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Ota et al.

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[54] **GRINDING MACHINE**

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[51] **Int. Cl.** **B24b 51/00**

[58] **Field of Search** ..... 51/5 D, 165 R, 165.87, 51/165.88, 165.8

[56] **References Cited**

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[57] **ABSTRACT**

A grinding machine having a bed, workpiece supporting means, a wheel slide rotatably supporting a grinding wheel, a dresser for dressing the grinding wheel, and dresser feed means for feeding the dresser toward the grinding wheel by a predetermined dressing amount whenever a dressing operation is requested includes original position determination means having shiftable means supported on the wheel slide and movable together with the same, drive means serving to move the shiftable means by an amount corresponding to the predetermined dressing amount in a direction of retraction of the wheel slide whenever the dressing operation on the grinding wheel is performed, and means for detecting an original position of the wheel slide in co-operation with the shiftable means and generating a signal serving to stop the movement of the wheel slide, whereby the wheel slide can be accurately positioned at the original position thereof which must be varied in accordance with a reduction of the grinding wheel by dressing operations thereon.

11 Claims, 3 Drawing Figures

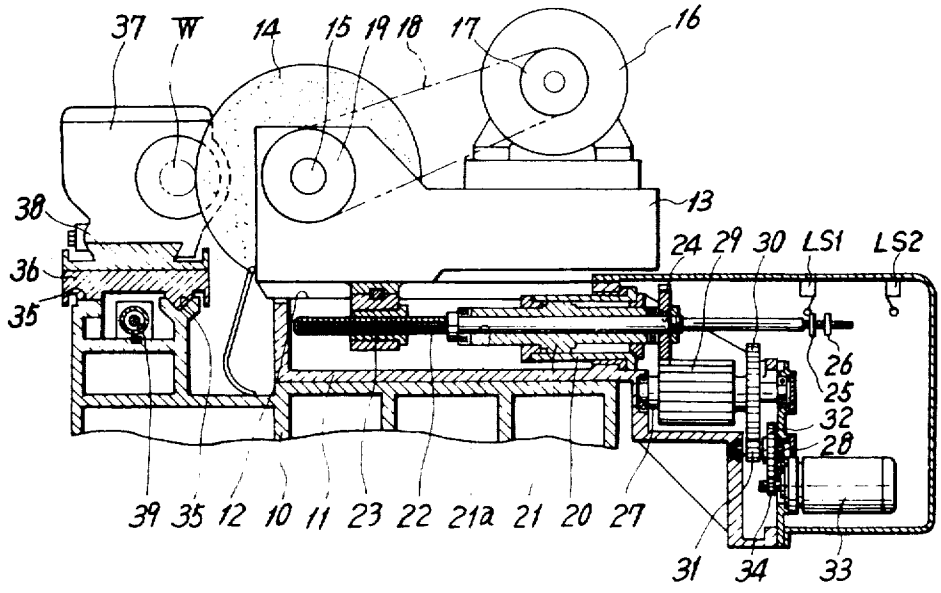

Fig. 1

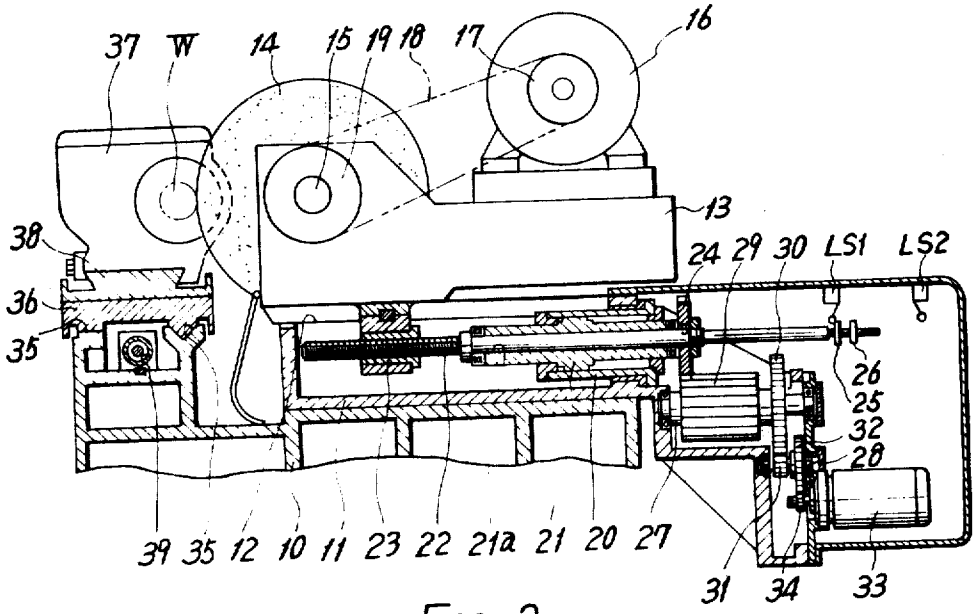
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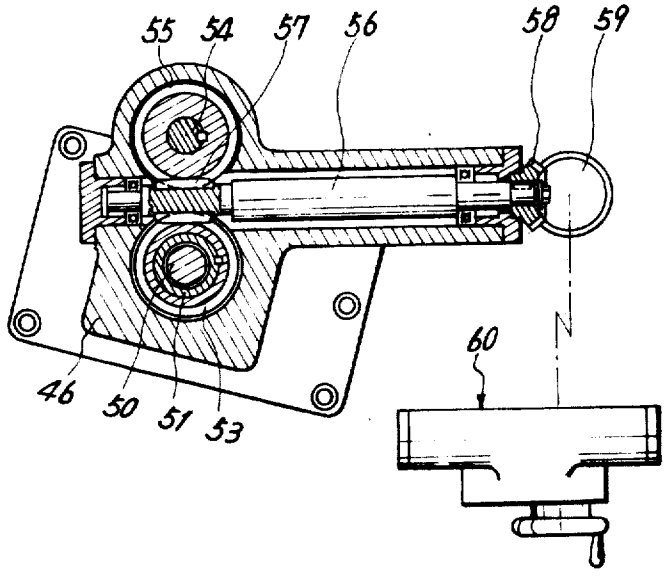
Fig. 3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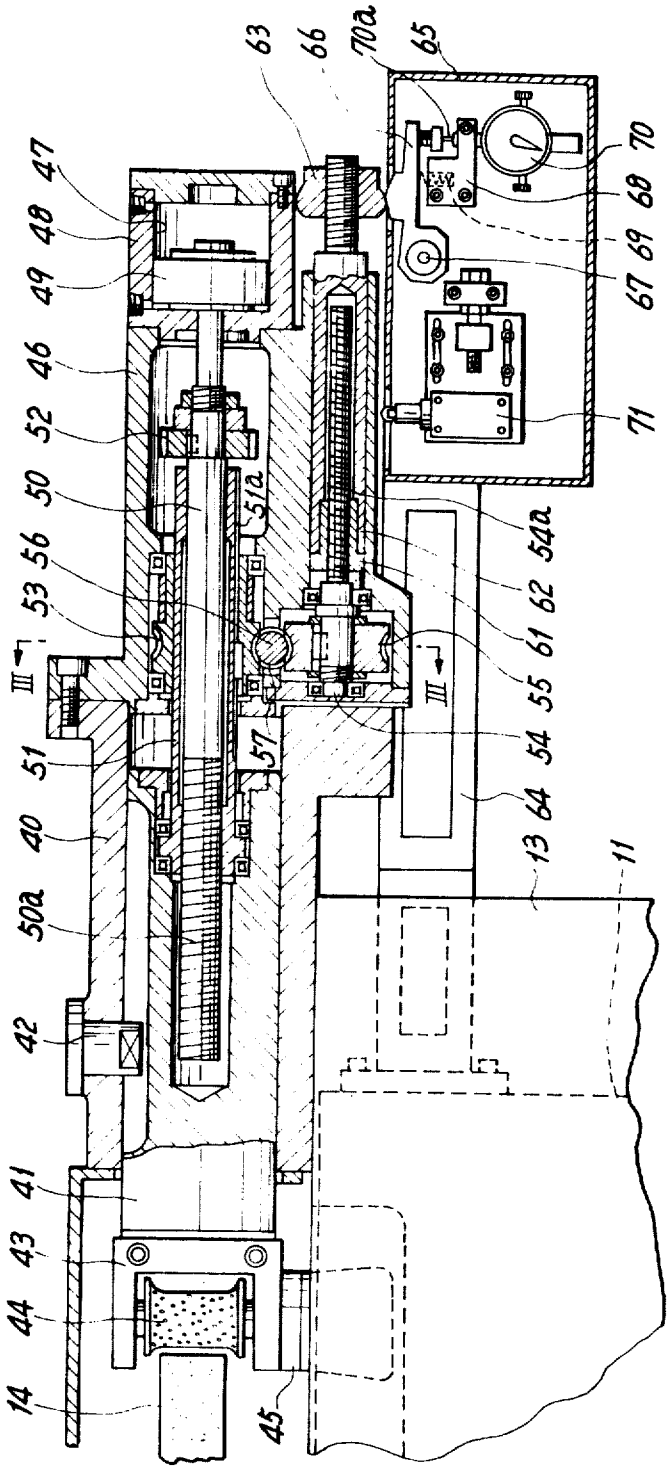
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Fig. 2

