United States Patent

Asano et al.

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[54] GRINDING MACHINES

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[30] Foreign Application Priority Data

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[52] U.S. Cl. 51/105

[51] Int. Cl. B24b 5/00, B24b 17/00

[58] Field of Search 51/95, 95.1, 105

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Primary Examiner—Othell M. Simpson

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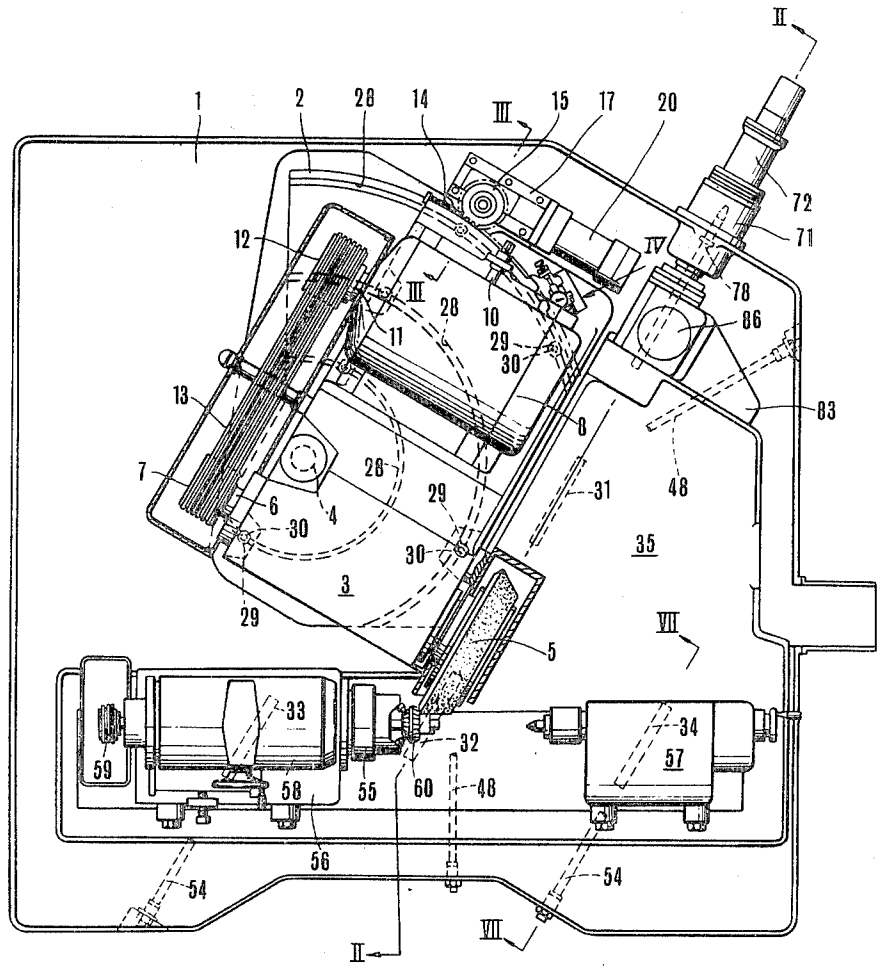
[57] ABSTRACT

In a grinding machine comprising a motor-driven grinding wheel and a headstock for holding a workpiece to be ground by the grinding wheel, the base for supporting the grinding wheel is secured to a stationary bed, a table for supporting the headstock is slidably mounted on the bed and a feed shaft is provided for the table to feed it toward the grinding wheel. The feed shaft is located in a plane perpendicular to the axis of the grinding wheel and passing through substantially the center of the width of the grinding wheel.

