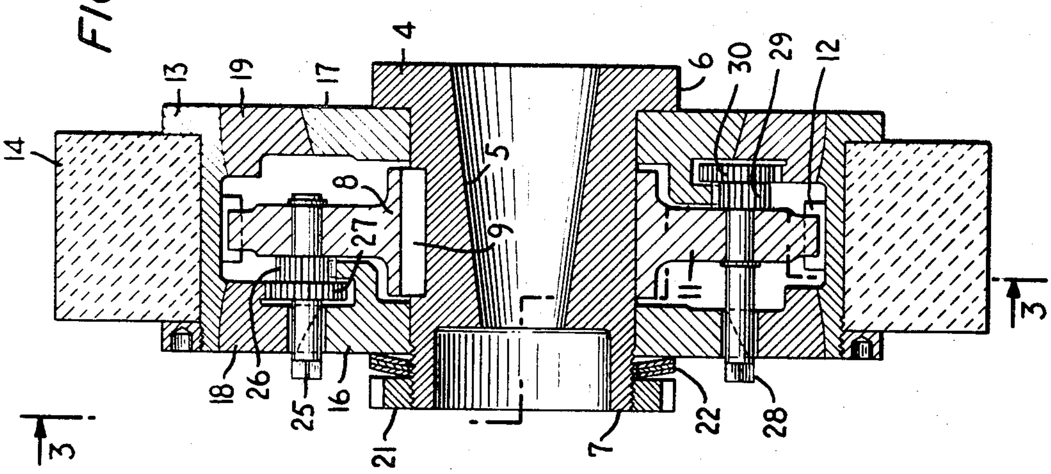


FIG. 2



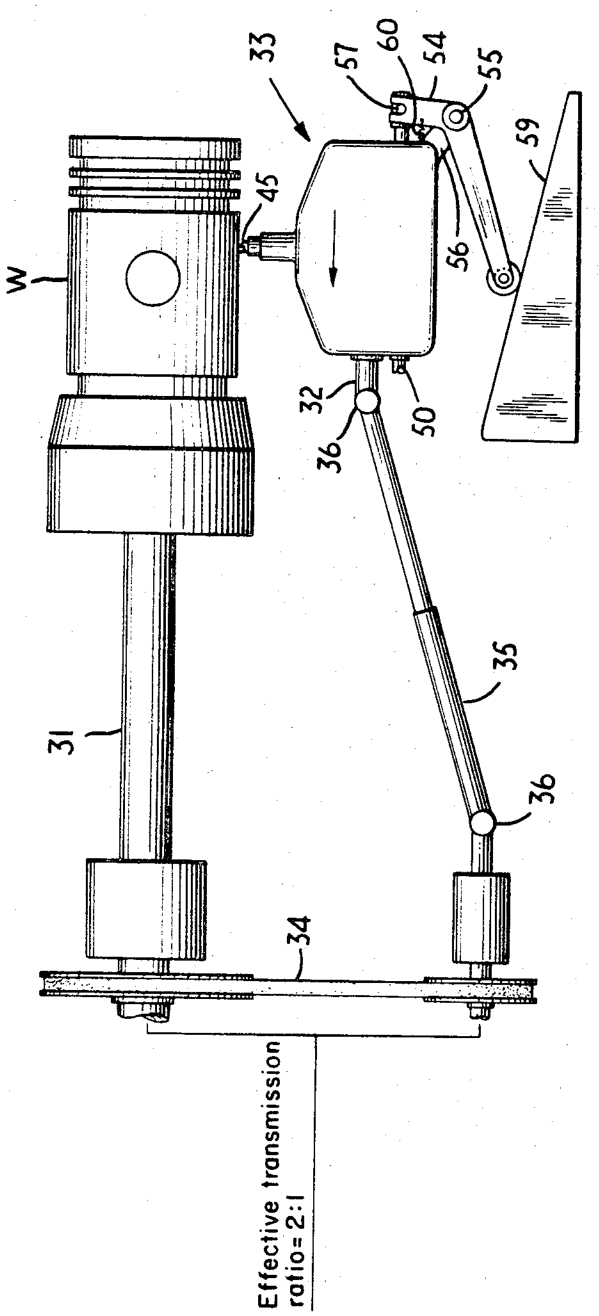

W
33
57
60
54
55
59
45
56
32
36
50
35
31
34
Effective transmission ratio=2:1

