May 13, 1941. E. G. HJARPE 2,242,031

MACHINE FOR GRINDING BODIES OF ROTATION WITH CURVED GENERATRICES

Filed March 28, 1939 5 Sheets-Sheet 1

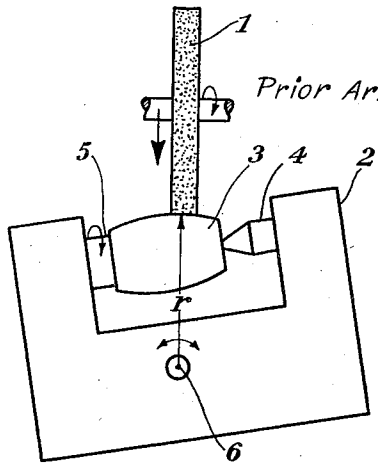


Fig.1.

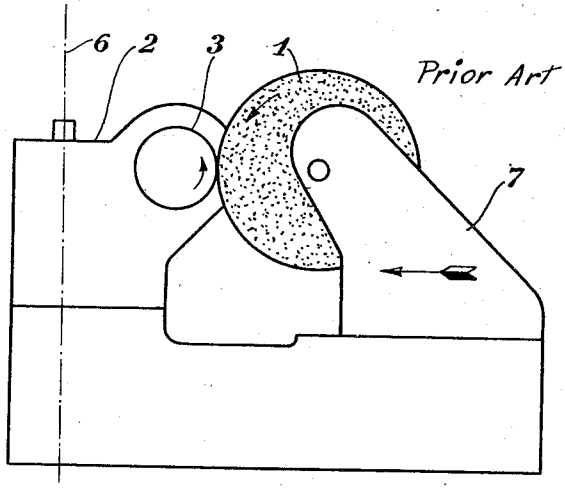


Fig.2.

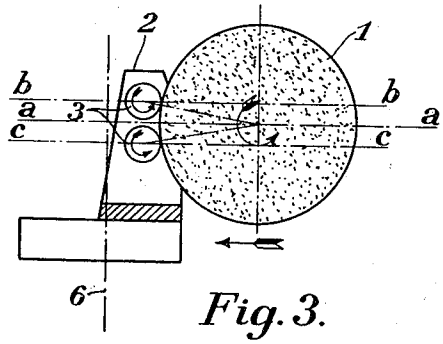


Fig.3.

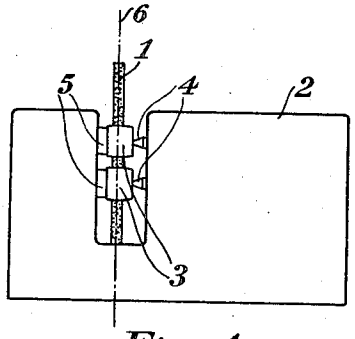


Fig.4.

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MACHINE FOR GRINDING BODIES OF ROTATION WITH CURVED GENERATRICES

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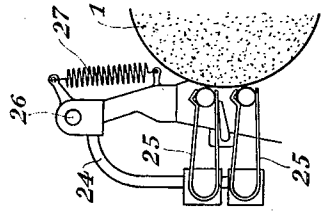


Fig. 6.

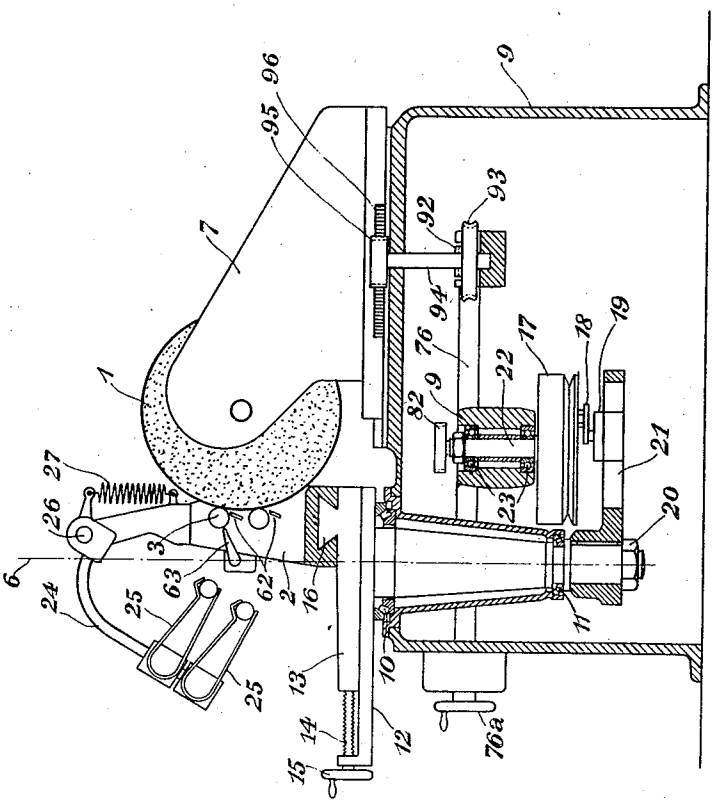


Fig. 5.

