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Van Der Meer

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[54] **DEVICE FOR GRINDING CURVED SURFACES**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **51/234**

[51] **Int. Cl.** **B24b 9/02**

[58] **Field of Search** ..... 51/72, 46, 65, 85 R, 86 R, 51/96, 115, 124, 234

[56] **References Cited**

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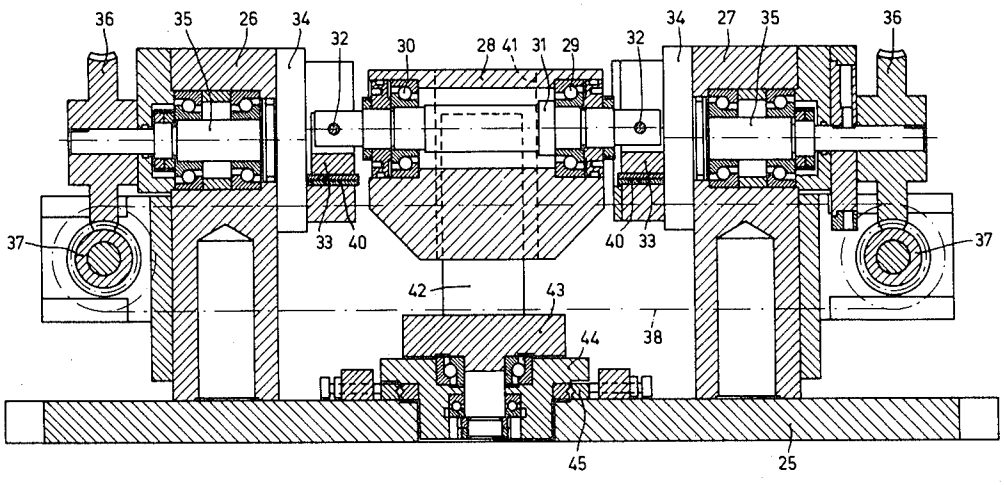
Primary Examiner—Othell M. Simpson

[57] **ABSTRACT**

A device for use with a grinding machine for grinding articles having curvatures. The grinding machine has a clamping table and a grinding wheel mounted for movement relative to the clamping table in three mutually perpendicular directions. The device comprises a frame which can be secured to the clamping table, and a workpiece table for supporting the workpiece. The workpiece table is suspended in the frame by two adjustable eccentrics which are rotatably journalled at one end thereof in the workpiece table and at the other end in the frame. The degree of eccentricity of the eccentrics is adjustable so as to correspond to the radius of curvature to be machined. The radius may be increased for convex curvatures and decreased for concave curvatures by the radius of the curvature of the part of the grinding wheel which is in contact with the workpiece.

