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SURFACE GRINDING MACHINES

Filed April 24, 1964 5 Sheets-Sheet 1

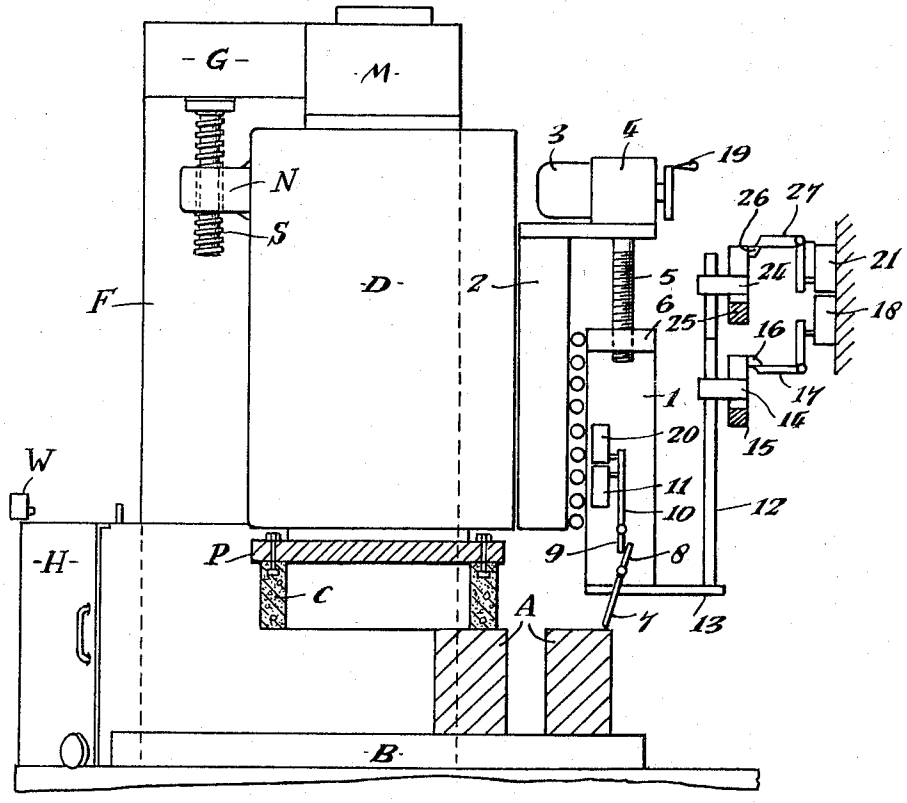


Fig. 1.

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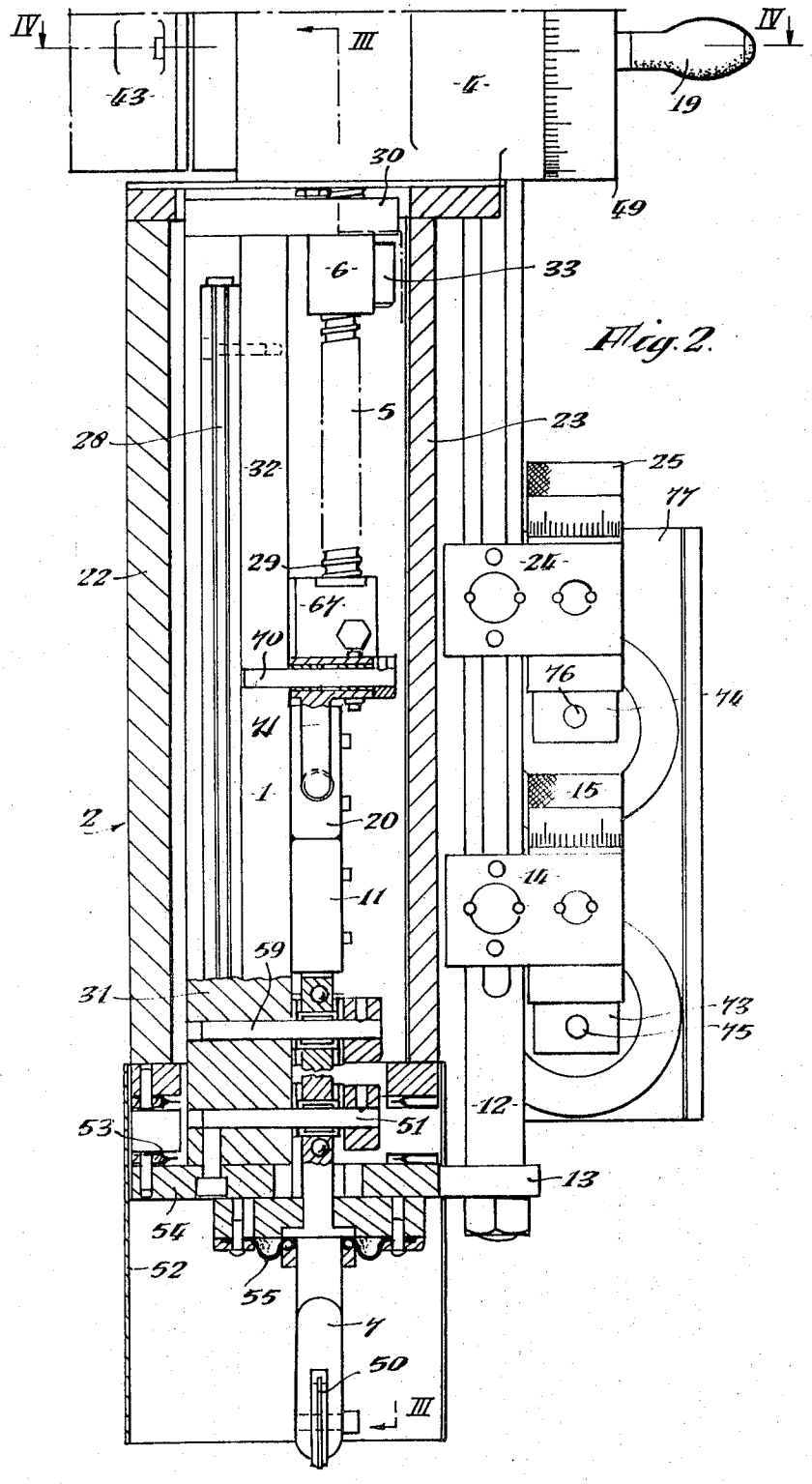