7 Claims, 11 Drawing Figures



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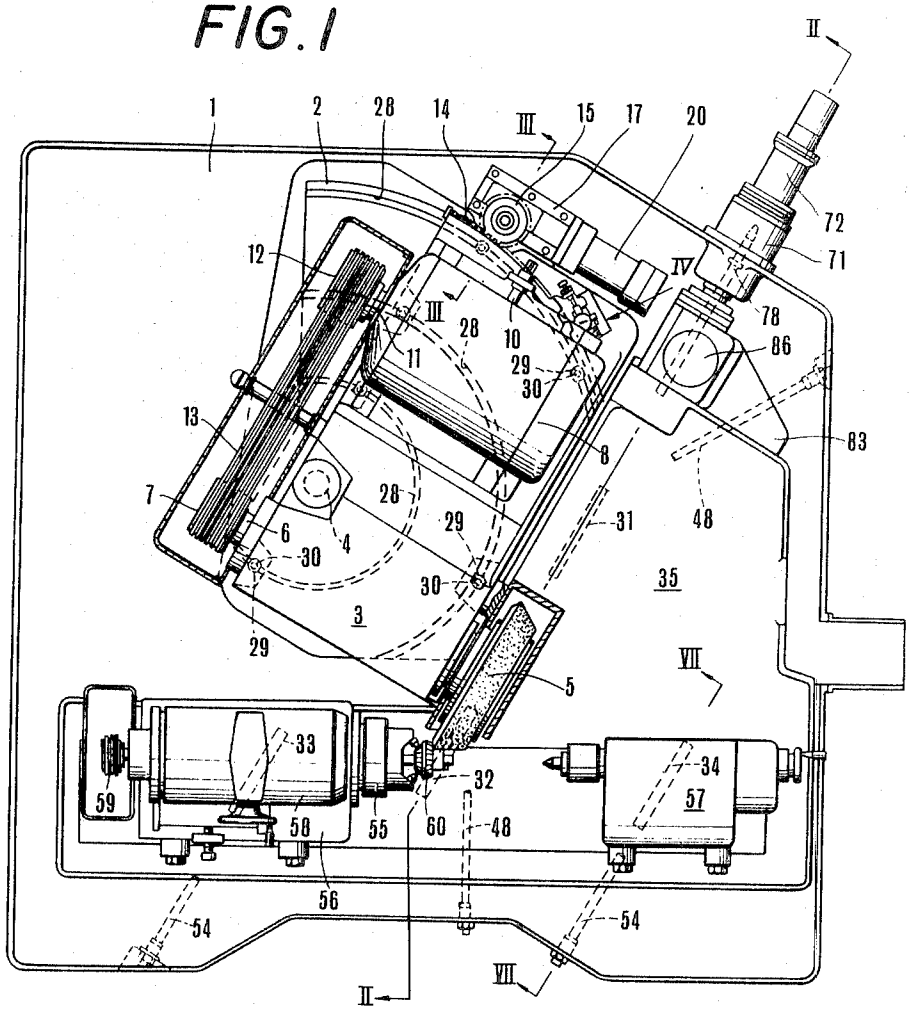
SHEET 1 OF 6

FIG. 1



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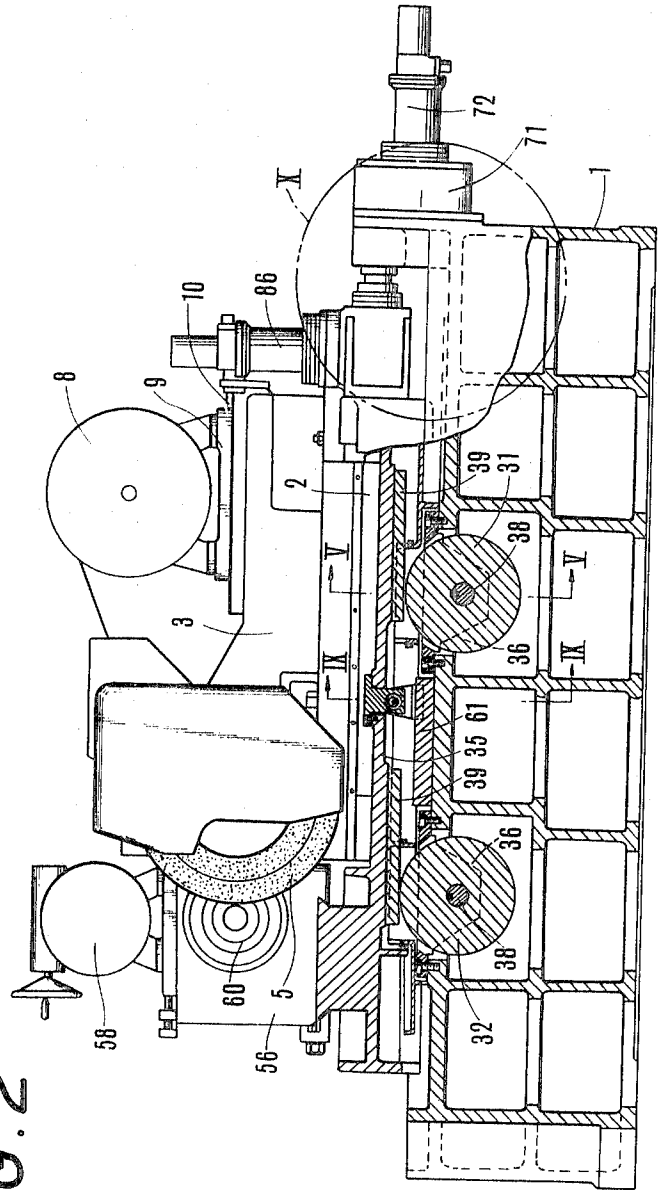