3 Claims, 8 Drawing Figures



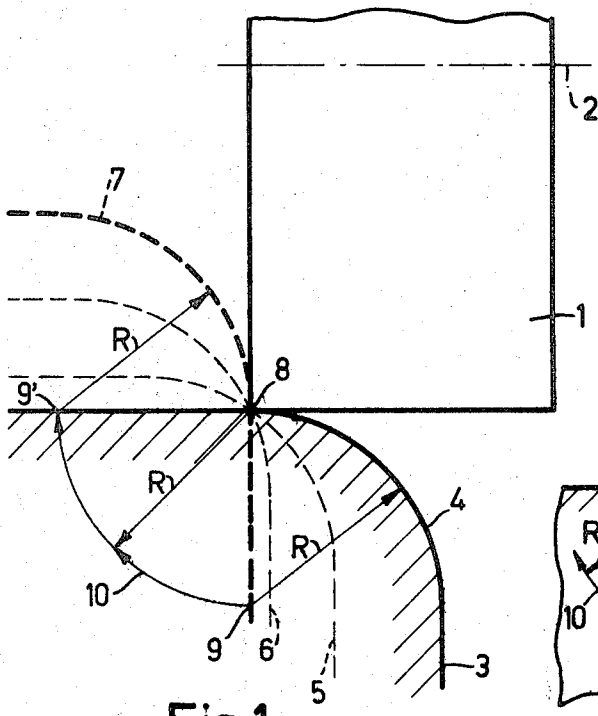


Fig.1

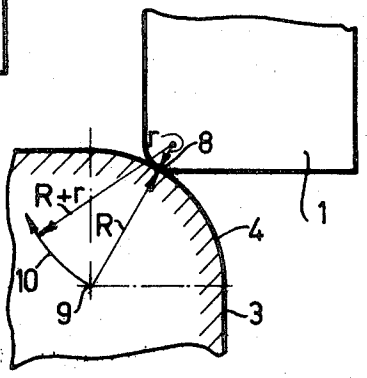


Fig.3

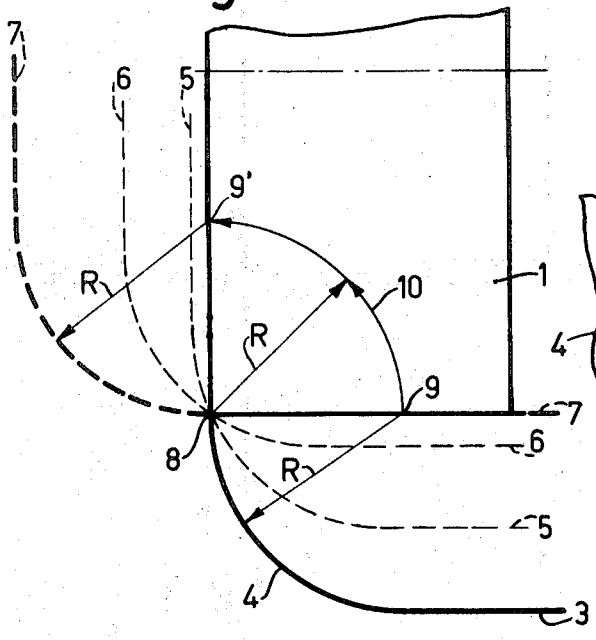


Fig.2