FIG. 5

Oct. 1, 1968 E. DE ALMEIDA FERREIRINHA 3,403,479

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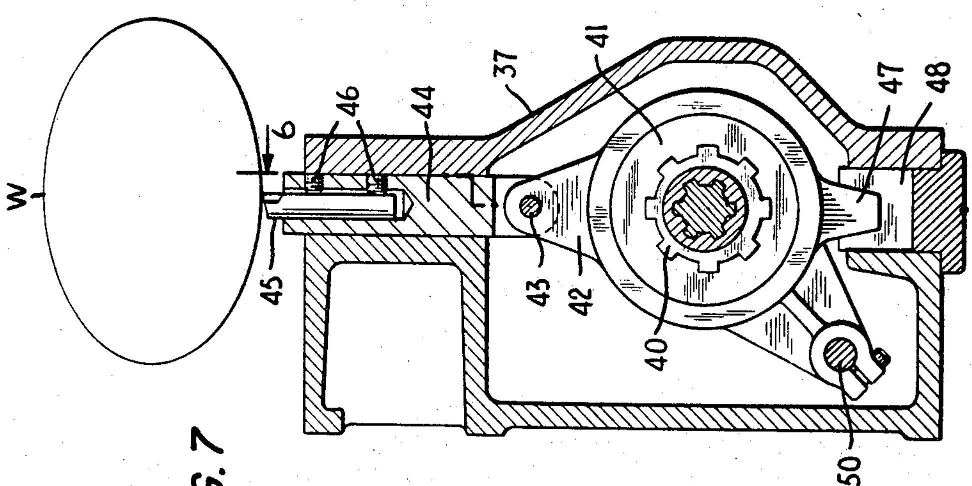