GRINDING MACHINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a grinding machine and more particularly to an improved grinding machine having an original position determination device.

2. Description of the Prior Art

In a conventional grinding machine, for example, in which the infeed of a wheel slide is numerically controlled by a stepping motor, there is a defect wherein it is vertually impossible to return the wheel slide to an original position which is varied in accordance with a reduction of the diameter of the grinding wheel through dressing or trueing operations thereon if the electric current is cut off or an emergency stop is performed in the course of a grinding operation because the content of a counter which records the amount of infeed of the wheel slide is cleared and a memory on energization of magnetic phase of a stepping motor drive unit is faded away.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved grinding machine having an original position determination device which is capable of memorizing the exact original position of the wheel slide or the grinding surface of the grinding wheel.

Another object of the present invention is the provision of an original position determination device which has a simple construction and is therefore capable of being easily produced at low cost.

The foregoing and other objects are obtained in accordance with one aspect of the present invention through the provision of a grinding machine having a bed; workpiece supporting means mounted on the bed; wheel slide means slidably mounted on the bed and rotatably supporting at least one grinding wheel rotated by a motor; wheel slide actuating means for moving the wheel slide means toward and away from the workpiece; grinding wheel dressing means being movable toward and away from the grinding wheel for dressing the same; dresser feed means for feeding the grinding wheel dressing means toward the grinding wheel by a predetermined dressing amount whenever a dressing operation on the grinding wheel is required; dresser actuating means for moving the grinding wheel dressing means so as to be able to perform a dressing operation on the grinding wheel; and original position determination means having shiftable means supported on the wheel slide means and movable together with the same, drive means serving to move the shiftable means by an amount corresponding to the predetermined dressing amount in a direction of retraction of the wheel slide means whenever the dressing operation on the grinding wheel is performed, and means for detecting an original position of the wheel slide means in co-operation with the shiftable means and generating a signal serving to stop the movement of the wheel slide means, whereby the wheel slide means can be accurately positioned at the original position thereof which must be varied in accordance with a reduction of the grinding wheel by dressing operations thereon.