Fig. 2.

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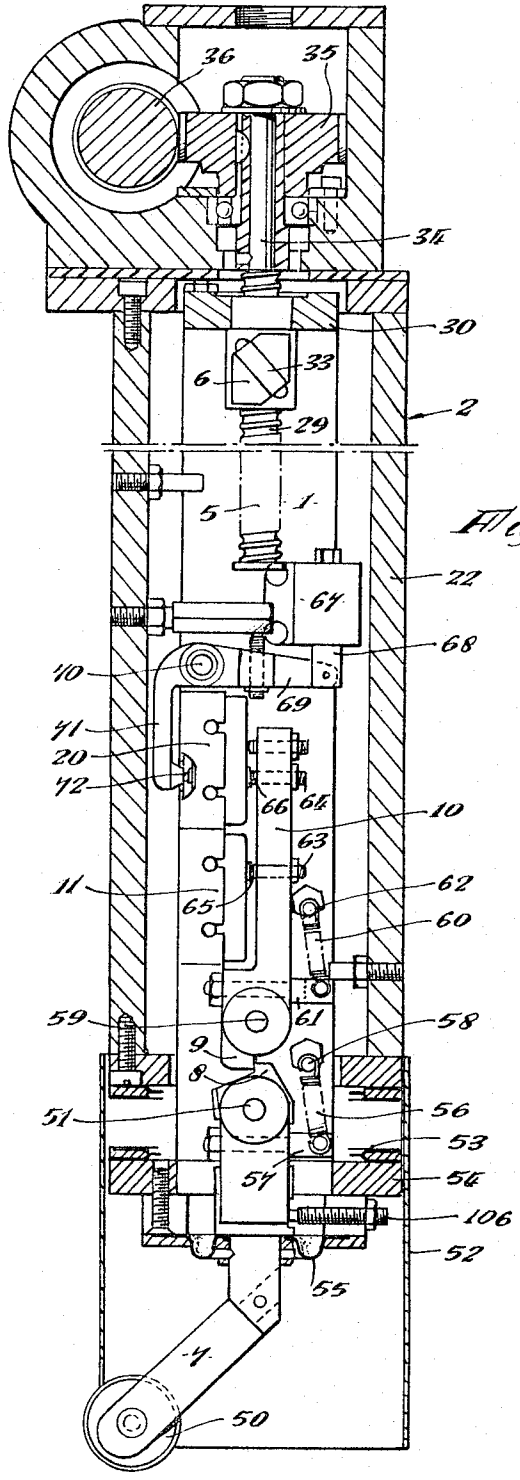


Fig. 3.