FIG. 2

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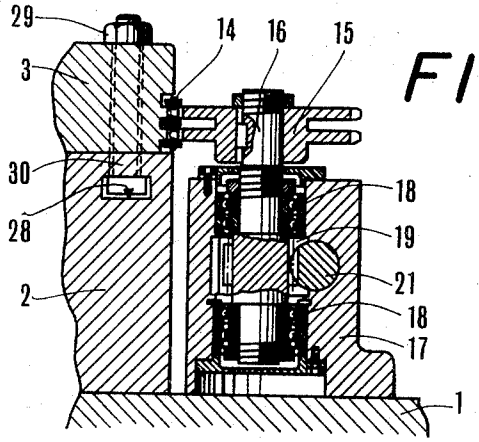

FIG. 3

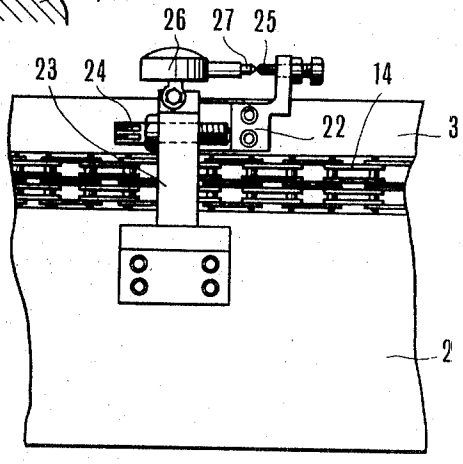

FIG. 4

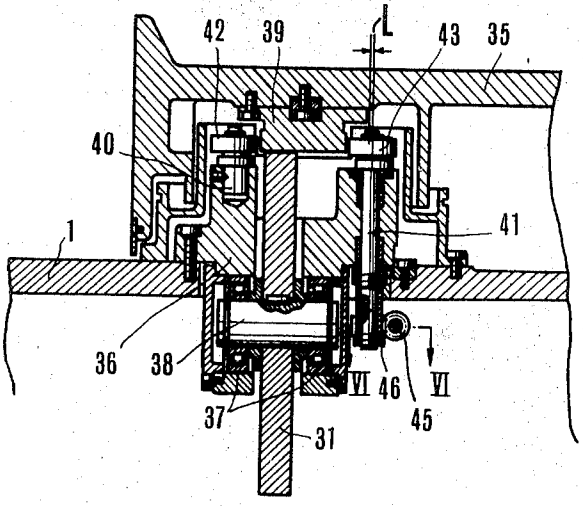

FIG. 5

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FIG. 7

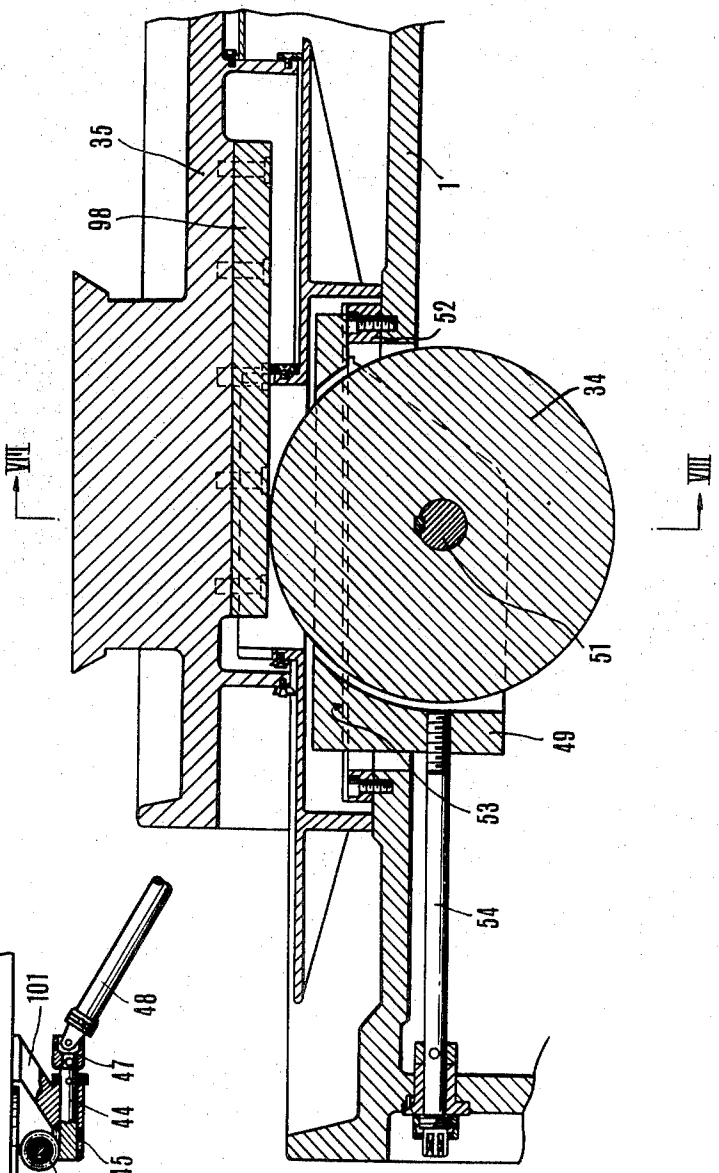
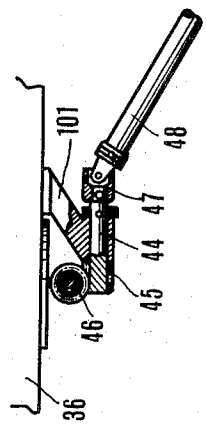


