United States Patent

[11] 3,630,187

[72] Inventor **Engelbert Vossebrecher**
Huckeswagen, Germany

[21] Appl. No. **51,192**
[22] Filed **June 30, 1970**
[45] Patented **Dec. 28, 1971**

[73] Assignee **W. Ferd. Klingelnberg & Sohne**
Germany

[32] Priority **July 4, 1969**
[33] **Germany**
[31] **P 19 34 035.3**

[54] **TRUEING DEVICE FOR GRINDING DISCS**
10 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** ..... **125/11 P**
[51] **Int. Cl.** **B24b 53/08**
[50] **Field of Search** 125/11

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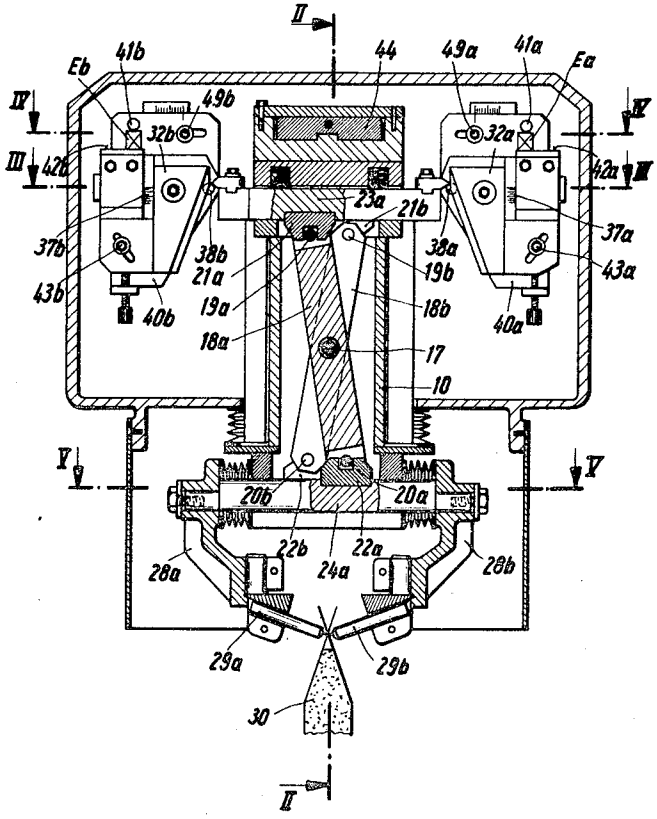
Primary Examiner—Harold D. Whitehead
Attorney—Walter Becker

ABSTRACT: An apparatus for dressing a grinding disc and, in particular, for dressing the flanks of a grinding disc for a worm or thread grinding machine. The apparatus has a stationary frame and a carriage is movable in the frame radially of the disc. A pair of opposed dressing elements are carried on the disc end of the carriage and slide thereon axially of the disc. A pair of slides on the other end of the carriage move parallel to the direction of movement of the dressing elements. Levers pivoted in the carriage connect each slide with a respective dressing element and each slide has a feeler on one end engageable with a templet in the frame. The edge of each feeler is a knife edge curved in a plane normal to the direction of travel of the carriage. Each templet has a knife edge for engagement with the edge of a respective feeler and extending at an angle to the edge of the respective feeler. Each templet is adjustable in the frame laterally with respect to the direction of travel of the carriage and angularly about a pair of axes extending angularly to each other and to the direction of travel of the carriage. The feelers are, preferably, adjustable on the slides in the direction in which the feeler edges extend.