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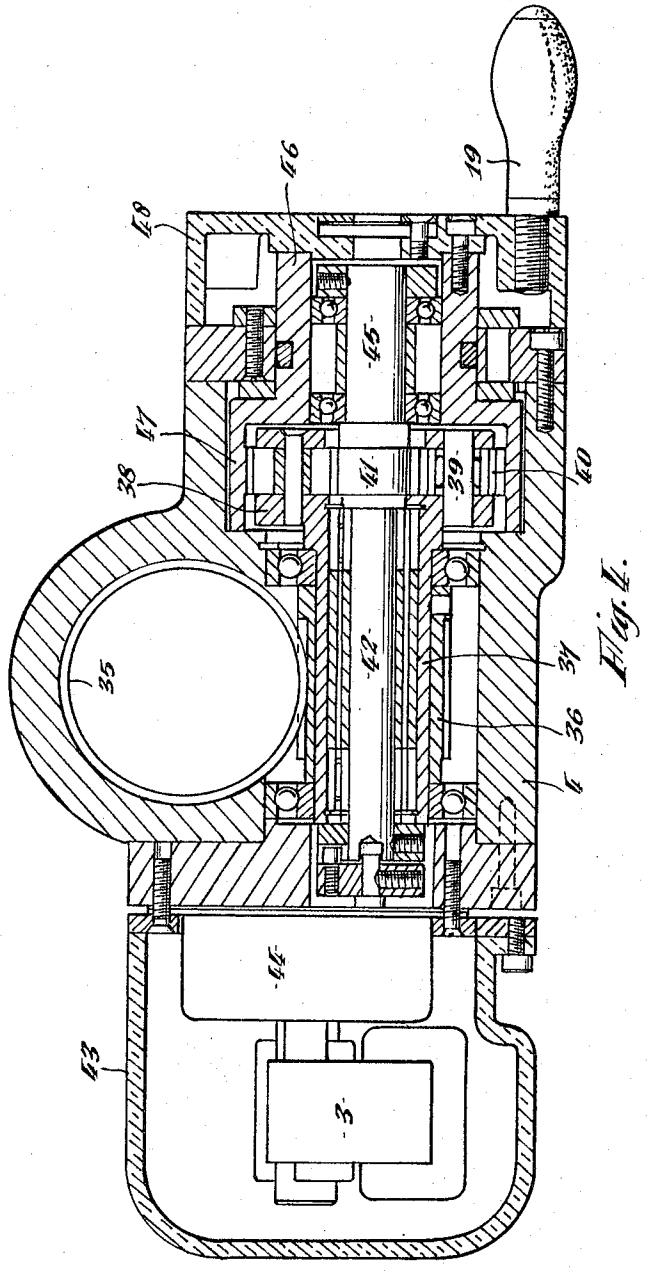


Fig. 4.

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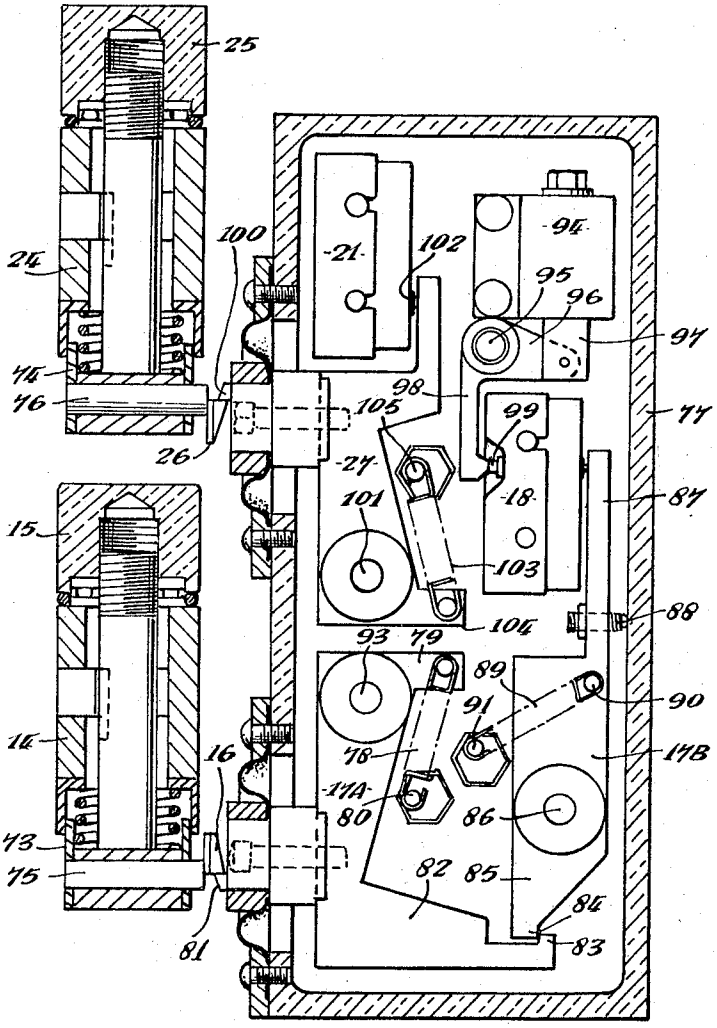


Fig. 5.