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MACHINE FOR GRINDING BODIES OF ROTATION WITH CURVED GENERATRICES

Filed March 28, 1939 5 Sheets-Sheet 3

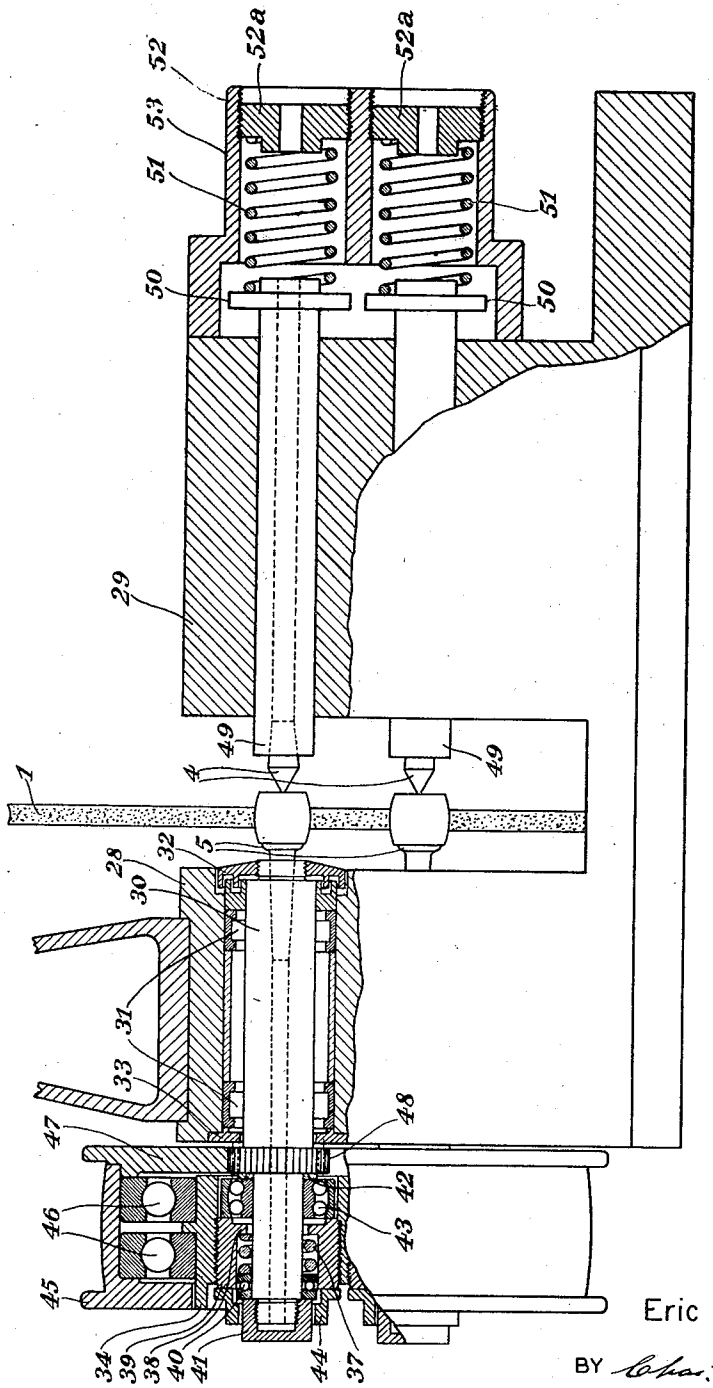


Fig. 7.

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MACHINE FOR GRINDING BODIES OF ROTATION WITH CURVED GENERATRICES

Filed March 28, 1939 5 Sheets-Sheet 4

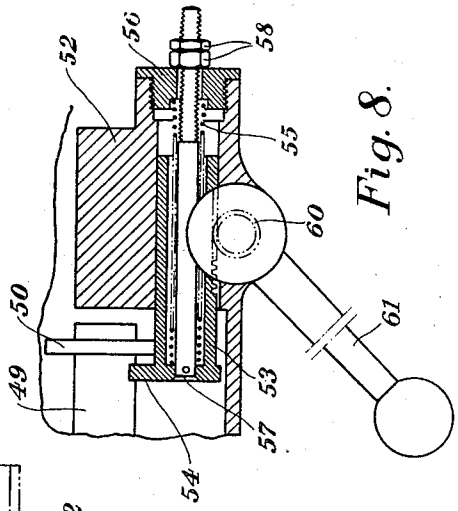


Fig. 8.