FIG. 7

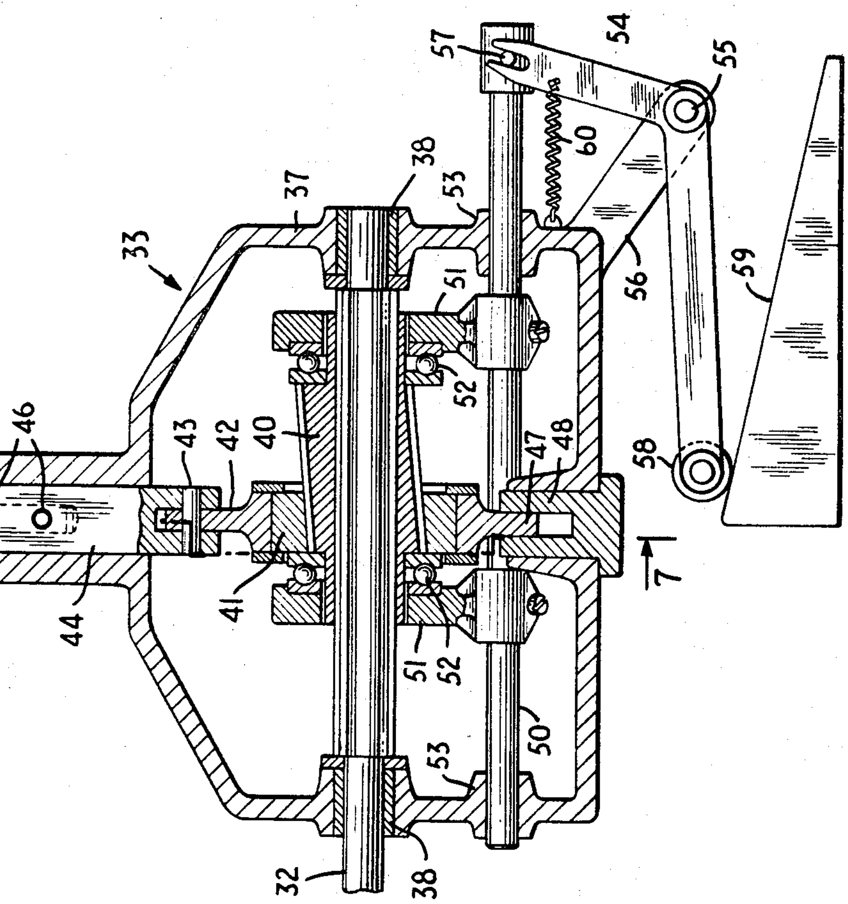

FIG. 6

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APPARATUS FOR FINISHING OVAL WORKPIECES

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5 Claims. (Cl. 51—105)

ABSTRACT OF THE DISCLOSURE

An oval workpiece is finished by rotating the workpiece about a fixed longitudinal axis, positioning cutting means in cutting relation with the peripheral surface of the workpiece and as the workpiece rotates moving the cutting means cyclically toward and away from the axis of the workpiece.

The present invention relates to a system for finishing workpieces of oval shape.

In accordance with prior practice in finishing oval workpieces, it has been necessary first to obtain a "master cam" having the desired size, shape and ovality. With the new system in accordance with the present invention, the need of providing a master cam is eliminated and the same results are obtained in a much simpler and more practical manner.

The system of finishing oval workpieces in accordance with the invention will be understood from the following description in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic view illustrating the system in accordance with the present invention,

FIG. 2 is an axial section of a grinding wheel for use in carrying out the invention,

FIG. 3 shows the grinding wheel of FIG. 2 partially in end elevation and partially in section taken approximately on the line 3—3 in FIG. 2,

FIG. 4 is a schematic view illustrating the manner of adjusting the eccentricity of the grinding wheel shown in FIGS. 2 and 3,

FIG. 5 is a schematic view illustrating other apparatus for carrying out the invention,

FIG. 6 is a schematic view partially in section on the line 6—6 in FIG. 7 illustrating in more detail, apparatus of the kind shown in FIG. 5, and

FIG. 7 is a schematic partial cross section taken approximately on the line 7—7 in FIG. 6.

In accordance with the present invention, the peripheral surface of a workpiece of oval cross section is finished by rotating the workpiece about a fixed longitudinal axis, positioning cutting means in cutting relation with the peripheral surface of the workpiece and moving the cutting means cyclically toward and away from the axis of the workpiece in selected time and phase relationship with the rotation of the workpiece. Each cycle of movement of the cutting means has a period equal to one half revolution of the workpiece. The amount of movement of the cutting means toward and away from the axis of the workpiece is equal to one half of the desired ovality of the workpiece. By ovality, is meant the different between the transverse dimensions of the workpiece measured respectively along the major and minor axes of the oval cross section.

As illustrated in the accompanying drawings, apparatus for finishing workpieces of oval cross section in accordance with the invention comprise means for rotating the workpiece about a first fixed axis, means for cutting the workpiece while it is rotated, means including an eccentric rotatable about a second fixed axis parallel to the first axis for cyclically varying the distance between an active portion of the cutting means and the axis of rotation of the workpiece and means for rotating the eccentric in selected time and phase relationship with the workpiece at a speed equal to twice the speed of the workpiece, the eccentricity of the eccentric being equal to one fourth of the ovality to be imparted to the workpiece. The cutting means may, for example, be a grinding wheel or a diamond or other cutting tool. In the case of a grinding wheel, the active portion is considered as being the portion which is at a given instant in engagement with the workpiece. The eccentric for varying the distance between an active portion of the cutting means and the axis of rotation of the workpiece, may, for example, comprise an eccentric mounting of a grinding wheel or an eccentric cam arrangement for moving a cutting tool toward and away from the workpiece axis.