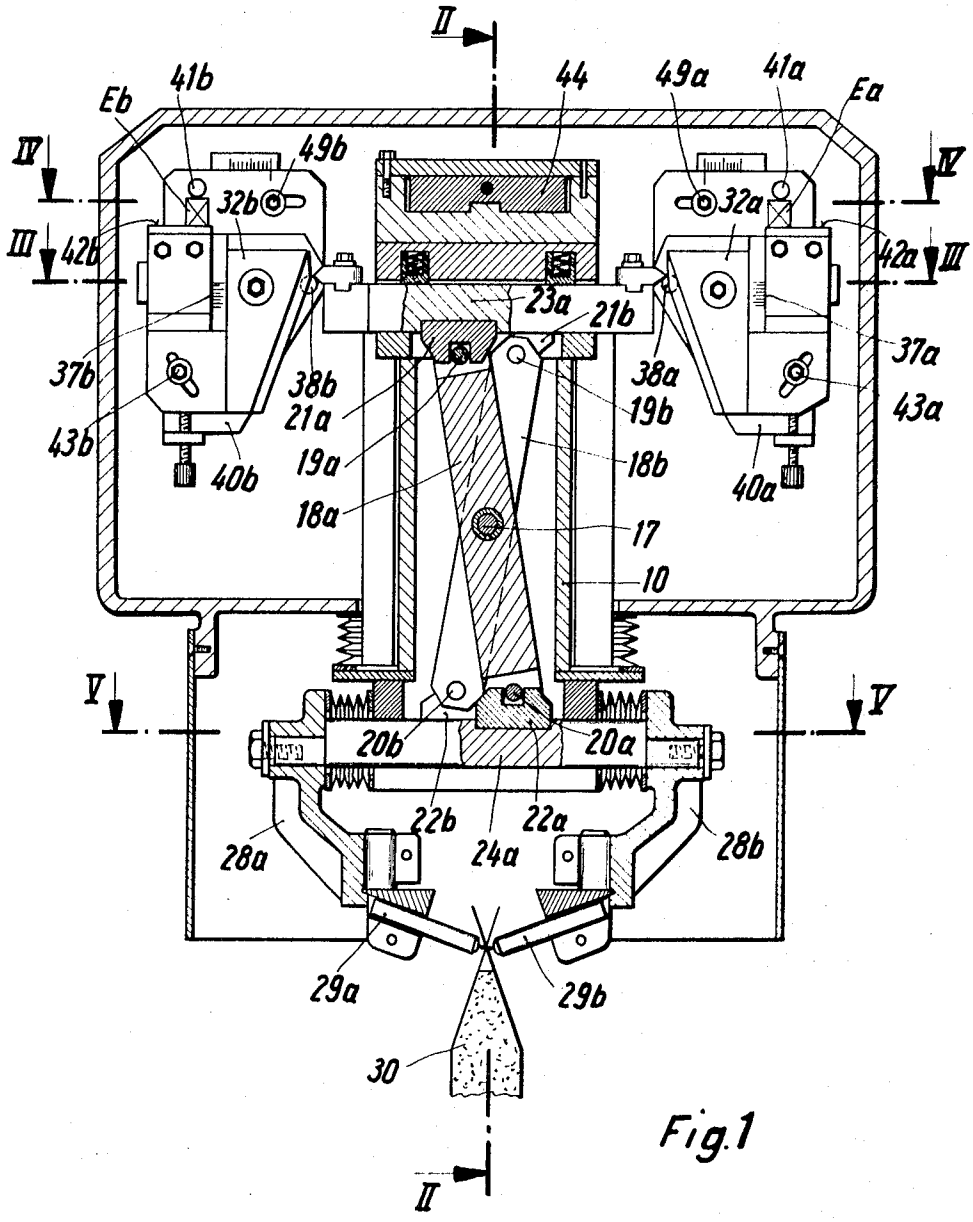


Fig.1

Inventor:
Engelbert Vossebrecker
By
Walter Becker

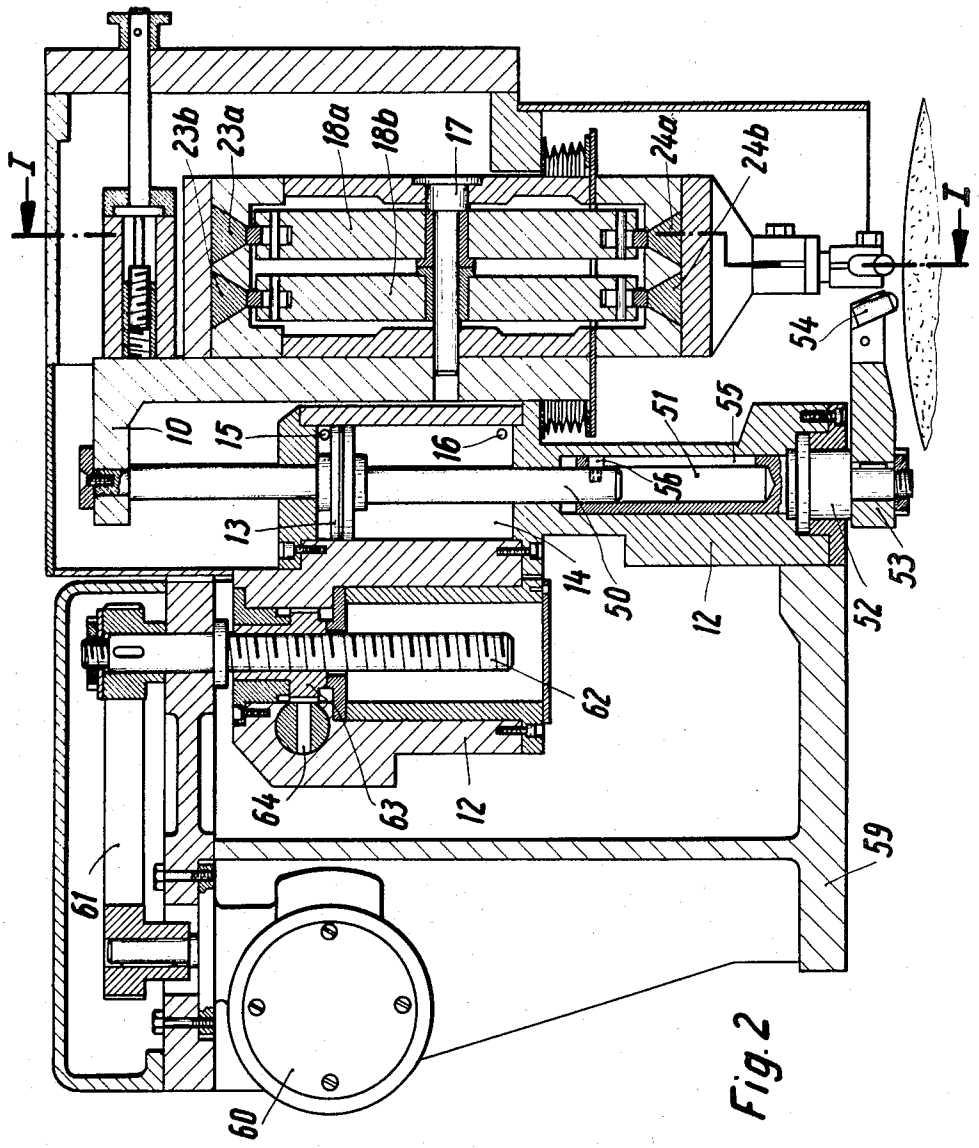


Fig. 2

Inventor:
Engelbert Vossebrecher
By
Walter Berker

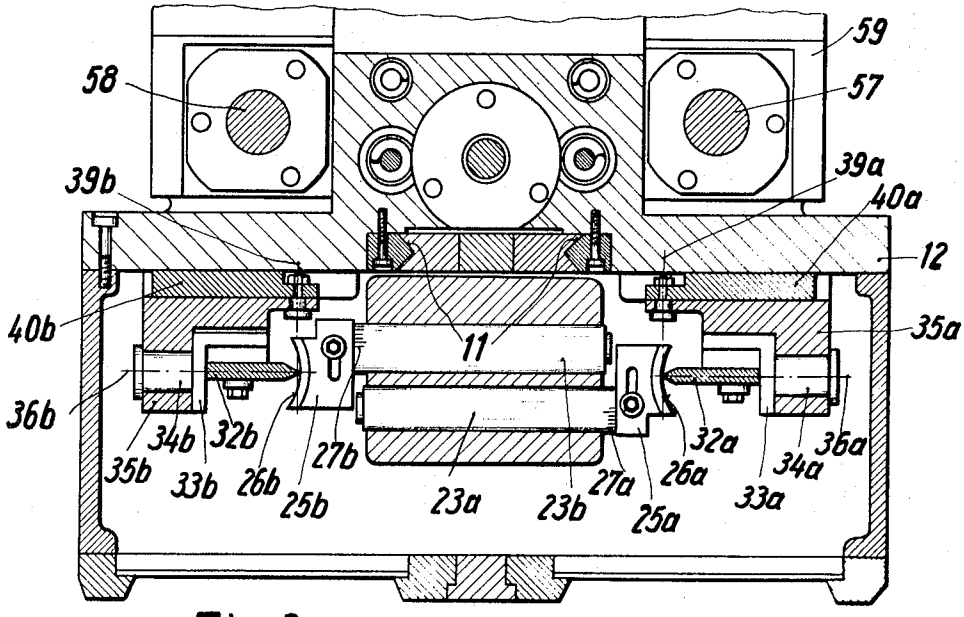


Fig. 3

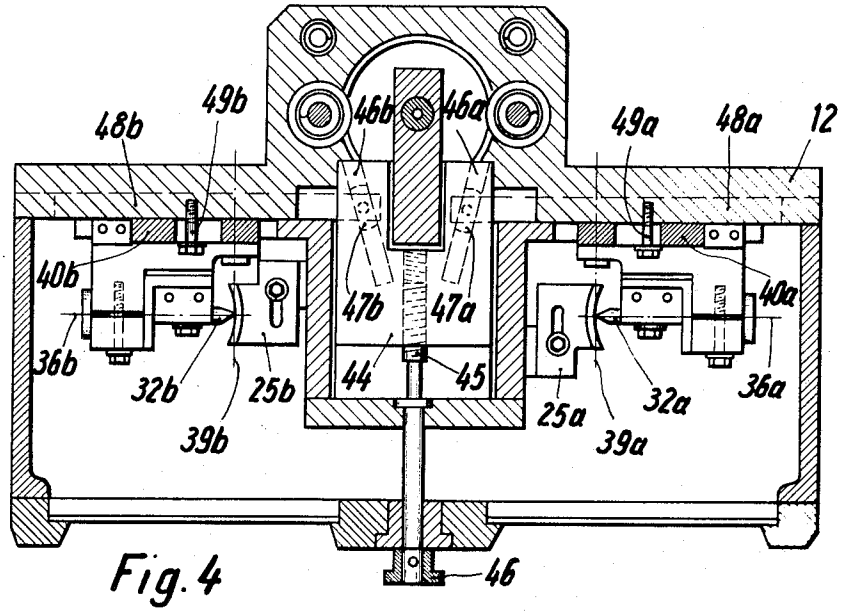


Fig. 4

Inventor:
Engelbert Vossebrecker
By

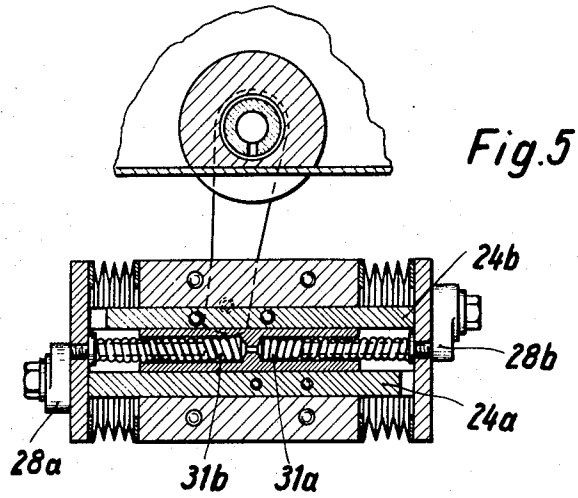


Fig.5

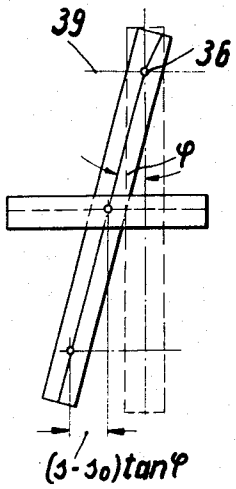


Fig.6a

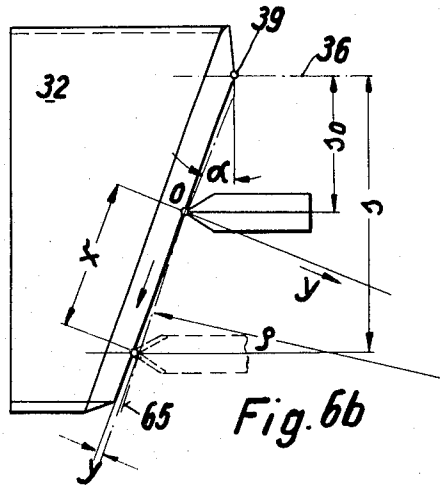


Fig.6b

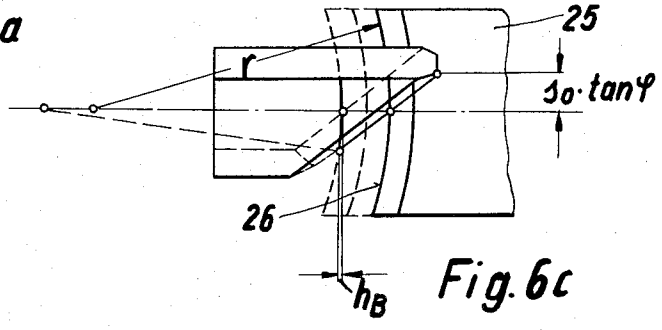


Fig.6c

Inventor:

Engelbert Vossebrecker

By Walter Burkey.

TRUEING DEVICE FOR GRINDING DISCS

The present invention relates to a trueing device for grinding discs.

The grinding of flanks of worms makes it necessary to profile the grinding discs in conformity with curve-shaped profiles, unless so-called K-worms are involved which are to be ground by means of a rectilinear trapezoidal conical disc. The curve-shaped grinding disc profile represents the counter profile to the profile of the worm flank which counter profile is determined by the helical interengagement of the helical surface (worm flank) to be produced with the grinding disc. When the grinding of so-called control worms (A-worm, N-worm, or E-worm) is involved, in other words, such worms the flanks of which are formed by the helical interengagement of a generating straight line which intersects the worm axis or crosses the same at a certain distance therefrom, the grinding disc may be correctly profiled by means of helical surface trueing devices. With such heretofore known devices, a trueing diamond is reciprocated along the generatrix of the worm flank while the diamond or the entire trueing device, which in place of the worm to be ground is received between the points of the grinding machine, is simultaneously relative to the grinding disc passed along a helical path as is the case later with the worm to be ground by the trued disc. The diamond thus automatically produces the profile on the grinding disc which profile is more or less curved and pertains to the worm flank to be trued.