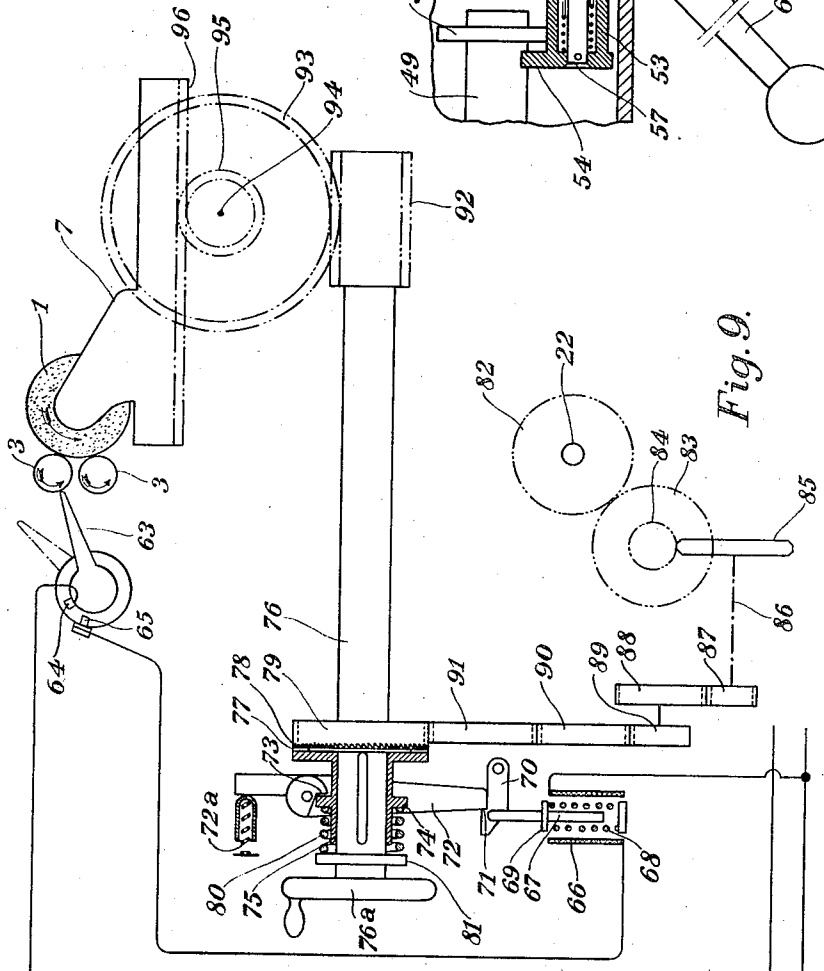


Fig. 9.

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MACHINE FOR GRINDING BODIES OF ROTATION WITH CURVED GENERATRICES

Filed March 28, 1939 5 Sheets-Sheet 5

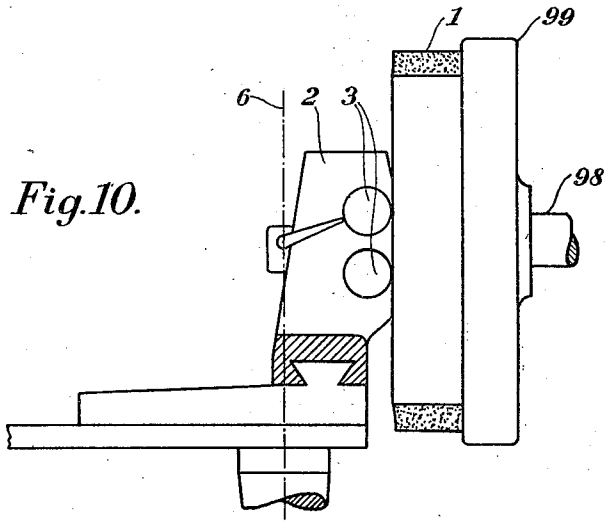


Fig.10.