BRIEF DESCRIPTION OF THE DRAWINGS

Various other objects, features and attendant advantages of the present invention will be more fully appreciated as the same becomes better understood from the following detailed description of a preferred embodiment of the present invention when considered in connection with the accompanying drawings in which:

FIG. 1 is a cross-section view of a feed mechanism of a grinding machine adopting the present invention;

FIG. 2 is a part view, partly in section, of a grinding machine embodying the subject matter of the present invention; and

FIG. 3 is a sectional view taken along the line III—III of FIG. 2.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the drawings, wherein like reference characters designate identical or corresponding parts throughout the several views, and more particularly to FIG. 1 thereof, a grinding machine is shown having a bed **10**, on which a stationary base **11** is fixedly mounted. A wheel slide **13** is slidably mounted on guide ways **12** which are formed on the upper surface of the base **11**. The wheel slide **13** rotatably supports a grinding wheel spindle **15** having a grinding wheel **14**, which spindle and grinding wheel are driven by a motor **16** through a belt **18** and pulleys **17, 19** respectively fixed on the motor **16** and the spindle **15**. Furthermore, a rapid feed cylinder **20** is fixedly mounted on the base **11**, and a piston **21** is slidably fitted in the cylinder **20**. Through a bore **21***a* formed in the piston **21**, a feed screw **22** is provided, which screw **22** is rotatable but is not movable in an axial direction thereof against the piston **21**. The screw **22** is threadedly engaged with a nut **23** fixed on the under surface of the wheel slide **13**. A gear **24** is securedly provided on an extension of the screw **22** which is extended out of the rear end of the piston **21** and on the end of the extension provided are dogs **25, 26** which cooperate with limit switches LS1, LS2, for respectively detecting an advanced end and a retracting end on the rapid feed movement. The gears **29, 30** are co-axially and fixedly mounted on a shaft **27** rotatably supported on the rear side of the base **11**. Moreover, the gears **31, 32** are securedly provided on a shaft **28** rotatably mounted on the same side of the base **11**. The gear **24** is engaged with the gear **29** and is slidable thereon. The gears **30** and **32** are respectively engaged with the gears **31** and **34**, which gear **34** is provided and secured on a drive shaft of a stepping motor **33**. On the above noted bed **10**, guide ways **35, 35** are formed in a direction perpendicular to the guide ways **12**, and a traverse table **36** is slidably guided thereon. A swivel table **38** supporting a work head **37** and a tail stock (not shown) is pivotally mounted on the traverse table **36**. The traverse table **36** can be moved or driven by a cylinder device **39** secured on the bed **10**. It is to be noted that a grinding wheel dressing device, which will be later described, is provided on the wheel slide **13**, and the grinding wheel **14** is dressed by the dresser through an infeed of a rotary dresser by a predetermined unit distance against a grinding surface of the grinding wheel. Thus, the compensation of the position of the wheel slide **13** is performed whenever the dressing operation on the grinding wheel **14** is performed, that is, the wheel slide **13** is compensated by the stepping motor **33** corresponding to a dressing amount before the start of a grinding operation whenever the dressing operation is performed. In

addition, an up-down counter is adopted for controlling the infeed amount of the wheel slide **13**.

Referring now to FIG. **2**, a rotary dressing device and an original position determination device are shown. The numeral **40** shows a base body of the rotary dressing device fixed on the wheel slide **13**, and in which base body a dresser supporting ram **41** is mounted and is slidable in an axial direction thereof against the grinding wheel **14**. The rotation of the ram is limited by the key **42**. On the front end of the ram **41**, a supporting member **43** is fixedly provided and rotatably supports a rotary dresser **44** which can be driven by a hydraulic motor **45** mounted on the supporting member **43**. On the rear end of the base body **40**, a gear box **40** is mounted and furthermore, a cylinder block **48** provided with a cylinder bore **47** is fixedly mounted on the rear end of the gear box **46**. The above noted cylinder is provided for a rapid advance of the dressing device. Moreover, a piston **49** slidably mounted on the cylinder bore **47** rotatably supports one end of a feed shaft **50**. A screw **50***a* formed on another end of the feed shaft **50** is engaged with a female screw formed in one end of a sleeve **51** which is rotatably supported in the ram **41** but which is not axially movable relative to the ram. The ram **41** supporting the rotary dresser **44** is, therefore, rapidly movable toward and away from the grinding wheel in accordance with the actuation of the cylinder mechanism **47, 48, 49** for the rapid feed movement.