While this method practically gives good results, it is rather time-consuming inasmuch as with each profiling of the disc, the workpiece has to be removed from the machine, and the threading, grinding disc has in its place to be arranged between the points.

In order to overcome the above-mentioned drawbacks, a method with pertaining devices has been developed according to which the grinding disc with the threading, dressing device has to be used only once and profiled only on one flank. With this unilaterally profiled grinding disc, by lateral plunge cutting, a templet inserted into the normal cut of the grinding disc is profiled. In conformity with this templet, it is then possible by means of a correspondingly designed copying dressing device connected to the grinding head of the machine, to profile and post-profile the two flanks of the grinding disc as often as desired. While this method results in a considerable saving of time with regard to the simple threading dressing, it likewise has some drawbacks. If it is necessary at both flanks of the work to grind different profiles as for instance with duplex worms, it is necessary to grind said profiles successively while employing the respectively required templets which were produced in the above-mentioned manner. One dressing diamond will each time have to be removed or moved out of engagement with the disc. While individual corrections at the flanks, for instance, the introduction of a somewhat reduced profile curvature for creating a crowned carrying of the flanks can be obtained within certain limits by the selection of different grinding disc diameters when preparing the templets and during the grinding of the worms, a serious drawback is seen in the fact that the flank profile generated on the worm with the same templets, i.e. grinding disc profile, depends on the grinding disc diameter so that these conditions have to be taken into consideration when narrow tolerances are involved. In addition thereto, it may be mentioned that a trueing or dressing device according to which both grinding disc flanks are, in the manner of an image, dressed by one templet, have to be produced with an extremely high precision if a proper profile symmetry is to be assured. A possibly necessary correction on one worm flank is not possible in view of the profiling of both flanks by one templet.

Instead of profiling the grinding discs and templets in the above-mentioned manner with a threading, dressing device and a templet grinding device on the machine itself, it would, of course, be possible to calculate the rated shape of the templet which is possible by the employment of electronic calculating devices but require considerable time. In such instances, the problem of producing the templets in conformity with the calculated coordinates within the very narrow required tolerances presents itself which makes this method uneconomical from the start in view of the multiplicity of the required profiles. The calculation of the templet profiles also indicates that in the majority of practical instances, the profiles can be approximated with sufficient precision by circular arcs. This method has actually been practiced but also in this instance, the number of the required circular templets is not economical.

It is, therefore, an object of the present invention to provide a dressing device for profiling grinding discs for grinding helical surfaces, which will make it possible in a crowned or hollow manner to dress the two flanks of the grinding disc while employing two straight templets in conformity with circular arcs which are infinitely adjustable with regard to their radii within a wide range and with a very good approximation within the range of application. The angle of inclination of the profile tangent is in the immediate profile point (intermediate profile angle) likewise adjustable in an infinitely fine manner, and in which the two flanks can be dressed accordingly to the same or different radii or profile angles.

It is a further object of this invention to provide a dressing device as set forth in the preceding paragraph according to which both flanks can be corrected independently of each other.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIG. 1 is a vertical section through the dressing device according to the invention, said section being taken along the line I—I of FIG. 2.

FIG. 2 represents a vertical section along the line II—II of FIG. 1.

FIG. 3 is a horizontal section taken along the line III—III of FIG. 1.

FIG. 4 is a horizontal section taken along the line IV—IV of FIG. 1.

FIG. 5 represents a horizontal section taken along the line V—V of FIG. 1.

FIGS. 6*a*–6*c* respectively diagrammatically indicate the arrangement of the templet and the feeler edge.

The dressing device according to the present invention is characterized primarily in that it is provided with two intercrossing two-arm levers which are mounted on a carriage radially displaceable with regard to the grinding disc, said levers being rotatable about a pivot. The two ends of said two-arm levers engage by means of studs two slides which move in guiding means in opposite direction with regard to each other. Of these slides, those slides which are arranged on the lever ends associated with the grinding disc carry the dressing diamonds for the two flanks of the grinding disc, whereas those slides which are associated with the other lever arms carry circularly curved flat feeler edges which in cross section are slanted in the manner of roof edges. These feeler edges engage two likewise similarly inclined rectilinear templets which are pivotable about two studs each and are arrestable. The axis of one templet extends at a right angle with regard to the plane of the templet, whereas the axis of the other templet is parallel to the plane of the templet and at a right angle with regard to the direction of movement of the dressing carriage.