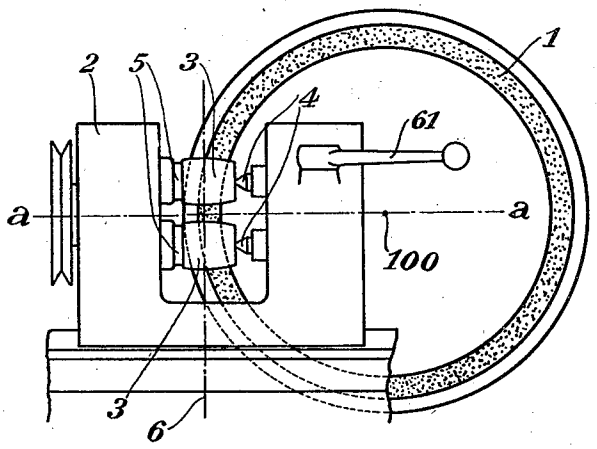


Fig.11.

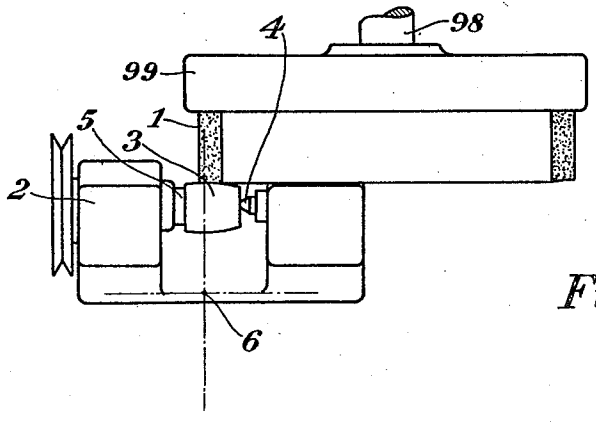


Fig12.

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Patented May 13, 1941 2,242,031

UNITED STATES PATENT OFFICE

2,242,031

MACHINE FOR GRINDING BODIES OF ROTATION WITH CURVED GENERATRICES

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Application March 28, 1939, Serial No. 264,568
In Sweden June 17, 1938

4 Claims. (Cl. 51—97)

The present invention relates to a grinding machine adapted for grinding bodies of rotation with curved generatrices, for instance rollers and race rings for ball and roller bearings, the said machine having a work head and a grinding wheel for relative oscillating and sliding movement between the work head and the grinding wheel. The object of the invention is to increase the capacity of grinding machines of this type and thereby make better use of the time of the machine operator than has hitherto been possible. The grinding machine according to the invention is characterized thereby that the work head carries two work holding devices, the axes of which are symmetrically arranged relative to a plane perpendicular to the axis of oscillation and containing the line which intersects both the axis of rotation of the grinding wheel and the axis of oscillation under right angles for simultaneous grinding of two work pieces with one and the same grinding wheel. The two work pieces being symmetrically supported relative to the plane mentioned, they will be ground to identically the same form, and the working surface of the grinding wheel will through wear against the work pieces be generated to such a form that it contacts with the work pieces along a considerable width, which is of prime importance for the grinding capacity of the machine and accuracy of the grinding. In some embodiments of the invention the axis of oscillation of the work head is perpendicular to the axis of rotation of the grinding wheel. In such grinding machines the two work holding devices are arranged symmetrically relative to a plane perpendicular to the axis of oscillation and containing the axis of rotation of the grinding wheel.

Two embodiments of the invention in which the axis of rotation of the grinding wheel is perpendicular to the axis of oscillation are shown in Figures 3 to 10 of the accompanying drawings.

Figures 1 and 2 show schematically a horizontal and a vertical projection respectively of a grinding machine with an oscillable work head of known type which as it has hitherto been the custom is provided with a single work holding device. These figures are intended only to illustrate the principle of generating bodies of rotation with curved generatrices through grinding with an oscillating work head.

Figure 3 shows schematically in part a vertical projection of a grinding machine according to the invention.

Figure 4 shows a vertical projection at right angles to Figure 3.

Figure 5 is a longitudinal section of the grinding machine schematically shown in Figures 3 and 4.

Figure 6 is a fragment of Figure 5 showing certain members in another position.

Figure 7 shows partly in section a side view of the work head seen at right angles to the view shown in Figure 5.

Figure 8 shows a hoizontal section through part of the work head.

Figure 9 is a diagram of the feed arrangement and a gauging device for automatical disengagement of the feed when the work piece has been ground to the dimension desired.

Figure 10 shows a vertical projection of a machine according to a modified embodiment of the invention.

Figure 11 is a view at right angles to Figure 10, and

Figure 12 is a plan view of the device illustrated in Figures 10 and 11.

In all the figures the same designations are used for corresponding parts.