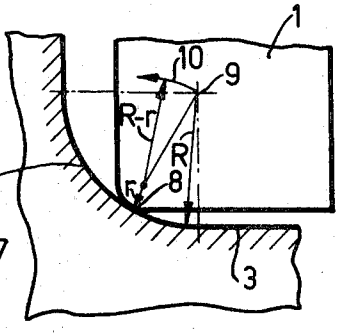


Fig.4

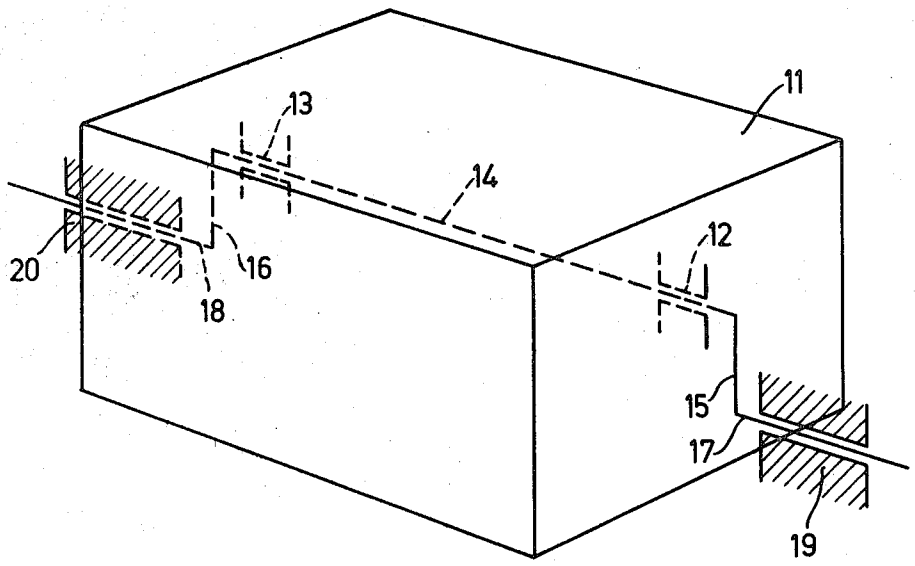


Fig.5

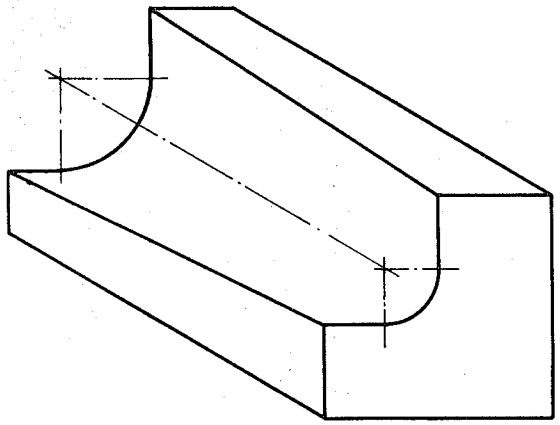
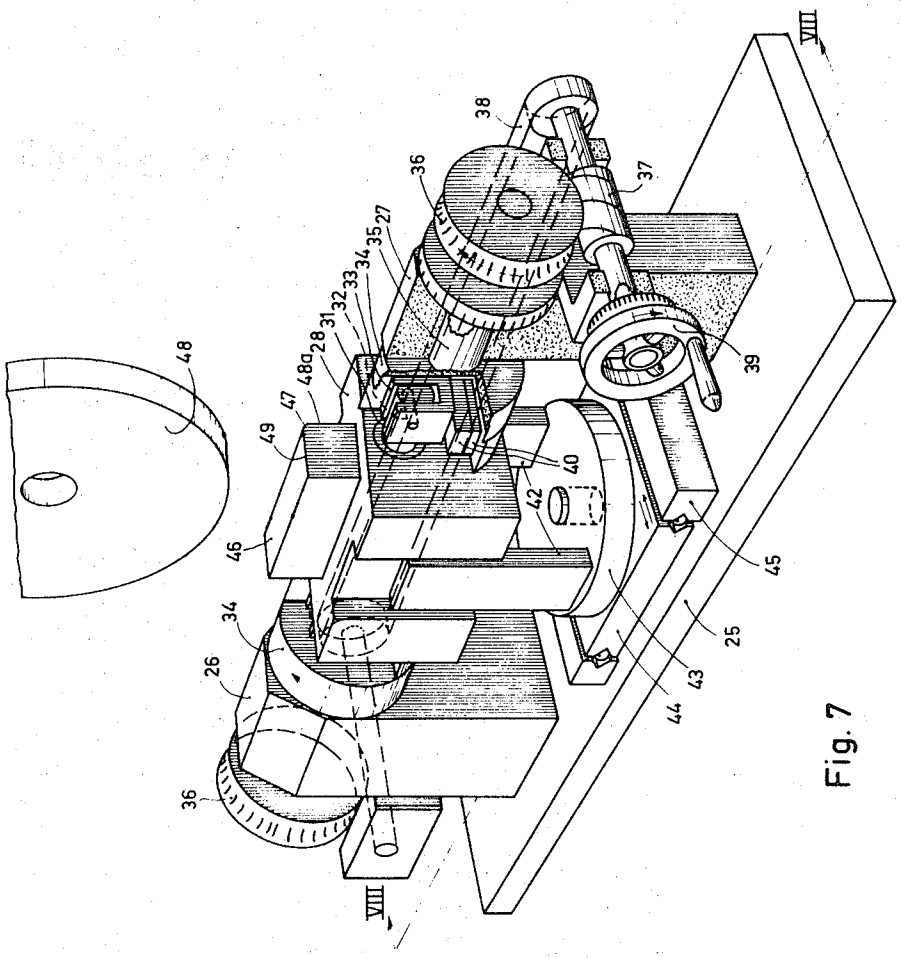