Referring now to the drawings in detail, FIGS. 1 to 3 illustrate a carriage **10** which henceforth may be designated as dressing carriage. This carriage is slidable in prismatic guides **11** in a vertical direction, the guiding strips of said prismatic guides **11** being connected to a baseplate **12**. The dressing carriage is moved upwardly and downwardly by a piston **13** which is driven in a cylinder **14** consisting of one piece with the baseplate **12**, while the actuating oil under pressure is introduced into and withdrawn from said cylinder **14** through openings **15** and **16** respectively. The openings **15** and **16** are, through conduits and control valves (not shown) connected to the hydraulic system of the machine.

Two intercrossing levers **18***a* and **18***b* with the same lever arms are journaled on a bearing bolt **17** in the dressing carriage. These levers **18***a* and **18***b* are provided at their upper and lower ends with pivots **19***a*, **19***b* and **20***a* and **20***b* by means of which they engage upper and lower slots of two follower members **21***a* and **21***b* and **22***a* and **22***b*. These follower members are each connected to two prismatic slides **23***a* and **23***b* and **24***a* and **24***b*. The said slides are guided in the upper and lower part respectively of the dressing carriage in a horizontal direction as will be clearly evident from FIGS. **1** and **2**. Those ends of the upper slides **23***a*, **23***b* which protrude from their guiding means, have connected thereto feeler bodies **25***a* and **25***b* which are provided with feeler edges **26***a* and **26***b* which are inclined in a roof edge-shaped manner and, according to the embodiment shown in FIGS. **3** and **4**, are curved along arcs. The feeler bodies **25***a*, **25***b* are adjustable on slides **23***a*, **23***b* in grooves and, more specifically, in a direction transverse to the longitudinal direction of said slides. As will be seen from FIGS. **1**, **3** and **4**, the said feeler bodies **25***a*, **25***b* can be arrested by tightening screws. The respective position of said feeler bodies can be read on dials **27***a* and **27***b*.

The slides **24***a*, **24***b* in the lower part of the dressing carriage, have those ends thereof which protrude from the guiding means provided with diamond holders **28***a* and **28***b* in which dressing diamonds **29***a* and **29***b* are clamped fast (FIG. **1**) for the right-hand and left-hand flank respectively of the grinding disc **30**.

The circular feeler edges **26***a* and **26***b* are, by means of springs **32***a* and **31***b* (FIG. **5**), pressed against templets **32***a* and **32***b*. Said springs **31***a* and **31***b* are located in bores in the lower end of the dressing carriage and act upon the slides **24***a*, **24***b* while through the intervention of follower members **22***a*, **22***b* spreading the levers **18***a*, **18***b* apart. These straight line templets, which are likewise slanted in a roof-edge manner, are by means of screws connected to templet holders **33***a* and **33***b*. The templet holders are, by means of studs **34***a* and **34***b* in slotted bearing bodies **35***a* and **35***b*, rotatable about axes **36***a* and **36***b* and by means of clamping screws are adapted to be arrested in customary manner. The angular positions can be read on the dials **37***a* and **37***b*.

The bearing bodies **35***a* and **35***b* are mounted on baseplates **40***a* and **40***b* and are pivotable about trunnion screws **38***a* and **38***b* with their axes **39***a* and **39***b*. The pivot angle is determined by end measure Eand E_b which may be placed between the bolts **41***a* and **41***b* and engaging surfaces **42***a* and **42***b* on the bearing bodies **35***a*, **35***b*. After effected adjustment, the bearing bodies are clamped to the baseplates **40***a*, **40***b* by means of screws **43***a* and **43***b* extending through arched slots provided in said bearing bodies. The two axes **36***a*, **39***a* and **36***b*, **39***b* intersect at the starting point of the templet profile which, consequently is retained in an unchanged manner with each adjustment of its position.

Guided in the upper portion of the dressing carriage is a slide **44** which, by means of an adjusting screw **45** with actuating head **46**, is adapted to be moved forwardly and backwardly (FIG. **4**). This slide has its bottom side provided with two grooves **46***a* and **46***b* which extend at an angle with regard to its direction of movement. It is in these grooves that the blocks **47***a* and **47***b*, screwed onto bars **48***a* and **48***b*, are movable. The said bars **48***a* and **48***b* are in their turn connected to baseplates **40***a*, **40***b* which can be clamped to the bottom plate **12** by means of clamping screws **49***a* and **49***b*. After loosening the clamping screws **49***a*, **49***b*, by actuating the adjusting screw **45**, it is possible through the intervention of the blocks **47***a*, **47***b* slidable in grooves **46***a*, **46***b* to move the bars **48***a*, **48***b* and together therewith the baseplates plates **40***a*, **40***b* with the templet holders toward the outside or toward the inside for setting the dressing diamond to the disc thickness required for the modulous of the worm to be ground.