FIG. 6



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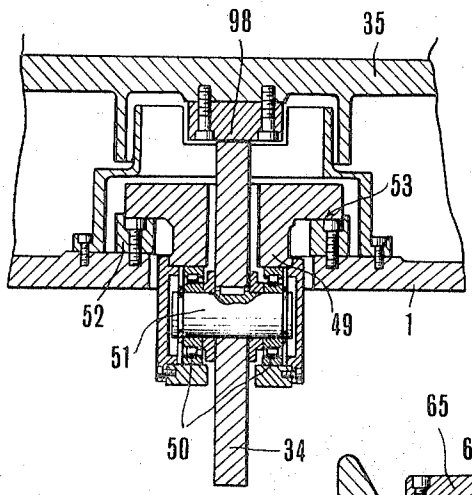

FIG. 8

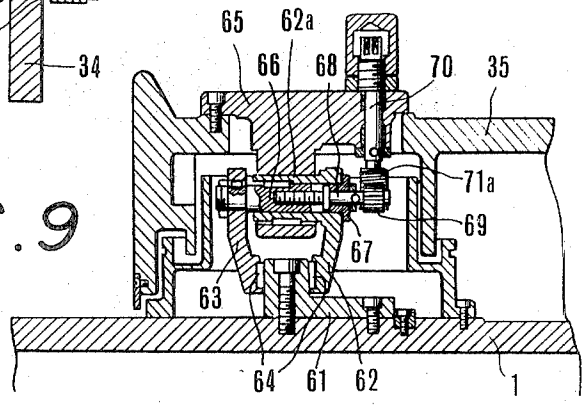

FIG. 9

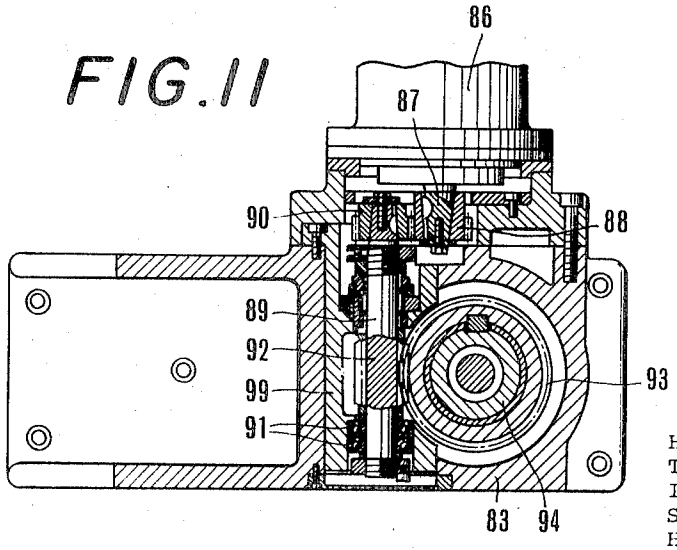

FIG. 11

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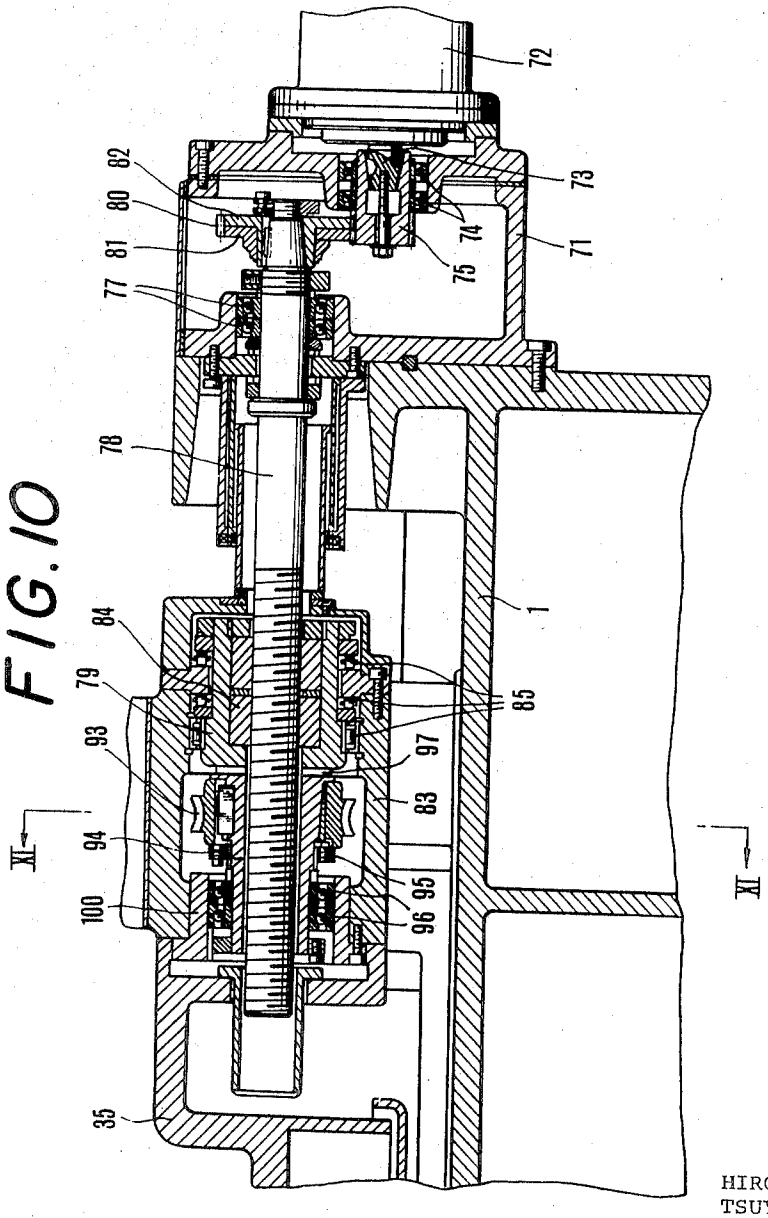
FIG. 10



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GRINDING MACHINES

BACKGROUND OF THE INVENTION

This invention relates to a grinding machine, more particularly to grinding machines operating at high speeds.

To improve the grinding efficiency of a grinding machine, the peripheral speed of the grinding wheel and the grinding speed thereof have been greatly increased in modern grinding machines. However, such high-speed grinding operations require driving motors of increased power, weight and dimensions. To reduce vibration of the large-size motor it is necessary to use a massive supporting base. In the prior grinding machine, the driving motor is fixed to the supporting base and the grinding wheelbase is fed by the motor to perform the grinding operation so that large weight or vibration of the driving motor affect the fine feeding of the grinding wheelbase or its accurate stopping thus decreasing the accuracy of the grinding operation. Further, in such a feed mechanism of the grinding wheelbase, since the grinding wheel is supported by its base in a cantilever fashion and since the feed shaft for the base extends substantially at the center thereof it is difficult to locate the feed shaft in a plane perpendicular to the axis of the grinding wheel and passing substantially the center of the width of the grinding wheel. For this reason, under an extremely large cutting resistance as in the high-speed grinding operation, such large cutting resistance applies a rotary moment to the grinding wheel base to render difficult smooth sliding movement of the base.

SUMMARY OF THE INVENTION

It is an object of this invention to provide an improved grinding machine capable of operating at high speeds without decreasing the working accuracy by the effect of vibration and weight of the driving motor.

According to this invention there is provided a grinding machine comprising a stationary bed, a motor-driven grinding wheel, a base for supporting the grinding wheel and secured to the bed, a table movably mounted on the bed, a headstock mounted on the table to support a workpiece, and a feed shaft for feeding the table toward the grinding wheel to grind the workpiece by the grinding wheel, the feed shaft being located in a plane perpendicular to the axis of the grinding wheel and passing through substantially the center of the width of the grinding wheel.