Fig.6


VIII
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VIII

Fig. 7

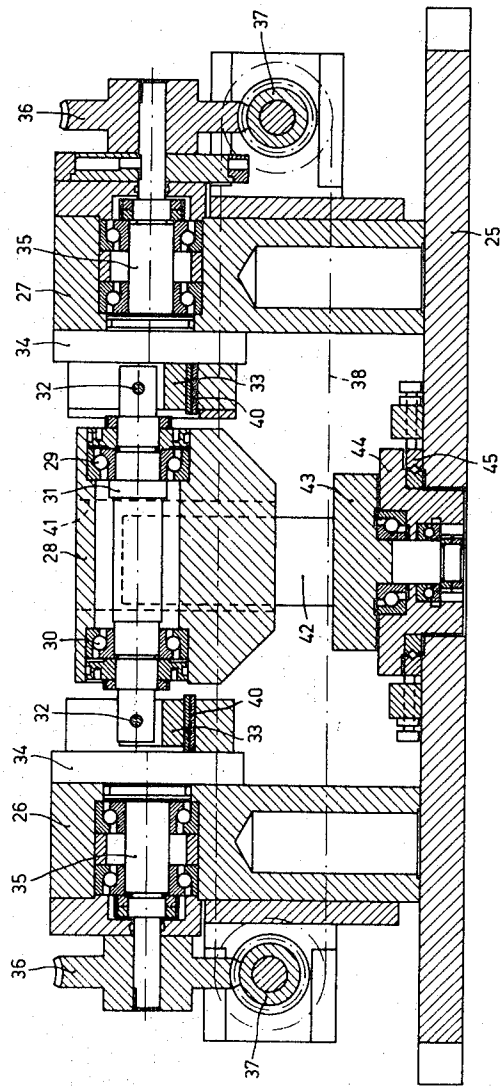

Fig.8

DEVICE FOR GRINDING CURVED SURFACES

The invention relates to a device suitable for use with a grinding machine for grinding articles having curvatures. The grinding machine has a drivable and rotatable grinding wheel and a clamping table, the grinding wheel and the clamping table are movable relative to each other in three mutually perpendicular directions.

For grinding round corners on a workpiece it is known to use a profile grinding machine. In a known machine of this type a sensor moves along a template and the movement of the sensor is transmitted to the grinding wheel which grinds the curvature.

Another known method is to clamp the workpiece between two rotatable centres which are arranged on the clamping table of a surface grinding machine. In order to be able to do this, the end faces of the workpiece must first be pre-machined and be pre-drilled for the centres which have to engage accurately in the axis of the curvature.

Still another method is to use a profiled wheel which has the desirable curvature. The manufacture and the use of such a wheel is expensive and a differently curved wheel should be in stock for each individual curvature.

All these known methods have several drawbacks, for example, the price of the profile grinding machine, expensive pre-operations for the method mentioned secondly and expensive grinding wheel in the last-mentioned method.

It is the object of the invention to provide a device with which a large number of different curvatures can be ground rapidly and reliably in a particularly simple manner and by using a normal surface grinding machine.

In order to realize this objective, the device according to the invention is characterized in that it comprises a frame which can be secured to the clamping table of a grinding machine. A clamping table for the workpiece is suspended in the frame by two adjustable eccentrics which are journalled in the frame so as to be rotatable in the frame and rotatable in the table. The value of the eccentricity of the eccentrics is adjustable so as to correspond to the radius of the curvature to be machined. If desirable, the eccentricity can be increased for convex curvatures and decreased for concave curvatures by the radius of curvature of the part of the grinding wheel which contacts the workpiece. Any point of the clamping table and the workpiece secured thereto will perform a circular movement in its plane at right angles to the axis of rotation of the eccentrics the radius of which corresponds to the radius of the curvature.

In this manner a device is obtained with which such a movement can be imparted to a workpiece by adjusting the value of the eccentricity that the curvature in question rolls off along the grinding wheel. Any wear of the grinding wheel can be compensated for by taking it into account in adjusting the eccentricity.

The device according to the invention may be used in combination with, for example, a surface grinding machine. This has the great advantage that it is not necessary to buy a separate grinding machine for grinding curvatures. It is not necessary either to use special grinding wheels. Furthermore, the device according to the invention is simple to operate and is of a comparatively inexpensive construction.