In the grinding machine diagrammatically shown in Figures 1 and 2 and of hitherto known design **1** is the grinding wheel and **2** the work head in which a single work piece, a roller **3**, is chucked between a centre **4** and a drive plate **5**. The grinding wheel **1** is supported by a head **7** shown in Figure 2, which is slidable in the direction shown by the arrow for feeding against the work. The work head is provided with means, not shown, for rotating the grinding wheel in the direction shown by an arrow. The work head **2** is oscillable about an axis **6** and is provided with means, also not shown, preferably for rotating the drive plate **5** in the direction shown by an arrow.

When the work head is caused to oscillate across the grinding wheel, the work piece and the grinding wheel simultaneously rotating around their own axes and a relative feed movement taking place between the work head and the grinding head, the work piece assumes the shape of a body of rotation with curved generatrix, as shown in Figure 1. Since the axis of rotation of the grinding wheel and the line of contact between the grinding wheel and the work piece are located in the same plane perpendicular to the axis of oscillation, the generatrix, as shown in Figure 1, assumes the form of an arc of a circle having its centre on the axis of oscillation **6**. The radius r of the arc will be equal to

the distance between the line of contact and the axis of oscillation. During grinding the grinding wheel is also formed through wear against the work piece in such a manner that its own generatrix assumes the form of an arc with the same radius and the same center as that of the work piece. Owing to this condition the grinding wheel will bear against the work piece along the whole width of its effective working surface, whereby uniform and accurate grinding and high efficiency results.

Figures 3 and 4 show schematically a part of a machine according to the invention for simultaneously grinding two work pieces, which in the embodiment shown are roller bearing rollers **3**. The work head **2** of the machine is oscillable, and the support for the grinding wheel is slidable toward and from the work pieces and carries a driving motor for the grinding wheel in substantially the same manner as in the machine according to Figures 1 and 2. The work head **2** carries two work holding devices symmetrically arranged relative to a plane *a—a* at right angles to the axis **6** of oscillation and containing the line which intersects both the axis of oscillation **6** and the axis of rotation of the grinding wheel. As in the embodiment shown these axes are perpendicular to each other, the plane *a—a* also contains the axis of rotation of the grinding wheel. As the axes of the rollers are not disposed in the plane *a—a*, their generatrices do not assume the exact form of a circular arm. The general requirements for generating a mathematically true arc of a circle are that a plane at right angle to the axis of oscillation and containing the axis of rotation of the work piece shall also contain the contact line between the work piece and the grinding wheel. Two planes at right angles to the axis of oscillation and containing the axis of rotation of the work pieces are indicated in Figure 3 by the lines *b—b* and *c—c*. As will be seen, these lines do not pass through the points of contact between the grinding wheel and the work piece, and thus the condition mentioned above is not satisfied in the machine schematically shown in Figures 3 and 4. As the two rollers **3** are carried symmetrically relative to the plane *a—a*, they will be ground to identically the same form and each generate the same form of the working surface of the grinding wheel. Accurate tests have shown that the deviation from the true circular form of the arc of the generatrices of the work pieces is very insignificant and has no injurious influence on the practical use of the rollers, provided the distance between the planes *b—b* and *c—c* is small compared to the diameter of the grinding wheel. The grinding wheel will bear against the rollers with its whole effective working surface, and the grinding therefore takes place effectively and with the accuracy desired. The feed movement of the grinding wheel head is directed parallel with the plane *a—a*, so that said condition of symmetry is maintained during the whole grinding operation.

In the embodiment shown each work holding device comprises a centre **4** and a drive plate **5** arranged in alignment, whereby the latter is rotatably driven, in order to rotate the work piece **3** about its axis.

The grinding machine schematically shown in Figures 3 and 4 is further illustrated in Figure 5. The machine bed **9** carries with the aid of conical roller bearings **10** and **11** a table **12** having a downwardly directed vertical shaft forming the axis of oscillation of the work head. On the table is an intermediate slide **13**, which can be moved lengthwise of the machine by means of a screw **14** and a hand wheel **15**. On a dove-tail guide **16** the intermediate slide **13** supports the work head **2** proper, which by means of operating members, not shown, is slidable in the transverse direction of the machine. The oscillating means is driven from a pulley **17** which in its turn is driven by a drive motor not shown. The power is transmitted from the pulley **17** over a crank **18** to a sliding head **19**, which is slidably mounted in a slot of an arm **21** fixed by means of a nut **20** at the lower end of the oscillating shaft. The pulley **17** is carried by a vertical shaft **22**, which is mounted on the machine bed **9** by means of ball bearings **23**.