The system for finishing a workpiece of oval cross section in accordance with the present invention by means of an eccentrically mounted grinding wheel is illustrated schematically in FIG. 1. A workpiece W which is to be finished, is mounted on a first shaft or spindle **1** rotatable about its axis A1 and a grinding wheel G is mounted on a second shaft or spindle **2** rotatable about an axis A2. The two shafts are coupled by suitable transmission means so that the grinding wheel G turns at twice the speed of the workpiece W. The grinding wheel is initially dressed to roundness, for example, by conventional dressing means and is then mounted off center of its axis of rotation as will be described more fully below to provide an eccentricity *e* as illustrated in FIG. 1. When the workpiece and grinding wheel are then rotated in timed relation to one another with the speed of the grinding wheel twice that of the workpiece, the grinding wheel will produce on the workpiece, a surface having an ovality equal to four times the eccentricity *e* of the grinding wheel. During the rotation of the workpiece and grinding wheel, the two are maintained in correct phase relation as illustrated in FIG. 1.

In FIGS. 2, 3 and 4, there is illustrated by way of example a practical method of mounting the grinding wheel eccentrically. A hub **4** is provided with a tapered bore **5** and is adapted to be mounted on a rotating spindle, for example the shaft of a lathe. At one end, the hub **4** is provided with an annular flange **6** while the other end **7** is externally threaded and is counterbored to receive a nut for securing the hub on the spindle or shaft on which it is mounted. A spider **8** surrounding the hub and secured to it by a key **9** has opposite radially projecting arms **11**, the outer end portions of which are received between lugs **12** on the inner periphery of a support ring **13** of an annular grinding wheel **14**. The engagement of the arms **11** between the lugs **12** provides a driving connection causing the support ring **13** and grinding wheel **14** to rotate with the hub **4** while permitting a certain amount of movement between the hub and grinding wheel in a radial direction for the purpose of adjusting the eccentricity of the grinding wheel with respect to the hub as will be described below.

Two axially spaced inner rings **16** and **17** are rotatably mounted on the hub **4** on opposite sides of the spider **8** and have conical outer peripheries which are eccentric with respect to the hub as illustrated schematically in FIG. 4. Rotatable on the outer peripheries of the inner rings **16** and **17**, there are two outer rings **18** and **19** which have conical inner peripheries matching the conical outer peripheries of the inner rings **16** and **17** and outer peripheries having spherical surfaces matching corresponding spherical surfaces provided on the inner periphery of the grinding wheel support ring **13**. The inner peripheries of the outer rings **18** and **19** are eccentric with respect to the outer peripheries by an amount equal to the eccentricity of the inner rings **16** and **17** as illustrated in FIG. 4. The entire assembly comprising the spider **8** support ring **13**, grinding wheel **14** and inner and outer rings **16–19** is secured on the hub **4** by means of a nut **21** screwed onto the threaded end **7** of the hub and pressing resiliently on the inner ring **16** through spring washers **22**. The inner and outer rings **16–19** and grinding wheel support ring **13** are held in assembled relation with one another between the spring washer **22** and the flange **6** of the hub by reason of their conical and spherical interengaging surfaces as described above. Since the parts are held in place resiliently rather than rigidly, it is possible to turn the inner and outer rings relative to one another to adjust the eccentricity of the grinding wheel as will now be described.

The inner and outer rings **16, 18** can be turned relative to one another by means of a shaft **25** which is rotatably supported in the spider **8** and is provided with pinions **26** and **27** engaging respectively gear teeth provided on the inner and outer rings. Inner and outer rings **17** and **19** can similarly be turned relative to one another by means of a shaft **28** rotatably mounted in the spider **8** and provided with pinions **29** and **30** engaging respectively gear teeth provided on the inner and outer rings. The two sets of inner and outer rings can thus be adjusted independently of one another.