A further embodiment of the device according to the invention is characterized in that the further clamping table comprises at least one guide groove extending at right angles to its surface, said groove incorporating with ample fit a guide element which is rotatably journalled in a slide which is movable along a guide which extends transversely to the journal axis of the eccentrics in the frame and is connected to the frame.

In order to increase the rigidity of the construction, which results in a more accurate machining, each of the eccentrics in a further favourable embodiment is coupled to a driving mechanism.

In order to be able to perform spatial relief grinding, which means be able to grind curvatures the radius of which gradually increases or decreases, the value of the eccentricity of the eccentrics in a further favourable embodiment is differently adjustable.

The invention will be described in greater detail with reference to the drawing.

FIGS. **1** to **4** show in what manner the workpiece is to be moved along the grinding wheel when a curvature is ground

FIG. **5** shows how the desirable movement can be obtained in principle.

FIG. **6** shows a workpiece with a spatially relief-ground curvature

FIGS. **7** and **8** are a partly broken away perspective view and a sectional view, respectively, of a structural embodiment of the device according to the invention.

Reference numeral **1** in FIG. **1** denotes a grinding wheel which is rotatable about its axis **2.** The workpiece to be ground is denoted by reference numeral **3.** Said workpiece has a curvature **4** of radius R. In order to grind said curvature, the workpiece **3** is moved from its solid line position via the dot-and-dash lines **5** and **6** to the final position **7** shown in broken lines. The curvature **4** has rolled off along the edge **8** of the grinding wheel **1,** the whole workpiece being moved without its position in the horizontal and vertical directions varying. Each point of the workpiece has traversed an arc of a circle the radius of which corresponds to that of the curvature **4.** The point **9** (centre of the curvature **4**) traverses the arc of a circle **10** to position **9'**.

FIG. **2** shows how a workpiece **3** with concave curvature **4** rolls off along the edge **8** of the grinding wheel. In this case also each point of the workpiece performs a circular movement having a radius equal to that of the curvature, in which the workpiece is again transported in the horizontal and vertical directions, which means that the position of the workpiece is always the same.

It is remarkable that, whereas in FIG. **1** upon grinding a convex curvature the arc along which each point of the workpiece moves is "concave," in the situation of FIG. **2** upon grinding a concave curvature, each point of the workpiece moves along a "convex" arc of a circle.

In indicating the principle of FIGS. **1** and **2** the basic idea is that the grinding wheel has a sharp edge **8.** Of course, in practice said edge **8** will often be more or less rounded. In that case, upon grinding a convex curvature, any point of the workpiece should move along an arc of a circle the radius of which corresponds to the radius R of the curvature increased by the radius *r* of

the curvature of the edge **8** of the grinding wheel. This is shown diagrammatically in FIG. **3.** FIG. **4** shows diagrammatically, that in the case of a concave curvature the radius of the circular movement of any point of the workpiece should correspond to the radius R of the curvature of the workpiece decreased by the radius *r* of the curvature of the edge **8** of the grinding wheel. It is achieved in this manner that in spite of the curvature of the grinding wheel the workpiece rolls off accurately along the grinding wheel.

FIG. **5** shows diagrammatically how in principle a movement as described above can be imparted to a workpiece clamping table. For this purpose the clamping table **11** is rotatably journalled **12, 13** on a shaft **14** which is connected via eccentrics **15** and **16** to the shafts **17** and **18** which in turn are rotatably journalled **19, 20** in a frame not shown. Furthermore, measures not shown should be taken which ensure that the clamping table always assumes its horizontal position.

By adjusting the value of the eccentricity of the eccentrics **15** and **16,** the clamping table **11** and hence the workpiece provided thereon may be given such a movement that any point of the workpiece performs a circular movement in its plane at right angles to the shafts **17, 18.**

When the eccentricity of the eccentrics **15** and **16** is of the same value, the radius of the said circular movement is equally large in any plane. If on the contrary the value of the eccentricities of the eccentrics **15** and **16** is chosen to be different, the radius of the performed circular movement will also vary with a spatial relief-grinding as a result, for example, as is shown in FIG. **6** which shows a workpiece having a curvature the radius of which varies in the longitudinal direction.