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3,305,978

SURFACE GRINDING MACHINES

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Claims priority, application Great Britain, Apr. 26, 1963, 16,525/63
15 Claims. (Cl. 51—165)

This invention relates to surface grinding machines and is to give automatic sizing of the work.

On this type of machine the table carrying the work continuously traverses the face of the grinding wheel, either by rotation or reciprocation, while the grinding wheel is fed into the surface of the work. A difficulty in automatically grinding to size is due to the uncertainty introduced by wear on the grinding wheel. It is a practice to provide a trip mechanism which stops the in-feed after the wheel has fed in a predetermined amount. The tripping point is set by the operator and adjusted for each successive table load with regard to the finished size of the work and the estimated amount of wheel wear, but the probable error in the estimate forbids the use of this trip for grinding to close tolerances.

The object of the invention is to provide automatic compensation for wheel wear, whereby the trip is constantly adjusted so that its operation is delayed in proportion with the extent of wear of the grinding wheel during the progress of the work.

The invention accordingly provides means for automatically terminating the feed of a grinding wheel of a surface grinding machine with regard to the progress of wear of the working surface of said wheel, when said working surface is at a predetermined distance from the work table, said means comprising a slideway fixed to the wheelhead, a slide displaceable in said slideway in the direction of movement of wheelhead, a probe pivotally mounted on said slide and projecting towards the work table, a magnifying lever engaged with said probe and displaceable when the probe engages a workpiece to actuate a switch, means for displacing said slide with respect to the slideway, a motor operable by said switch when actuated to move said displacing means to displace said slide away from work table, and a trip cam carried by said slide to be displaceable therewith, said trip cam serving to actuate a stop switch.

In the means stated, the effect of the probe, which may be arranged to trail over the workpiece or workpieces, is that as the working surface of the wheel wears away the probe is projected in advance of (or through the plane of) said working surface, and comes into contact with a workpiece, by which it is deflected. This deflection, which may be minute, causes or permits displacement of the magnifying lever so that the starter switch is actuated to move the slide and the probe carried thereby relative to the slideway and the wheelhead until the probe is withdrawn to the plane of the working surface of the wheel, which by its normal feed (.004–.040 inch per minute in a rotary table machine or .0005–.005 inch per stroke in a reciprocating table machine) is maintained constantly in abrading contact with the workpiece. At the same time, the trip cam carried by the slide is displaced to maintain a constant location relative to the wearing surface of the wheel, so that the wheel feed motor is stopped when the workpiece has been ground down to the required dimension precisely, and irrespective of the extent of wear of the wheel.

The trip cam may be mounted on a post carried by the slide, and comprise a body securable by clamping in a position of relatively coarse adjustment on said post, said body supporting with the aid of micrometer screw means a cam nose adapted to engage an actuator associated with the stop switch.

The foregoing and other features of the invention will be better understood from the following description with reference to the accompanying drawings, wherein FIG. 1 is a diagrammatic elevation which shows means according to the invention applied to vertical spindle, rotary table, grinding machine, so as to determine the finished size of workpieces A mounted on a table B to be operated on by a grinding wheel C secured as by bolts having their heads embedded in said wheel to a rotary faceplace P carried by the wheelhead D. This wheelhead is in known manner mounted, to be vertically displaceable towards and away from said table B, in a fixed column or frame F, by means diagrammatically indicated as a nut N fixed to the wheelhead D and a screw S rotatable through a gear box G from a motor M which also serves to rotate the grinding wheel C. Further, referring to the drawings:

FIG. 2 is a view, partly in elevation and partly in section, of a probe-carrying slide and associated means mounted on a slideway,

FIG. 3 is a transverse section on the line III—III of FIG. 2,

FIG. 4 is a horizontal section on the line IV—IV of FIG. 2, and

FIG. 5 shows an arrangement of wheelhead motor control switches and actuating means for the same.