The base of the grinding wheel is pivotally mounted on the bed and the bed is formed with one or more arcuate groove to receive T-bolts secured to the base. This permit swinging motion of the bed to a position convenient for exchanging the grinding wheel.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a plan view of a grinding machine embodying this invention;

FIG. 2 is a sectional view taken along a line II—II in FIG. 1;

FIG. 3 is a partial sectional view taken along a line III—III in FIG. 1;

FIG. 4 is a partial side view as viewed in the direction of an arrow IV in FIG. 1;

FIG. 5 is a sectional view taken along a line V—V in FIG. 2;

FIG. 6 is a sectional view taken along a line VI—VI in FIG. 5;

FIG. 7 is a sectional view taken along a line VII—VII in FIG. 1;

FIG. 8 is a sectional view taken along a line VIII—VIII in FIG. 7;

FIG. 9 is a sectional view taken along a line IX—IX in FIG. 2;

FIG. 10 is an enlarged sectional view of the portions encircled by a circle X in FIG. 1 and;

FIG. 11 is a sectional view taken along a line XI—XI in FIG. 10.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The embodiment of the invention shown in FIG. 1 and 2 comprises a stationary bed 1 having a stationary base 2 thereon. A grinding wheelbase 3 is pivotally mounted on the stationary base 2 about a pivot shaft 4. A grinding wheel spindle 6 supporting a grinding wheel 5 at one end thereof is rotatably journaled by the grinding wheelbase 3 and on the outer end of spindle 6 is keyed a pulley 7. A motor base 9 supporting an electric motor 8 for driving the grinding wheel 5 is mounted on base 3 to be adjustable by means of an adjusting screw 10. The pulley 7 and a pulley 12 keyed to a motor shaft 11 are operatively connected by transmission belts 13. Thus, the motor 8 drives the grinding wheel 5 at a high speed through pulleys 7 and 12 and the belt 13. As shown in FIG. 1 and FIG. 3 a continuous chain 14 is mounted on the rear side of the base 3 to engage a sprocket wheel 15 keyed to one end of a shaft 16 which is rotatably supported by bearings 18, 18 in a bracket 17 secured to bed 1. Shaft 16 is provided with an integral pinion 19 meshing racked rod 21 connected to the piston rod (not shown) of a piston cylinder assembly 20. As shown in FIG. 4, a stop 22 is secured to the rear surface of base 3 to engage a bolt 24 threaded in a stop member 23 secured to the base 2. Upon operation of the piston cylinder assembly 20 the grinding wheel supporting base 3 is pivoted about pivot shaft 4 to a position not interfering with a headstock 58, a tailstock 57, and others during the grinding wheel exchanging operation. Moreover, it may be realized to operate the desired tapered grinding operation by means of pivotal movement of grinding wheelbase 3. This pivotal movement in one direction is limited by the stroke of the piston cylinder assembly 20 while that in the opposite direction is limited by the engagement of bolt 24 and stop 22. Further, an adjusting bolt 25 is threaded through stop 22 to engage a measuring member 27 of a dial gauge 26 secured to stop member 23 thereby providing fine adjustments of the pivoted position of the base 3. Arcuate T-shaped grooves 28, 28, 28 are formed on the surface of stationary base 2 about pivot shaft 4, as shown in FIG. 1, to receive heads of T-bolts 30 provided with nuts 29 and extending through base 3 as best shown in FIG. 3. Consequently, when nuts 29 are loosened base 3 can be rotated about pivot shaft 4 whereas when nuts 29 are tightened base 3 is fixedly secured to stationary base 2.

A table 35 (as shown in FIG. 1) is movably supported on the bed 1 by means of four supporting rollers 31, 32, 33 and 34. A headstock 56 rotatably supporting a work spindle 55, and a tailstock 57 are mounted on table 35. Headstock 56 supports an electric motor 58 with a reduction gearing, the rotary motion of motor 58 being transmitted to main shaft 55 through "X" transmission belts 59. A workpiece 60 is mounted on the front end of the work spindle 55 by means of a suitable chuck.