When the pulley **17** is caused to rotate, the lever **18** and the sliding head **19** convert this rotation into an oscillating movement of the arm **21**, whereby the work head **2** is made to oscillate to and fro, so that the work pieces **3** are caused to sweep across the surface of the grinding wheel and their profiles are generated to the form of arcs of circles. Through adjustment of the work head in the lengthwise direction of the machine by means of the hand wheel **15** it is possible to vary the position of the work pieces relative to the axis of oscillation and thus obtain different curve radii of the generatrices. The grinding wheel must be readjusted in the longitudinal direction of the machine, so that the proper contact with the work pieces is obtained. By locating the work piece at the opposite side of the axis of oscillation relative to the centre of the grinding wheel it is possible to grind bodies of rotation having concave instead of convex generatrices as shown. Through displacement of the work head **2** in the transverse direction of the machine on the guide **16** it is possible to move the rollers parallel with the axis of rotation of the grinding wheel. In this manner it is rendered possible to alter, if desired, the form of the rollers so that their thickest part will be located near the one or the other end or intermediate thereof, as shown in the drawing. When grinding concavely curved rollers it is possible to place the part of at least diameter of the roller in any desired position along its length in a corresponding manner.

In order to reduce the improductive time of the machine operator, the grinding machine is provided with a work inserting device, into which the operator can insert a pair of work pieces during grinding of another pair of work pieces. The last mentioned pair of work pieces having been finished and removed from the work holding devices, the work inserting device is brought to a position, in which the pair of work pieces placed in the device can be gripped by the work holding devices. The work inserting device, according to the embodiment shown, consists of an arm **24** mounted on the work head and capable of being turned about an axis **26**, the said arm carrying two spring claws **25**, the free ends of which are formed as gripping members for gripping the work pieces. The work inserting device is normally maintained in the position shown in Figure 5 by means of a spring **27** thus making it possible for the operator to introduce a workpiece between the gripping members of each claw. When a pair of work pieces has been finish ground and it is desired to insert another pair of work pieces into the work holding device, the operator brings the work inserting device into the

position shown in Figure 6. In this position the work pieces can be gripped by the work holding devices, the centres of which are axially adjustable. The work pieces having been gripped, the work inserting device returns to the position shown in Figure 5 by the action of the spring 27.

The design of the work head is further illustrated in Figures 7 and 8. It consists generally of a base and two housings 28 and 29 arranged on the same, the former of which provides support for the drive plates 5 and the latter receiving the centres 4. Each drive plate 5 is supported at the end of a shaft 30, which passes through and extends outside a bore in the housing 28 and is mounted on roller bearings 31, 31, the rollers of which rotate directly on the shaft. The bore is sealed at each end by means of a labyrinth seal 32 and a sealing disc 33. On the outer end face of the housing 28 a bearing 34 is fastened, which has two bores lying in line with the bores of the housing 28 and containing an adjusting and mounting device for the shaft 30 in order to provide an accurate adjustment of the drive plates 5 in exactly the same plane. During grinding, the centres are pressed against the work pieces, and the pressure is transmitted to the shafts 30. In order that this pressure shall not occasion a displacement of the shafts 30, thereby destroying the adjustment of the end faces of the plates in the same plane, a strong pressure spring 37 is provided in each bore, in order to exert a considerable and constant thrust on the shafts 30. Each pressure spring 37 acts between a flange 38 on a sleeve 39 screwed into the bore of the bearing housing and a nut 41 screwed on to the end of the shaft 30. A thrust bearing 40 is provided between the spring 37 and the nut 41. The shaft 30 is pressed against the inwardly directed end face of the sleeve 39 by thrust from the spring transmitted through a washer 42 and a double selfaligning ball bearing 43. The position of the end face of the sleeve 39 determines the axial position of the shaft 30 and thereby also that of the drive plate 5, and an alteration of the position is effected through respectively screwing in or screwing out the sleeve 39 in the bearing housing 34. On the outer end face of the sleeve 39 a cap 44 is screwed, with an interspace surrounding the nut 41.

A pulley 45 is mounted on the bearing housing 34 upon two ball bearings 46 and is formed with an internal gear 47 engaging two gear wheels 48 fastened to the shafts 30. When the pulley rotates, the two shafts 30 rotate in the same direction and at equal speeds, whereby both work pieces are caused to rotate in the same direction.