In the arrangement shown diagrammatically in FIG. 1, a slide 1 is mounted on a slideway 2 secured to the wheelhead D, and is vertically displaceable relative to said slideway by a unidirectional motor 3 or by a handwheel 19, through differential reduction gearing 4 and screw and nut means 5, 6. The slide 1 carries a pivotally mounted probe 7 projecting from its lower end. The upper arm 8 of the probe engages a lower shorter arm 9 of a magnifying lever 10 adapted to actuate a switch 11, controlling the motor 3.

A post 12 is mounted on a bracket 13 secured to the slide 1, and a body 14 slideable on said post carriers micrometer screw adjusting means 15 for a trip cam 16. This trip cam is disposed to engage an actuator 17 for a switch 18 which when actuated stops the feed motor (not shown) for the wheelhead D.

For the purpose of setting the grinding wheel C is initially fed downwards, without being rotated, into contact with a gauge piece having the height of the finished work, and the handwheel 19 is rotated to move the slide 1, until the probe 7 engages the same gauge piece, whereupon the probe is displaced and permits the lever 10, which is resiliently biassed, to actuate switch 11, thereby starting the motor 3 which lifts slide 1 until the probe 7 is merely in touch with the gauge piece and withdraws lever 10 to release switch 11 and thereby stop motor 3. At this point, the cam nose 16 is adjusted to engage but not displace the actuator 17.

When in operation the wheel C is subsequently brought down into abrading engagement with the workpieces A, as its working surface is worn away so that its plane does not advance as fast as the tip of the probe 7, the latter comes into contact with the workpieces so as to be displaced thereby, and switch 11 is actuated to cause the motor 3 to raise the slide 1 until the probe is merely in touch with the work and withdraws the lever 10 to enable switch 11 to stop the motor 3. At the same time, trip nose 16 is raised so that its initial setting relative to the working surface of the wheel C is precisely restored. When the work surface is interrupted, as when several workpieces are mounted on the table as shown, switch 11 is repeatedly actuated and motor 3 runs intermittently until the probe merely touches the least reduced workpiece.

Eventually and regardless of wear of the grinding wheel, the working surface of the latter, and the tip of the probe, will be jointly brought down to the horizontal plane of the original gauge setting, whereupon the trip nose 16 will engage the actuator 17 to cause switch 18 to stop the wheel feed motor M.

The foregoing description refers to a simple combination of means comprising the invention. Further means contributing to more complete automatic control of a vertically rotary table surface grinding machine will now be described with further reference to FIGURE 1.

It is a common practice, in grinding machines of the kind last mentioned, to provide a hemi-cylindrical guard door H which is displaceable around its axis to cover the front of a cavity in the machine within which the rotary table B and the grinding wheel C are located. Closure of this door operates a switch W that automatically starts the table B rotating at fast or working speed, and starts downfeed of the wheelhead D at a fast "approach" rate. An addition switch 20 is provided on the slide 1, so as to be actuable by the lever 10, this switch being so connected into the control circuit that when the probe 7 first touches a workpiece (the probe having initially been adjusted to be slightly in advance of the working surface of the grinding wheel C) the downfeed of the wheelhead D is changed to the normal or grinding feed rate, as hereinbefore mentioned.

The grinding operation then continues as above described, under control of the probe 7 to compensate for wear of the grinding wheel, until the switch 18 is actuated by the trip cam 16 to stop the wheelhead feed. The circuit into which the switch 18 is connected is such that on the stoppage of the downfeed motor, the rate of rotation of the table B is changed from fast to slow speed, there is a timed pause for "spark-out," the wheelhead is then raised by a pre-set distance, and the table is stopped ready for unloading and the placing thereon of further workpieces to be ground. Said distance by which the wheelhead is raised, the slide 1 being of course raised therewith, is determined by a switch 21 having an actuator 27 which is engaged by a second trip cam 26 mounted on a second micrometric device 25 carried by a second body 24 slidably adjustable on the post 12.

As shown in FIG. 1, both the trip cams 16 and 26 are shown in the positions of adjustment in contact with (but not displacing) the actuators 17 and 27, whereas in practice they will be so adjusted that one of the trip cams will always be spaced from the associated actuator when the other cam contacts the actuator associated with it.

One mode of practical embodiment of the means according to the invention is illustrated, by way of example in further detail in FIGS. 2–5, and will now be described with reference to said figures (wherein parts equivalent to those indicated in FIG. 1 have the same reference numerals).