Beneath the central portion of table 35 are secured two supporting plates 39 which are supported by rollers 31 and 32. As shown in FIGS. 2 and 5 these rollers are keyed to shaft 38 rotatably journaled in bearings 37 in supporting brackets 36 secured to bed 1. Each supporting bracket 36 securely holds a vertical shaft 40 and rotatably supports a vertical shaft 41 and guide rollers 42 and 43 are rotatably mounted on the upper ends of shafts 40 and 41 as shown in FIG. 5. Each of the supporting plates 39 described above is interposed between guide rollers 42 and 43 to guide table 35 in the longitudinal direction of the supporting plates 39. Guide roller 43 is eccentrically mounted on shaft 41 by an amount "L" so that by rotating shaft 41 it is possible to adjust the clamping force applied to guide plate 39 by guide rollers 42 and 43. More particularly, a worm wheel 46 is keyed to one end of shaft 41 to mesh a worm 45 formed on a shaft 44 which is rotatably supported by a bracket 101 secured to the bracket 36 as best shown in FIG. 6. The other end of worm shaft 44 is connected to an operating shaft 48 through a universal joint 47, the opposite end of the operating shaft being operable from outside of bed 1 as shown in FIG. 1. Thus, by rotating operating shaft 48 it is possible to adjust to any desired value of the clamping force for the supporting plate exerted by guide rollers 42 and 43.

As shown in FIGS. 7 and 8 a supporting plate 98 is secured to the lower side of the table 35 on one side thereof and the supporting plate 98 is supported by supporting rollers 33 and 34 described above. Each of the supporting rollers is keyed to a shaft 51 rotatably supported by a sliding member 49 through bearings 50. The sliding member 49 is slidably mounted on sliding members 52 secured to bed 1; the guide surfaces 53 of sliding members 52 being longitudinally slightly inclined. Each of the sliding members 49 threadedly receives the inner end of an operating shaft 54 having an outer end operable from outside. Thus, by rotating these operating shafts slidable members 49 are reciprocated along inclined guide surfaces 53 of sliding members 52 whereby to adjust supporting rollers in the vertical direction to correct the inclination of the table 35.

As shown in FIGS. 2 and 9, a vibration-absorbing plate 61 having a letter "L" shaped cross section is secured on the upper surface of bed 1 along the sliding direction of table 35. The vertical legged portion of this vibration-absorbing plate 61 is clamped between a pair of arms 62 and 63 via vibration-absorbing members 64 made of Teflon (registered trademark), for example, thereby to absorb vibrations of table 35 during its sliding movement.

As shown in FIG. 9, arm 62 has a horizontal cylindrical portion 62*a* axially slidably received in a bore in a bracket 65 secured to table 35, while arm 63 is provided with a plunger 66 slidably received in said cylindrical portion 62*a*. A threaded rod 68 is received in a lid 67 of the cylindrical portion 62*a* of arm 62 such that it can rotate freely but can not move axially. The inner end of rod 68 is threaded in plunger 66 and the outer end carries a worm wheel 69 keyed thereto and meshing a worm 71*a* on shaft 70. Thus rotation of shaft 70 moves arms 62 and 63 towards and away each other to adjust the clamping force exerted upon vibration absorbing plate 61 thus effectively absorbing vibrations of the table 35 created at the time of its sliding movement.

To the rear side of bed 1, is provided a table feed mechanism (as shown in FIG. 2) which reciprocate table 35. More particularly, as shown in FIGS. 10 and 11, a gearbox 71 is secured to the rear side of bed 1 and an electrohydraulic pulse motor 72 is secured to the outside of gearbox 71. A gear 75 rotatably received in bearings 74 secured to gearbox 71 is keyed to the output shaft 73 of electrohydraulic pulse motor 72. Gear 75 meshes a gear 80 keyed to a feed shaft 78. Feed shaft 78 is rotatably mounted in bearings 77 in gearbox 71 in a plane perpendicular to the axis of the grinding wheel 5 and passing through substantially the center of the width of the grinding wheel. With this arrangement, the grinding resistance acts directly upon shaft 78 and does not apply any rotary moment to table 35. Further, feed shaft 78 is located on the line passing through the center of gravity of table 35. Gear 80 comprises two spur gears 81 and 82 which are impacted with a relative torque by suitable means (not shown) to eliminate the backlash of the gear. Another gearbox 83 is secured to the rear surface of table 35 and a nut housing member 79 is rotatably received in gearbox 83 through bearings 85. A feed nut 84 is solidly secured in nut housing member 79. Feed shaft 78 mates with feed nut 84 through a train of balls (not shown), said feed shaft 78, balls and feed nut 84 cooperate to constitute a ball screw device. As shown in FIG. 11 an electrohydraulic pulse motor 86 is secured to gearbox 83 and a worm 88 is keyed to an output shaft 87 of the electrohydraulic pulse motor 86. The worm 88 meshes a worm wheel 90 keyed to shaft 87 which is rotatably journaled by gearings 91 in a sleeve 97 inserted in gearbox 83. A worm 92 formed on worm shaft 89 meshes a worm wheel 93 which is keyed to a supporting sleeve 94 and is further held stationary by nuts 95. One end of sleeve 94 is rotatably mounted in bearings 96 in a sleeve 100 secured to gearbox 83 while the other end is connected with nut housing member 79 through coupling teeth 97. As shown in FIG. 10, feed shaft 78 freely extends through sleeve 94. As the electrohydraulic pulse motor 72 is energized by an electric pulse the rotation of pulse motor 72 is transmitted to feed shaft 78 through gears 75 and 80. At this time, since feed nut 84 is prevented from being rotated by worm 92 and worm wheel 93 table 35 will be fed forwardly at a high speed by the ball screw device comprising feed shaft 78, balls (not shown) and feed nut 84. After table 35 has been quickly advanced a predetermined distance electrohydraulic pulse motor 72 is deenergized to stop rotation of feed shaft 78. When an electric pulse is supplied to electrohydraulic pulse motor 86 the rotation thereof will be transmitted to feed nut 84 via gears 88, 90, worm shaft 89, worm 92, worm wheel 93 and sleeve 94 to apply the required grinding feed to table 35 through above-mentioned ball screw device to grind at high speed the workpiece 60 by grinding wheel 5.