When the eccentricities of the inner and outer rings are opposite one another as illustrated in FIG. 4, the grinding wheel is centered with respect to the axis A2. With the rings in this position, the grinding wheel is dressed so as to be concentric with the axis of rotation. If the inner and outer rings are now turned relative to one another in the directions indicated respectively by the arrows F1 and F2 in FIG. 4, the grinding wheel is moved off center of the axis in the direction indicated by the arrow F3 by an amount proportional to the amount the inner and outer rings are turned relative to one another. As will be understood from the foregoing description, the two pairs of rings **16, 18** and **17, 19** can be shifted independently of one another. This results in the possibility of positioning the grinding wheel so that the eccentricity at one end face is different from that at the other end face. In this manner, it is possible to obtain finished parts having greater ovality at one end than at the other provided the length of the parts does not exceed that of the grinding wheel.

Suitable indicia or graduations may be provided on adjacent portions of the inner and outer rings **16, 18** and **17, 19** in order to indicate with precision, the eccentricity and any angular deviation of the grinding wheel with respect to the axis of rotation. It will be understood that the grinding wheel is used in the manner illustrated in FIG. 1 to finish a workpiece of oval cross section.

FIGS. 5, 6 and 7 illustrate the finishing of workpieces of oval cross section by means of a cutting tool, for example a tool like those used in a lathe. A workpiece W, which is shown as a piston for an engine, is mounted concentrically on a work spindle **31** which is connected with the drive shaft **32** of an oval generating unit **33** by means of a transmission **34** and a telescopic connection **35** having universal joints **36**. The transmission **34**, which, may for example, be a chain drive, provides a speed ratio of 2 to 1 between the drive shaft **32** of the oval generating unit **33** and the work spindle **31**.

As shown in FIGS. 6 and 7, the oval generating unit **33** comprises a housing **37** in which the shaft **32** is rotatably mounted by means of bearings **38**. An elongated bushing **40** is splined on the shaft **32** so as to rotate therewith, but is slidable lengthwise of the shaft. The bushing **40** is of generally cylindrical shape, but is inclined with respect to the axis of the shaft **32** so that a left end portion as viewed in FIG. 6 is concentric with the shaft while a right hand portion is eccentric with respect to the shaft. A ring **41** is splined on the bushing **40** so as to rotate therewith, but be slidable lengthwise of the bushing. The inner bore of the ring **41** which engages the bushing **40** is inclined with respect to the cylindrical outer periphery of the ring so

that the axis of the outer periphery is parallel to that of the shaft **32**. The outer periphery of the ring **41** is engaged by a connecting rod **42** which is connected by a wrist pin **43** with a cutting tool holder **44** in which a suitable cutting tool **45** is secured, for example by set screws **46**. A tail **47** on the connecting rod is received between guides **48** (FIG. 7) on the housing to assist in keeping the connecting rod in proper alignment.

Means is provided for moving the bushing **40** in a lengthwise direction relative to the ring **41** and thereby shift the ring from a position concentric with the shaft **32** to a position eccentric of the shaft. In FIGS. 6 and 7, the means for shifting the bushing is illustrated as comprising a shaft **50** which is parallel to the drive shaft **32** and carries two arms **51** having portions encircling that shaft **32** and supporting thrust bearings **52** at opposite ends of the bushing **40**. The shaft **50** is supported in the housing **37** by bearings **53** which permit the shaft **50** to be moved in a lengthwise direction so as to shift the bushing **40** axially of the drive shaft **32**. Means for shifting the shaft **50** is illustrated as comprising a bell crank lever **54** pivotally supported at **55** on a bracket **56** extending from the housing. At one end, the lever **54** is slotted to engage a transverse pin **57** on a projecting outer end portion of the shaft **50**. At the other end, the lever **54** is provided with a roller **58** engaging an inclined surface **59**. Suitable means such as a tension spring **60** is provided for biasing the roller **58** into engagement with the inclined surface **59**.