The slideway 2, which comprises a channel section member 22 with a cover 23, within which the slide 1 is mounted on a pair of linear bearings 28. The slideway is mounted in any suitable manner for vertical displacement with the wheelhead D (FIG. 1). The slide 1 comprises a T-section element of which the shank web 31 is located between said bearings 28, and the table web 32 carries operating means. At its upper end the slide 1 has a transverse plate 30 beneath which is secured a nut 6 of the kind enclosing a series of contiguous balls for engaging in the helical, semi-circular groove 29 of the vertical lead screw 5. The nut 6 is of a conventional type having an internal helical groove from end to end of which the balls circulate in contact with the screw 5, returning by way of an external bypass 33.

The screw 5 has an upward extension 34 on which is secured a spiral gear wheel 35, in mesh with a driving spiral gear 36 mounted in the gear box 4, which is secured on top of the slideway 2. Said driving spiral gear 36 is

secured, as shown in FIG. 4, to a sleeve 37 having at one end a flange 38 forming part of a planet cage of a differential gear. This cage supports, by means of dowels 39, a plurality of planet pinions 40, in mesh with a sun pinion 41 secured on a horizontal shaft 42. At one end of the gear box 4 there is located within a cover 43, a slow-speed electric motor 3, adapted to drive the shaft 42 through a reduction gearing 44. The sleeve 37 is mounted for rotation about and relative to said shaft 42, and the latter has, beyond the sun pinion 41, a projection 45 on which is mounted for relative rotation a sleeve 46 carrying an internally toothed orbit gear wheel 47 in mesh with the planet pinions 40. Said sleeve 46 has secured to it a member 48 with a cylindrical periphery bearing a circular scale 49 (FIG. 2) and the handle 19 is secured in said member 48. The ratios of the sun-and-planet gear are such that when the orbit gear 47 is immobile, shaft 42 drives the spiral gear 36 with a ratio of ¼, while when the shaft 42 is stationary, the spiral gear 36 is rotatable by the handle 19 with a ratio of ¾.

Referring now to FIGS. 2 and 3, the probe 7, carrying at the end of its lower arm a wheel 50 for engaging the workpieces, is pivotally mounted on a spindle 51 secured in the lower end part of the slide 1. The probe is protected by a sleeve 52 mounted at the lower end of the slideway 2, and said lower end is closed by a bellows 53 fastened between said end and a plate 54 on the lower end of the slide 1, which plate has an aperture through which the probe 7 extends, and said aperture closed by a flexible diaphragm 55. The short arm 8 of the probe 7 is biassed into engagement with the short arm 9 of the lever 10 by a spring 56 anchored between a stud 57 on the probe and a fixed pin 58, said spring holding the probe against a stop 106.

The lever 10 is pivotally mounted on a spindle 59 also carried by the slide 1, and is biassed by a spring 60 anchored between a stud 61 on said lever and a fixed pin 62. The effect of spring 60 is to hold the short arm 9 of said lever 10 in engagement with the short arm 8 of the probe, and the lever 10 so that two adjustable studs 63 and 64 therein are in contact with plungers 65 and 66 of microswitches 11 and 20. Switch 11 is of the normally open type, and its plunger is depressed by the lever 10 when the probe is displaced on contact with a workpiece, lever 10 being then caused by spring 60 to move slightly anticlockwise (as seen in FIG. 3) and by depressing the plunger 65 to close switch 11, and energise the motor 3. Thereby the slide 1 is raised and the probe is lifted until it is merely touching the workpieces, whereupon the lever 10 is caused again to release plunger 65, opening switch 11 and causing the motor 3 to stop.

Switch 20, that serves to change the downfeed of the wheelhead from approach rate to grinding rate when the probe 7 first comes into contact with workpieces upon which grinding is to be commenced, is a switch of the maintained contact type.

The plunger of this switch remains depressed until the switch is reset by a solenoid 67, the armature 68 of which is articulated to one arm 69 of a crank lever pivoted on a spindle 70, the other arm 71 of said lever bearing upon a second plunger 72 in the switch 20. The solenoid 67 is arranged to be energised when switch 18 is actuated, and de-energised when switch 21 is actuated.

As also shown in FIG. 2, the plate 54 secured to the lower end of the slide 1 has a projection constituting the aforesaid bracket 13, upon which is mounted the vertical post 12. Upon this post there are mounted slidably, and securable in positions of relatively coarse adjustment thereon, first and second bodies 14 and 24, which carry respectively elements 73 and 74, wherein are mounted shanks 75 and 76 of trip cams, and micrometric screw devices 15 and 25 for fine adjustment of said cams. These means are also illustrated in FIG. 5, together with switch means actuable thereby.