Each centre 4 is fixed to the end of a rod 49, which extends through and is adjustably mounted in a bore of the centre housing 29. At the opposite end of the centre each rod 49 is provided with a flange 50 located outside the end of the bore, against which a pressure spring 51 is applied in order to maintain the centre pressed against the work piece with considerable pressure. The opposite end of the pressure spring 51 abuts against a washer 52*a*, which is screwed into a cap 52 threaded on the end face of the centre housing. Movement of the centres 4 in the direction away from the drive plates 5, so that finished ground work pieces are released, is effected by the arrangement shown in Figure 8. This arrangement consists of a sleeve 53, which is parallel with the rods 49 and has a flange 54 engaging the two flanges 50. The sleeve 53 is pressed in the direction against the centres by a pressure spring 55, which abuts against a cap 56 screwed into the casing or cap 52. A screw 57 passes through the sleeve 53 and is fixed to the sleeve. The screw 57 also passes through the cap 56 and outside the cap is provided with nuts 58 acting as abutments and limiting the movement of the sleeve to the left in Figure 8. The sleeve 53 is externally formed as a rack engaging a pinion 60, which is part of or rigidly connected to an operating lever 61. By turning the operating lever 61 in a clockwise direction, as shown in Figure 8, the sleeve 53 is displaced to the right, so that its flange engages the flanges 50 and displaces the rods 49 to the right and the centres are disengaged from the respective work pieces, which are allowed to drop. When falling down, the work pieces are prevented from touching or being damaged by the grinding wheel by the inclined guard plates 62, Figure 5, which are supported by the work head.

Figure 9 shows in diagram form the gauging device which automatically disengages the feed when the work piece has been ground to the required diameter. The gauging device proper consists of a pivotal spring actuated gauging finger 63 provided with a diamond point. As a result of the symmetrical support arrangement for the work pieces in relation to the plane *a*—*a*, Figure 3, and the equal dimensions obtained hereby during grinding of the two work pieces it is only necessary to provide a single gauging finger on one of the work pieces. During the grinding operation the gauging finger bears against the upper work piece in the manner shown by the full lines in Figure 9 and when the work piece has attained the desired dimension, the gauging finger pivots under spring pressure in a counter clockwise direction to the position indicated by the dot and dash lines. When new work pieces are introduced into the machine in the manner described in connection with Figures 5 and 6, the upper gripping member 25 again depresses the gauging finger to the position shown in Figure 6, so that the gauging finger will bear against the upper work piece when the feed arrangement has been returned to the position shown in Figure 5.

The hub part of the gauging finger carries an electric contact pin 64 connected in an electric circuit. The support for the gauging finger which, as shown in Figure 5, is supported by the work head, is inwardly provided with a contact pin 65 in the path of the contact pin 64, so that contact ensues between these two pins when the gauging finger has been released by the work piece. The fixed contact pin 65 is connected at the one end to an electric induction coil 66, the opposite end of which is connected to the electric circuit. Inside the induction coil 66 is a moveable iron core 67 acted upon in an outward direction from the coil by a pressure spring 68 acting between the machine bed and a flange 69 provided on the iron core. The end of the core protruding from the coil is pivotally connected to a pivotally mounted one-armed lever 70 provided with a shoulder 71 against which the end of a pivotally mounted two-armed lever 72 is held. This lever is actuated at its opposite end by a pressure spring 72*a* abutting against the machine bed, which pressure spring tends to turn the lever 72 in a clockwise direction. This pivoting movement is normally prevented by the contact between the end of the lever 72 and the shoulder 71. The lever 72 is at its hub part provided with a shoulder 73, which normally is at some distance

from a flange 74 on a sleeve 75, which is axially displaceable but not rotatably mounted on the feed shaft 76, also shown in Figure 5, provided for the feed of the grinding wheel head. The sleeve 75 carries a toothed wheel with coupling teeth 77 intended to engage corresponding teeth 78 on a gear wheel 79, which is freely rotatable but not slidably mounted on the feed shaft 76. The sleeve 75 is actuated in a direction towards the gear wheel 79 by means of a pressure spring 80 acting between a washer 81 rigidly fixed to the feed shaft and a flange 74 on the sleeve 75. On the end of the feed shaft 76 protruding outside the machine bed 9 is carried a hand wheel 76a for manual displacement of the grinding wheel head 7 in the longitudinal direction of the machine.

The driving power for the feed is obtained from a gear wheel 82 fixed to the upper end of the vertical shaft 22, Figure 5, whence it is transmitted further by means of a gear wheel 83, a worm gear 84, a screw wheel 85 on a shaft 86 parallel with the feed shaft to the gear wheels 87, 88, 89, 90 and 91, to the gear wheel 79 which is freely rotatable on the feed shaft 76. When the feed is engaged, the gear coupling teeth 77, 78 are in engagement and hereby the driving power is transmitted through the sleeve 75 to the feed shaft 76 and over a worm 92, a worm wheel 93, a vertical shaft 94, Figure 5, to a gear wheel 95, which is in engagement with a rack 96 provided on the head 7 of the grinding wheel 1.