A gear **52** is securedly mounted on the feed shaft **50** and is connected to a rack and piston mechanism (not shown in Figures) through a gear train having a worm gear and worm wheel (not shown). The gear **52** can be rotated in a clockwise and a counter clockwise direction by a predetermined amount in response to forwardly and backwardly reciprocal actuations of the rack and piston mechanism. In accordance with the rotation of the gear **52**, the feed shaft **50**, with the screw **50***a*, is rotated in a clockwise or counter clockwise direction and therefore, the ram **41** is moved in an axial direction thereof through the sleeve engaged with the screw **50***a*. It should be noted that the foregoing movement of ram **41** is performed after the rapid advance thereof by actuation of the cylinder mechanism **47, 48, 49**. Accordingly, the dresser **44** on the ram **41** can cut or dress the grinding wheel by a predetermined dressing amount or depth which was defined by an infeed means which will be later described. On the outer surface of the sleeve **51**, a recess **51***a* for a key engagement is formed in an axial direction thereof. A worm wheel **53** is provided coaxially to the sleeve and is rotatably mounted in the gear box **46**. The worm wheel **53** is connected with the sleeve **51** through the key and is axially movable relative to the sleeve **51**. Moreover, a rotary shaft **54** is rotatably mounted in the gear box **46** in parallel to the feed shaft **50** and a worm wheel **55** of the same dimensions as the worm wheel **53** is securedly mounted on the shaft **54**. As shown in FIGS. **2** and **3**, these worm wheels **53, 54** are engaged with a worm **57** which is formed on one end of a worm shaft **56** rotatably mounted in the gear box **46**. A bevel gear **58**, fixedly mounted on another end of the worm shaft **56**, is engaged with a bevel gear **59** which is connected to an infeed means **60** having an intermittent motion mechanism like a ratchet mechanism (not shown). It is to be noted that the infeed means **60** is usually actuated before the actuation of the rack piston mechanism serving to rotate the gear **52** and serves to rotate the worm shaft **56** by a predetermined value in each actuation thereof. By the rotation of the shaft **56** i.e., the worm **57**, both worm wheels **53, 55**. i.e., the sleeve **51** and the shaft **54** are synchronously rotated by a predetermined amount. Thus, the ram **41** with the dresser can be advanced by a predetermined small distance corresponding to a dressing amount or a grinding wheel removal previously to the infeed movement by the rotation of the gear **52**. In addition, the ram **41** is quickly reversed to a starting position thereof by driving the worm shaft **56** by a motor (not shown), when the grinding wheel **14** is reduced to a predetermined limit diameter and is, therefore, to be changed to a fresh one having a predetermined large diameter.

The shaft **54** is provided with a screw **54***a* which is extended in a direction of a retraction of the wheel slide **13**. The screw **54***a* is engaged with a nut **61** which is fixed on one end of a shaft **62** slidably mounted in the gear box **46**. The pitch of the screw **54***a* is formed on the same as that of the feed screw **50***a* on the feed shaft **50**, and therefore, the shaft **62** is shifted in a direction of retraction of the wheel slide **13** by a distance equal to the infeed amount of the ram **41**, that is, to the dressing amount in each dressing operation. It is to be noted that the wheel slide **13** is compensated by the stepping motor **33** in response to the dressing amount, as is above noted, because the number of pulses applied to the stepping motor are predetermined corresponding to the mechanical infeed amount given by the infeed means **60**. However, the shaft **62** can substantially be positioned at the original position thereof when the wheel slide **13** is existing at its nominal original position even if the position of the wheel slide **13** is compensated in response to the reduction of the grinding wheel diameter caused by the dressing operations, because the shaft **62** is backwardly shifted by a distance equal to the advancing distance by the compensation of the wheel slide position.