As shown in FIG. 5, there is mounted adjacent to the post 12 a switch box 77. In this box there are mounted the switches 18 and 21, and their actuators 17A, 17B and 27. The actuator 17A is an L-form lever, pivoted on a spindle 93 and biassed by a spring 78, anchored between a short serif arm 79 on said lever and a fixed pin 80, which spring causes a nose 81 on the shank of the lever to project into the vertical path of trip cam 16 carried by the body 14. The foot portion 82 of actuator 17A has an upstanding toe 82 which serves as a hook detent for a nose 84 on a shorter arm 85 of actuator 17B pivoted on a spindle 86 so as to hold the longer arm 87 of said actuator 17B with an adjustable stop 88 therein pressed against the side wall of the casing 77. A biasing spring 89, anchored between a pin 90 on the arm 87 and a fixed pin 91, causes the nose 84 to bear against the toe 83 of lever 17A. Thus, when the nose on actuator 17A is depressed by trip cam 16 (upon the grinding wheel C reaching the limit of its grinding operation as determined by the pre-setting of said cam and adjustments thereof made by any operation of the probe 7 to vary the position of slide 1, post 12 and body 14 carried by said post, during the grinding operation) actuator 17A is displaced against the tension of the spring and the movement of toe 83 permits the spring 89 to displace actuator 17B so that the arm 87 thereof depresses the plunger 92 of switch 18. Actuation of the switch 18 stops downward feeding of the wheelhead D, and sets in train control operations including reduction of the rotation rate of table B, raising of the wheelhead and therewith the body 14, and stopping of said table as hereinbefore referred to.

Said raising of the wheelhead is accompanied by raising of the slide 1 and therewith the trip cam 16 from engagement with the actuator nose 81, so that the actuator 17A resumes its position as illustrated in FIG. 5. The switch 18 is of the maintained contact type, and the associated electric circuit includes a solenoid 94 which is energised to reset the switch, so that the actuator 17B is restored to its position as indicated. The resetting is effected by a crank lever pivoted on a spindle 95 and having one arm 96 articulated to the solenoid armature 97 and its other arm 98 disposed to bear on a second plunger 99 of the switch 18.

The raising of the wheelhead D is limited by switch 21 also included in the switch box 77 as shown in FIG. 5, said switch 21 being actuated as will be described by trip cam 26 engaging a nose 100 projected into its path by the actuator 27. As shown in FIG. 5, both the trip cams 16 and 26 are in contact with the respective actuator noses 81 and 100, but in practice, when either is in contact, the other will be spaced a little apart from its respective actuator nose. Of course, the actual displacement of the wheelhead is small, since it is normally not required to remove any substantial depth of metal by grinding, and the table B can be unloaded and reloaded with workpieces A over successive areas of said table which are not immediately beneath the grinding wheel C.

The actuator 27 for switch 21 is pivoted on a spindle 101 and biassed to depress the plunger 102 of said switch by a spring 103 anchored between a short arm 104 of said actuator and a fixed pin 105. The switch 21 is of the "normal open" type (that is, open when its plunger is not depressed). When the nose 100 is engaged by trip cam 26 and the actuator 27 is turned, against the tension of spring 103, to release the plunger 102, switch 21 is permitted to open, and the circuit of the wheelhead motor M, previously set by switch 18 to effect operations including raising of the wheelhead, is likewise opened to stop said motor M at the limit of raising determined by the fine presetting of the trip cam 26.

The whole machine, including its electrical circuits are now in condition, on completion of reloading of the table and subsequent reclosing of the guard door, to recommence operation as hereinbefore described. A first effect of lowering of the wheelhead is to displace the trip cam 26 from the actuator nose 100, thereby permitting reclosing of switch 21. It is also not required after each operation to reset the trip cam 16, since the probe 7 will have been kept adjusted to the plane of the wearing face of the grinding wheel C. Such resetting of the trip cams 16 and 26 is required only when the slide 1 carrying the probe 7 has been raised, relative to the slideway 2 and wheelhead D, to the limit of its displacement, at which time it is usually necessary also to replace the worn grinding wheel C.

What I claim and desire to secure by Letters Patent is:

1. In a surface grinding machine comprising a work table, a fixed column, a wheelhead mounted in said column and displaceable towards and away from said work table, a motor, feed means associated with said motor for displacing said wheelhead, and a grinding wheel mounted in said wheelhead, the combination of means for automatically terminating the feed displacement of said wheelhead towards said work table, with regard to the progress of wear of the working surface of said grinding wheel, when said working surface is at a predetermined distance from the work table, said means comprising a slideway fixed to the wheelhead, a slide displaceable in said slideway in the direction of movement of the wheelhead, a probe pivotally mounted on said slide and projecting towards the work table, a magnifying lever engaged with said probe and displaceable when the probe engages a workpiece, a control switch actuable by said magnifying lever, means for displacing said slide with respect to the slideway, an auxiliary motor operable by said control switch when actuated to move said displacing means to displace said slide away from said work table, a feed stop switch in circuit with said motor, and a trip cam carried by said slide to be displaceable therewith, said trip cam serving to actuate said feed stop switch.