The downwardly extended piston rod **50** of the piston **13** extends into a bore **51** of a rotatable part **52** (FIG. **2**). The part **52** is rotatably journaled in the baseplate **12** for rotation about its axis and has its lower end provided with a holder **53** for a diamond **54** adapted to dress the outer diameter of the grinding disc. The rotatable part **52** has a helical slot **55** into which extends a pivot **56** screwed fast to the piston rod **50**. The piston rod **50** has its upper end nonrotatably connected to a nose of the dressing carriage. During the upward and downward movement of the piston **13** and thereby of the dressing carriage, it will be appreciated that the rotatable part **52** and thus the dressing diamond connected thereto will, by means of the pivot **56** and helical slot **55**, be subjected to reciprocatory movement whereby simultaneously with the dressing of the flanks of the grinding disc also the outer diameter of the disc is dressed.

The baseplate is in vertical direction (FIG. **3**) guided on columns **57** and **58** (FIG. **3**) which columns are anchored to a stand **59**. The stand **59** is, in a nonillustrated manner, screwed to the grinding head of the machine which grinding head comprises the bearing means and drive for the grinding disc. Connected to the stand **59** is a transmission motor **60** which, through the intervention of a worm drive and a toothed belt **61**, drives a helical spindle **62**. The spindle **62** screws into a ratchet wheel **63** which is journaled in the baseplate **12** and is designed in form of a nut. This drive serves for a fast downward movement of the baseplate with the dressing carriage onto the grinding disc or for moving upwardly away from the dressing position. The feeding into dressing position is effected in small steps by means of a pawl **64** which engages said ratchet wheel and is actuated by a nonillustrated oil operated piston. Inasmuch as this device does not form the subject matter of the present invention and is principally known, a further description of this device appears to be superfluous.

The operation of the dressing device, as far as it is not clear yet from the preceding description, will now be explained in connection with FIGS. **6***a*, **6***b* and **6***c* for the elements of the dressing device which dress the right-hand flank of the grinding disc. For the sake of simplicity, the index *b* characterizing this side has been omitted. For the left-hand flank, the image arrangement, corresponding remarks apply. When the templet **32** occupies its zero position as indicated in dash lines in FIG. **6***a*, in other words, when the angle $\phi=0$, it will be appreciated that since the lever **18** has arms of the same size, the described transmission mechanism will convey the rectilinear profile of the templet at a scale of 1:1 to the grinding disc. The stroke of the dressing carriage and thus of the diamond in vertical direction simultaneously represents the stroke of the feeler edge **26**, and the stroke of the lower slide **24** with the diamond **29** in horizontal direction corresponds to the stroke of the feeler edges in this direction, which last mentioned stroke is controlled by the templets.

If, however, the templet has been pivoted about the axis **36** by an angle ϕ, its contact point with the arc-shaped factor edge will be displaced during the vertical stroke in lateral direction (FIG. **6***c*), and the horizontal stroke of the feeler edge and thus of the diamond is smaller in the range passed through by the extent of the height of the arc h_B of the feeler edge than is the case in the zero position of the templet. Each point of the feeler edge, for instance, its zenith point located in zero position on the axis **36**, will thus pass through a curved path **65** as indicated in dot-dash lines in FIG. **6***b*, and this path is also passed through by the dressing diamond.

Referring to the *x*-*y*-coordinate system of FIG. **6***b* which the abscissa coincides with the templet edge in the zero position ($\phi=0$) of the templet, in other words, extends at an angle α with regard to the direction of movement of the dressing carriage, the components *x* and *y* of the movement from the starting position indicated by s_o are obtained in which starting position the feeler edge **25** is laterally displaced from its zero position of $s_o \cdot x \tan \phi$. Thus, the following values will be obtained for the components *x* and *y*:

$$x=s-s_0/\cos \alpha$$

and:

$$y=h_B \cdot x \cos \alpha = (r-\sqrt{r^2-x^2 \cos^2 \alpha \tan^2 \phi}) \cos \alpha$$