As seen in FIG. 5, the oval generating unit **33** is positioned so that the cutting tool **45** is in engagement with the workpiece W. The work spindle **31** and drive shaft **32** of the oval generating unit **33** are driven in timed relation with one another through suitable power means (not shown), the shaft **32** being driven at twice the speed of the work spindle **31**. When the bushing **40** is in the right hand position shown in FIG. 6, the ring **41** is centered with respect to the shaft **32** and hence no reciprocating movement is imparted to the cutting tool **45**. The workpiece W will hence be machined circular. If the bushing **40** is shifted toward the left, the ring **41** is displaced so as to be eccentric to the shaft **32** and will hence impart to the cutting tool **45** a cyclical reciprocatory movement toward and away from the axis of the work spindle **31**. This will produce an oval surface on the workpiece. The amount of eccentricity of the ring **41** and hence the amount of ovality of the workpiece, will depend on the amount the bushing **40** is shifted toward the left. The ovality of the workpiece will be equal to four times the eccentricity of the ring **41**.

If it is desired to machine a workpiece having an ovality which progressively increases from one end toward the other, the oval generating unit **33** is mounted on a suitable carriage, for example, the carriage of a lathe movable parallel to the work spindle **31**, while the inclined surface **59** is mounted stationary on the bed of the machine. Hence, as the oval generating unit **33** is moved lengthwise of the workpiece as indicated by the arrows in FIG. 5, the roller **58** correspondingly moves along the inclined plane **59** so as to shift the bushing **40** progressively lengthwise of the shaft **32**, thereby progressively changing the eccentricity of the ring **41** and hence the ovality of the workpiece. The rate of change of eccentricity may be varied by varying the angle of inclination of the inclined surface **59**.

While preferred embodiments of apparatus for carrying out the present invention have been shown by way of example in the drawings, it will be understood that the novel system of finishing workpieces of oval cross section is in no way limited to the embodiments illustrated in the drawings and specifically described.

What I claim is:

1. Apparatus for finishing workpieces of oval cross section which comprises means for rotating said workpiece about a first fixed axis, means for cutting said workpiece while rotated, means including an eccentric rotatable about a second fixed axis parallel to said first axis for cyclically varying the distance between an active portion of said cutting means and said first axis, means for rotating said eccentric in timed relation with said workpiece and at twice the speed of said workpiece, the eccentricity of said eccentric being equal to one fourth of the ovality to be imparted to the workpiece, said cutting means comprising a circular annular grinding wheel and said eccentric comprising means for mounting said grinding wheel eccentrically on said second axis.

2. Apparatus according to claim **1**, in which said mounting means comprises a central hub, a first annular member having a circular inner periphery concentrically engaging said hub and a circular outer periphery eccentric with respect to said inner periphery, a second annular member having a circular inner periphery engaging the outer periphery of said first annular member and an outer circular periphery eccentric with respect to its inner periphery and engaging the inner periphery of said annular grinding wheel, the eccentricity of said second annular member being equal to the eccentricity of said first annular member, and means for rotating said annular members relative to one another and retaining them in selected portions, whereby the eccentricity of said grinding wheel relative to said hub can be selected.

3. Apparatus according to claim **1**, in which said mounting means comprises means for tilting the axis of said annular grinding wheel relative to said shaft.

4. Apparatus according to claim **3**, in which said mounting means comprises a central hub having an axial extent, axially spaced first and second inner annular members

each having a circular inner periphery concentrically engaging said hub and a circular outer periphery eccentric with respect to said inner periphery, first and second outer annular members having circular inner peripheries engaging respectively the outer peripheries of said inner annular members and circular outer peripheries eccentric with respect to their inner peripheries and engaging axially spaced portions of the inner periphery of said annular grinding wheel, the eccentricity of said outer annular members being equal to the eccentricity of said inner annular members respectively, means for rotating said first inner and outer annular members relative to one another and retaining them in selected position and means for rotating said second inner and outer annular members relative to one another and retaining them in selected position.

5. Apparatus according to claim **4**, in which the outer peripheries of said outer annular members and engaging surfaces of said grinding wheel are part-spherical.

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