FIGS. **7** and **8** are successively a perspective view partly broken away and a sectional view, respectively, of how the device can be realized structurally. The device comprises a frame which is formed by a base plate **25** on which two columns **26** and **27** are secured.

A workpiece clamping table **28** is suspended from a shaft **31** via bearings **29** and **30.** The shaft **31** is connected on either side by a pin **32** to a sliding member **33** which is incorporated in a groove in a disk **34.** The disks **34** are each connected to a shaft **35** which is journalled in columns **27** and **26,** respectively. At its end remote from the disk, each of the shafts **35** has a worm-wheel **36** which co-operates with a worm **37.** The two worms are coupled by a geared belt **38** while furthermore the right-hand worm has a hand wheel **39.** The value of the eccentricity of the shaft **31** relative to the shaft **35** is adjustable by means of gauge blocks **40** which can be provided below the sliding members **33.**

The front and rear side of the clamping table **28** has a slot-like recess **41** which extends at right angles to the surface of the table **28.** A guide element which fits in said recesses with a small amount of play is present in each of the said recesses. The elements **42** are secured to a turntable **43** which is journalled in a slide **44** which is movable in a direction at right angles to the direction of the shaft **35** along a guide **45** which is connected to the frame. It is achieved in this manner that the clamping table **28** can perform horizontal and vertical movements only, in other words, the clamping table **28** always remains horizontal. Since the elements **42** fit in the slots **41** with a small amount of play it is possible to adjust the eccentricity so as to be different on either side by means of the gauge blocks **40** so that in that case the clamping table **28** is slightly inclined for spatial relief-grinding (see FIG. **6**).

The operation of the device is as follows. The desired eccentricity corresponding to the curvature of the workpiece is first adjusted by means of the gauge blocks **40.** The workpiece **46** is then secured to the table **28** for grinding the curvature **47.** The grinding wheel **48** is then contacted with the side **48***a* of the workpiece, the eccentrics (sliding member **33** etc.) pointing forward horizontally. The grinding wheel is then moved upwards and the eccentrics are moved to their lowermost position by means of the hand wheel **39,** the worm **37** and the wormwheel **36,** after which the lower side of the grinding wheel is contacted with the upper side **49** of the workpiece. Grinding then begins in which the eccentrics are moved forward through **90°** by means of the handwheel **39** etc. so that at the end the side of the grinding wheel again contacts the side **48***a* of the workpiece. So in this manner the curvature **47** has been ground.

As already apparent from the foregoing description, the device according to the invention has the following advantages. The device can readily be combined with a surface grinding machine, it being even possible to perform the surface grinding while the workpiece is clamped on the clamping table **25** of the device, the same grinding wheel being used for surface grinding and profile grinding.

A great accuracy can very easily be obtained.

Since the operations can be carried out with a large flat circumferential grinding wheel, a high machining speed is possible. The device is very simple and hence cheap. Spatial relief-grinding is possible without further measures.

I claim:

1. A device for use with a grinding machine of the type having a rotatably mounted grinding wheel and a clamping table movable relative to each other in three mutually perpendicular directions, for grinding curved surfaces, said device comprising a frame to be secured to said clamping table, a workpiece table movably mounted in said frame for supporting a workpiece to be ground, two eccentric couplings each rotatably journalled at one end thereof in said workpiece table and at the other end thereof in said frame for supporting said workpiece table in said frame for movement therein, means for separately adjusting the degree of eccentricity of each of said couplings for varying the radius of curvature of the curved surface to be machined, and means for causing rotational movement of said eccentrics so that a point on said workpiece and said workpiece table will describe a circular path in a plane at right angles to the axis of rotation of said eccentric couplings, the radius of said circular path being equal to the radius of curvature of the curved surface to be ground.

2. The device according to claim **1** further comprising at least one guide groove in said workpiece table extending at right angles to the surface thereof which supports said workpiece, a guide element rotatably journalled in a movable slide on said frame and cooperatively engaged in said guide groove, said slide movable in a direction transverse to the journalling axis of said eccentric couplings.

3. The device according to claim **1** wherein said means for causing rotational movement of said eccentric couplings drives both of said couplings.

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