A simplification of the equation for *y* will indicate that the path of the feeler edge and thus of the dressing diamond represents an ellipse with the semiaxes:

$$a=r/(\cos \alpha \phi)$$

and

$$b=r \times \cos \alpha$$

The main zenith point of the ellipse which contacts the straight line inclined at the templet angle α at the zero point 0 of the x-y-coordinate system to which corresponds the point located on the intermediate profile height on the grinding disc flank. The grinding disc-profile angle at this point also equals α. The medium radius of curvature of the ellipse and thereby also of the grinding disc profile is:

$$p=a^2/b=r/(\cos^3 \alpha \times \tan^2 \phi)$$

Within a range for ϕ of from 0 to 30°, it is possible with an α of, for instance, 20°, infinitely to adjust radii of curvature p within the range of from approximately $3.6 \times r$ to ∞. The lower border of p can, by selecting a corresponding radius r of the feeler edge, be located so low that the practically required range is completely covered. A calculation will show that within the range of the practically occurring profile heights, the deviations of the elliptic diamond path from the radius of curvature p is negligibly small. With involute worm profiles extending to the neighborhood of the basic cylinder, the radius of curvature changes within the height of the tooth profile to a greater extent and decreases to zero when the base cylinder has been reached. However, the radial range of the profile with considerable curvature is only relatively small. This tendency can be taken into consideration to a certain extent by the dressing device according to the invention. As mentioned above, the main zenith point of the elliptical diamond path is, during the normal adjustment, located at the flank point on the intermediate profile height. If the zenith point is displaced further inwardly on the grinding disc profile, which can be effected without difficulties by a corresponding lateral displacement of the feeler edge 25, it will be appreciated that in view of approaching the secondary zenith point of the ellipse, toward the outer diameter of the disc profile, radii of a decreasing character are obtained which correspondingly act at the foot of the worm profile. In such an instance, of course, it is necessary that the profile angle will be maintained in the intermediate profile height. This is easily realized in view of the fact that the templet is pivotable about the axis 39 which makes it possible to adjust with one templet all practically employed profile angles α.

It is, of course, to be understood that the present invention is, by no means, limited to the particular construction shown in the drawings but also comprises any modifications within the scope of the appended claims. It is also to be noted that the dressing device according to the invention is not limited merely to the dressing or grinding discs by means of which worms or threads are to be ground which require a hollow curve grinding disc profile such as evolute worms. It is also possible according to the present invention to dress crowned grinding discs, for instance, for grinding worms with rectilinear normal cutting profile, so-called N-worms. To this end, it is merely necessary, as indicated in FIG. 3, to employ hollow feeler edges, whereas they have to be curved when they are intended for grinding evolute worms.

What is claimed is:

1. In a dressing device for dressing a grinding disc, especially a grinding disc for a worm or thread-grinding machine: a frame adapted to be fixedly mounted relative to the axis of the disc to be dressed, a carriage guided in the frame for movement radially of the disc, first and second dressing elements on said carriage at the disc end thereof in opposed axially spaced relation relative to the disc and movable transversely in the axial direction of the disc to dress the sides of the disc, a pair of slides slidable transversely on said carriage at the end thereof opposite said disc and in a direction axially of said disc, a pair of levers pivoted in said carriage and each having one end connected to a respective one of said slides and the other end connected to a respective one of said first and second dressing elements, a feeler member on one end of one slide and on the opposite end of the other slide, a templet in the frame adjacent each feeler member, said feeler members and templets having interengaging knife edges, the said edges on said feeler members being disposed in a plane normal to the direction of movement of said carriage and being curved in said plane, and means pivotally supporting said templets in said frame for angular adjustment about first and second axes angularly related to each other and to the direction of movement of said carriage in said frame.

2. A dressing device according to claim 1, in which the said edges of said templets extend generally in the direction of movement of said carriage, the said first axes being disposed in a second plane parallel to the direction of movement of said carriage and said second axes being normal to said second plane.

3. A dressing device according to claim 2, in which the said first and second axes for each templet intersect at one end of the said edge of the respective templet.

4. A dressing device according to claim 2, in which said feeler members are mounted on said slides for adjustment thereon in said first mentioned plane lateral to the direction of movement of said slides on said carriage.

5. A dressing device according to claim 2, which includes a baseplate for each templet and having means thereon forming the respective said first and second axes, and means for adjusting said baseplates on said frame in a direction transverse to the direction of movement of said carriage.

6. A dressing device according to claim 4, which includes a support member on each baseplate pivotally connected thereto on the respective second axis, and a shaft rotatable in each support member on the respective first axis and supporting the respective templet.

7. A dressing device according to claim 6, which includes an abutment stud on each baseplate and an opposed abutment surface on each support member adapted to receive a gauge block therebetween for setting the position of the respective support member on the baseplate pertaining thereto.

8. A dressing device according to claim 2, in which the said edge of each templet is linear.

9. A dressing device according to claim 2, which includes a third dressing element on said carriage at the disc end thereof presented radially toward said disc and movable axially of the disc for dressing the periphery of the disc.

10. A dressing device according to claim 2, which includes resilient means acting between said first and second dressing elements for biasing said slides in a direction to press the feeler members thereon against the respective templets.

* * * * *