Another end of the shaft **62** is extended out of the gear box **46** and on this end, an original position indicating dog **63** is threadedly engaged and secured thereon, which dog serves to determine or detect the original position of the wheel slide or grinding wheel. Moreover, a supporting bracket **64** is secured on the rear end of the base **11** in a manner that the same **64** never prevents the retraction or backward movement of the wheel slide **13**. On the bracket **64**, a detecting box **65** is mounted. A lever **66** is rotatably pivoted by the pin **67** in the box **65**, and is urged upwardly by a spring **69** provided between the same **66** and a supporting block **68** secured in the box **65** so that the lever **66** can be engaged with the dog **63**. A position detector **70** is provided on the supporting block **68** and whenever the wheel slide **13** is positioned at the original position thereof, an original position detecting switch in the detector **70** is closed to actuate because a senser **70***a* of the detector **70** is depressed by the lever **66** which is engaged with the dog **63** and is therefore swung against the force of the spring **69**.

In addition, a limit switch **71** for safety is provided in the box **65** and serves to generate a signal for an emergency retraction of the wheel slide **13** when the dog **63** depresses the limit switch **71** in case of an excessive advance of the wheel slide on account of, for example, a problem in a sizing device adopted in the grinding operation. Furthermore, the detector **70** has a slow down switch for a reduction of speed of the stepping motor

33, which switch is closed by the dog 63 before the above noted original position detecting switch is closed. The slow down signal generated, therefore serves to reduce the speed of the stepping motor 33 at a front point slightly before the original position in the course of the rapid retraction of the wheel slide by the stepping motor, which retraction is needed after a stoppage of electric current or an emergency stop of the wheel slide.

As above noted, the original position indicating dog 63 on the shaft 62 is shifted backwardly relative to the wheel shaft 13 by a distance equal to the compensating amount of the wheel slide, i.e., the dressing amount whenever the dressing operation is performed and so, the dog 63 necessarily depresses the sensor 70*a* of the detector 70 and therefore the original position detecting switch is enabled to work whenever the wheel slide 13 is returned to the original position which is gradually changed. That is, the grinding surface of the grinding wheel is returned to the original position which is a fixed point. However, in the course of normal grinding cycles, the original position detecting signal generated from the detector 70 is not utilized because a reversible counter, in which the advanced distance of the wheel slide 13 is added up, serves to control the retraction movement of the wheel slide 13 so that the retraction is stopped when the content of the reversible counter is reduced to zero.

When the stoppage of electrical current or the emergency stop occurs and it is therefore necessary to return the wheel slide to the original position thereof because a memory on the present position of the wheel slide 13 is cleared, a push button (not shown) for the retraction is depressed. By this operation at first, the wheel slide is rapidly moved by the rapid feed cylinder 20 in FIG. 1. When the completion of the retraction of the piston 21 is detected by the limit switch LS2, the stepping motor 33 is driven in a counter clockwise direction and therefore the wheel slide 13 is continuously reversed at a rapid speed by the driving pulse. Thereafter, as the slow down switch in the detector 70 is closed through the actuation of the lever 66 and the senser 70*a* by the movement of the dog 63 in the course of the pulse driving rapid retraction, the detector 70 generates a signal for reducing the speed of the stopping motor 33. Subsequently, as the original position detecting switch in the detector 70 is closed by the actuation of the dog 63, the detector 70 generates an original position detecting signal for stopping the pulse distribution to the stepping motor 33 and therefore, the wheel slide 13 or the grinding wheel 14 can be returned to and positioned at the original position thereof which is mechanically memorized by the dog 63 and the detector 70 independently of the electric control circuit.