The regulating device shown in Figure 9 operates in the following manner.

When grinding two work pieces the gauging finger 63 assumes the position indicated by the full lines and contacts with the upper work piece 3 under spring pressure. The contact 64, 65 is then open and the coil 66 is demagnetized. The iron core 67 is pressed outwards, and the abutment 71 of the lever 70 prevents the lever 72 from turning. The coupling 77, 78 is engaged and transmits driving power to the grinding wheel head 7, which is hereby continuously fed against the work pieces 3. When the upper work piece has been ground to the dimension required, the gauging finger turns by spring pressure to the position indicated by the dot and dash lines, whereby the contact 64, 65 is closed and the coil 66 is magnetized. The iron core 67 is hereby drawn into the coil and moves the abutment 71 out of the way of the lever 72, which by spring pressure is turned clockwise and displaces the sleeve 75 to the left, so that the coupling 77, 78 is disengaged. Hereby the gear wheel 79 will run free on the feed shaft without transmitting any power to the same, whereby the feed is stopped. By means of the lever 61 shown in Figure 8 the centres are withdrawn from engagement with the finished work pieces, which fall down into a receptacle. A new pair of work pieces is then introduced with the aid of the work inserting device 6 shown in Figures 5 and 6. During this operation the gauging finger is pressed down to the position shown in Figure 6, whereby the contact 64, 65 is broken and the coil 66 again becomes demagnetized. The pressure spring 68 now presses the iron core out of the coil, and by means of a hand wheel, not shown in the drawing, the lever 72 is returned to the position shown in Figure 9. The abutment 71 will again come into locking engagement with the end of the lever 72. After finish grinding of each pair of work pieces 3 the above described operation is repeated.

Figures 10–12 show schematically a modified embodiment of the grinding machine according to the invention. In this embodiment the grinding wheel 1 is made of a ring of grinding material, which is carried by a washer 99 on a horizontal shaft 98. The end surface of the ring 1 is the working surface. The work head 2 supports two work holding devices 4, 5, which are symmetrically arranged in relation to the plane a—a, which is at right angles to the axis of oscillation 6 and contains the axis of rotation 100 of the grinding wheel. The work head is caused to oscillate to and fro about the axis 6, while the grinding wheel is rotated and the rollers 3 are ground to the form of bodies of rotation. The generatrices in this case are accurate arcs of circles and, owing to the symmetric arrangement of the work holding devices, the generatrices of the two work pieces will be fully congruent and the work pieces identically equal in size. The grinding wheel is formed during grinding to such a shape that its working surface along its whole width bears against the work piece, whereby an effective grinding results. The work head and the arrangement for actuating the oscillating movement and the feed movement can be in principle of the same construction as shown in Figure 3–9.

In the embodiments of the invention shown above the work head is pivotally arranged and the grinding wheel head is slidably mounted in order to obtain a feed movement. It is however apparent that the arrangement can be reversed so that the grinding wheel head can be arranged pivotally and the work head slidably. As a further alternative either the work head or the grinding wheel head can be slidable as well as pivotal.

Changes may be made within the scope of the claims without departing from the spirit of my invention.

Having thus described my invention, I claim and desire to secure by Letters Patent the following:

1. In a machine for grinding bodies of rotation with curved generatrices, the combination with a grinding wheel carried by a grinding wheel head, and a work head, means for oscillating one head relative to the other, of two work holding devices carried by the work head and arranged symmetrically relative to a plane perpendicular to the axis of oscillation and containing the line which intersects both the axis of oscillation and the axis of rotation of the grinding wheel under right angles, and a work inserting device comprising spring gripping members for two work pieces, which work inserting device is adapted to be brought from a position in which its gripping members are at a distance from the work holding device to a position in which the work pieces carried by the gripping members are held in positions for their engagement by the work holding devices.

2. A grinding machine according to claim 1, characterized thereby that the work inserting device is pivotable about an axis substantially parallel with the axes of the work holding devices.

3. A grinding machine according to claim 1, characterized thereby that the work inserting mechanism consists of an arm pivotably mounted on the work head, said arm carrying two spring members, the free ends of which are

formed as gripping members for gripping the work.

4. In a grinding machine according to claim 1 the combination of a spring actuated gaging finger, arranged adjacent to one of the work holders in the path of one of the gripping members, so that the gaging finger is set to bear against the work piece by the inserting movement, and operatively connected with the feed arrangement, so as to disengage the feed arrangement, when the work piece has attained its desired dimension.

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