As above described, according to this invention the base of a grinding wheel upon which a grinding wheel driving motor is mounted is fixedly secured on a massive bed and a table is supported on the bed such that the table is movable toward the axis of the grinding wheel thereby to advance the table for grinding operation. Accordingly, it is not necessary to feed the grinding wheel base supporting the massive and vibrating driving motor. In addition, different from the connectional design of feeding the grinding wheel base there is no fear of decreasing the working accuracy caused by the adverse effect of the weight and vibration of the grinding wheel driving motor upon fine feeding of the grinding wheel base and upon the accuracy of the stopping thereof. Instead of sliding the grinding wheel base as in the conventional design, according to this invention the table is constructed to be movable and the feed shaft for feeding the table is located in a plane perpendicular to the axis of the grinding wheel and passing through the center of the width of the grinding wheel so that even when a high grinding resistance produced at the time of high-speed working is applied on the table no rotary moment is applied to the table thus ensuring smooth sliding movement thereof.

While in the above-described embodiment as a table feed device was used a combination of a feed screw device and an electrohydraulic pulse motor it should be understood that this invention is by no means limited to this particular table feed device but any well known automatic or manual table feed device can also be used.

We claim:

1. A grinding machine comprising a stationary bed, a motor-driven grinding wheel, a base for supporting said grinding wheel and secured to said bed, a table movably mounted on said bed, a headstock mounted on said table to support a workpiece, and a feed shaft for feeding said table toward said grinding wheel to grind said workpiece by said grinding wheel, said feed shaft being located in a plane perpendicular to the axis of said grinding wheel and passing through substantially the center of the width of said grinding wheel.

2. A grinding machine comprising a stationary bed, a grinding wheel base secured to said bed and rotatably supports a grinding wheel, driving means for rotating said grinding wheel, a table movably supported on said bed, a headstock mounted on said table to rotatably support a work spindle, drive means for rotating said work spindle, a feed shaft for said table located in a plane perpendicular to the axis of said grinding wheel and passing through substantially the middle of the width of said grinding wheel, screw means to operatively couple said feed shaft to said table, feed means to drive said feed shaft, and guide means to guide said table in the axial direction of said feed shaft whereby to feed said table to grind a workpiece supported by said headstock.

3. The grinding machine according to claim 2 wherein said guide means comprises supporting rollers rotatably mounted on said bed in a plane perpendicular to the axis of said feed shaft and in parallel planes on both sides of said planes, and a supporting member on said table to engage at least the outer periphery of said supporting roller.

4. The grinding machine according to claim 1 which further comprises means for absorbing vibrations of said table, said means being located in planes parallel to the axis of said feed shaft.

5. The grinding machine according to claim 1 wherein said grinding wheel base is pivotally mounted on said stationary base about a pivot shaft and wherein there are provided an arcuate guide groove for guiding the pivotal movement of said grinding wheelbase and means to rotate said base about said pivot shaft.

6. The grinding machine according to claim 2, wherein said feed means for driving said shaft comprises electrohydraulic pulse motors mounted on said bed and said table for rapid feed motion and grinding feed motion respectively.

7. The grinding machine according to claim 5, wherein said means for rotating said grinding wheelbase comprises a piston cylinder assembly secured on said bed, a sprocket wheel connected to said piston cylinder assembly through gear mechanism, and a continuous chain mounted on said grinding wheelbase and engaged with said sprocket wheel, whereby said grinding wheelbase is pivoted about said pivot shaft by means of said piston cylinder assembly.

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