In accordance with the present invention, the wheel slide 13 can be automatically and accurately returned to the original position for a grinding infeed and, the idling time in the course of the grinding operations can be minimized.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims the inventin may be practiced otherwise than as specifically described herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A grinding machine comprising:
a bed;
workpiece supporting means mounted on said bed;
a wheel slide slidably mounted on said bed and rotatably supporting a grinding wheel driven by a motor thereon;
a hydraulic cylinder provided on said bed and serving to rapidly move said wheel slide toward and away from a workpiece on said workpiece supporting means;
a stepping motor mounted on said bed and serving to feed said wheel slide toward and away from the workpiece for grinding the same;
dressing means mounted on said wheel slide and being movable toward and away from said grinding wheel for dressing the same;
first feed means mounted on said wheel slide for feeding said dressing means toward said grinding wheel by a predetermined dressing amount whenever a dressing operation on said grinding wheel is performed;
second feed means mounted on said wheel slide for actuating said dressing means so as to perform a dressing operation on said grinding wheel;
said stepping motor further serving to move said wheel slide toward the workpiece by a distance corresponding to said predetermined dressing amount whenever the dressing operation is performed; and
original position determination means, having shiftable means slidably supported on said wheel slide, drive means connected to said first feed means for shifting said shiftable means by a distance corresponding to said predetermined dressing amount in a direction of retraction of said wheel slide whenever the dressing operation is performed, and detecting means mounted on said bed for detecting an original retracted position of said wheel side in cooperation with said shiftable means and generating a signal for serving to stop the retraction movement of said wheel slide when said wheel slide is retracted from said workpiece,
whereby said wheel slide can be accurately positioned at the original retracted position thereof which must be varied in accordance with a reduction of said grinding wheel caused by dressing operations thereon.

2. A grinding machine according to claim 1, further comprising switching means for selectively utilizing said signal serving to stop the movement of said wheel slide.

3. A grinding machine according to claim 1, wherein said shiftable means comprises a shaft which is driven by said drive means connected to said first feed means in a direction of the retraction of said wheel slide by a distance corresponding to said predetermined dressing amount whenever the dressing operation is performed, and a dog member adjustably mounted on one end of said shaft, said dog member co-operating with said detecting means for determining said original position of said wheel slide.

4. A grinding machine according to claim 1, wherein said first feed means comprises an intermittent motion mechanism for feeding said dressing means toward said grinding wheel by said predetermined dressing amount in each dressing operation.

5. A grinding machine according to claim 1, wherein said detecting means comprises first and second switches for respectively generating a signal serving to reduce the speed of said wheel slide and a stopping signal serving to stop said wheel slide, when the same reaches the original position thereof, in co-operation with said shiftable means.

6. A grinding machine according to claim 1, further comprising second detecting means for detecting an advancing end of said wheel slide in cooperation with said shiftable means.

7. A grinding machine according to claim 3, wherein said detecting means comprises a box mounted on said bed, a lever pivotally mounted on said box and being swingable by an engagement of the same with said dog member, and a detector fixedly mounted on said box and having a sensor contacting said lever.

8. A grinding machine according to claim 7, further comprising an adjustable member provided between said lever and said sensor for adjusting the distance therebetween.

9. A grinding machine according to claim 1, wherein said first feed means comprises an intermittent infeed mechanism, a worm connected to said intermittent infeed mechanism, a first worm wheel engaged with said worm, a first screw connected to said first worm wheel for feeding said dressing means in accordance with rotation of said first worm wheel, and said drive means comprises a second worm wheel engaged with said worm and second screw connected to and rotated by said second worm wheel, said second screw being engaged with said shiftable means for shifting the same in accordance with rotation of said feed screw.

10. A grinding machine according to claim 9, wherein said first and second worm wheels have the same diameter.

11. A grinding machine according to claim 10, wherein said first and second screws have the same thread pitch.

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