2. Means according to claim 1, wherein the probe is arranged to trail over a workpiece or workpieces mounted on said work table, so that as the working surface of the wheel wears away the probe is projected in advance of said working surface and comes into contact with a workpiece, by which it is deflected.

3. Means according to claim 1, further comprising a post carried by said slide, a body securable by clamping in a position of relatively coarse adjustment on said post, micrometer screw means supported by said body, and a trip cam nose supported for fine adjustment by said screw means.

4. Means according to claim 1, further comprising a differential gear means, an element in said gear means connected with said auxiliary motor, a manually operable rotary member connected with another element in said gear means, and a driving member of said slide displacing means connected with a third element in said gear means.

5. Means according to claim 4, wherein said differential gear means comprises a shaft connected with said auxiliary motor, a sun pinion secured to said shaft, a sleeve rotatable upon and relative to said shaft, means secured to said sleeve constituting a planetary cage, planet pinions mounted in said cage and in mesh with said sun wheel, an internally toothed orbit gear member surrounding and in mesh with said planet pinions, said orbit gear member being secured to said manually operable member, and a driving gear element of said displacing means secured to said sleeve.

6. In a surface grinding machine comprising a work table, a fixed column, a wheelhead mounted in said column and displaceable towards and away from said work table, a motor, feed means associated with said motor for displacing said wheelhead, and a grinding wheel mounted in said wheelhead, the combination of means for automatically terminating the feed displacement of

said wheelhead towards said work table, with regard to the progress of wear of the working surface of said grinding wheel, when said working surface is at a predetermined distance from the work table, said means comprising a slideway constituted by a channel member fixed to the wheelhead, linear bearing means within said channel, a slide displaceable in said bearing means in the direction of movement of the wheelhead, a cover for the open side of said channel, a plate at an end of said channel, a probe pivotally mounted in said plate and projecting towards the work table, a magnifying lever mounted in said channel member to be engaged with said probe and displaceable when the probe engages a workpiece, a control switch actuable by said magnifying lever, means for displacing said slide with respect to the slideway, an expansible bellows closing the peripheral space between said plate and the adjacent end of said covered channel, an auxiliary motor operable by said control switch when actuated to move said displacing means to displace said slide away from said work table, a feed stop switch in circuit with said motor, and a trip cam carried by said slide to be displaceable therewith, said trip cam serving to actuate said feed stop switch.

7. Means according to claim 6, further comprising a bracket projection on said plate, a post mounted in said projection, a body securable by clamping in a position of relatively coarse adjustment on said post, micrometer screw means supported by said body, and a trip cam nose supported for fine adjustment by said screw means.

8. Means according to claim 6, further comprising a nut secured to said slide, a displacing screw engaged in said nut and rotatably mounted in the end of said channel member remote from said probe, a driven gear wheel secured to said screw, a differential gear means, one element in said gear means connected with said auxiliary motor, a manually operable rotary member connected with another element in said gear means, and a driving gear wheel in mesh with said driven gear wheel and connected with a third element in said differential gear means.

9. In a surface grinding machine comprising a work table, a fixed column, a wheelhead mounted in and axially displaceable relative to said column, a motor and feed means associated with said motor for displacing said wheelhead towards and away from said work table, and a grinding wheel mounted in said wheelhead, the combination of means for automatically terminating the feed displacement of said wheelhead, with regard to the progress of wear of the working surface of said grinding wheel, when said working surface is at a predetermined distance from the work table, said means comprising a slideway fixed to the wheelhead, a slide displaceable in said slideway in the direction of movement of the wheelhead, a probe pivotally mounted on said slide and projecting towards the work table, a magnifying lever engaged with said probe and displaceable when the probe engages a workpiece, a first switch actuable by said magnifying lever, means for displacing said slide with respect to the slideway, an auxiliary motor operable by said first switch when actuated to move said displacing means to displace said slide away from said work table, a second switch actuable by said magnifying lever, means operable by said second switch when actuated to limit the displacement of said wheelhead to a grinding feed rate, said second switch being automatically resetting after actuation thereof, a third, feed stop switch in circuit with said motor, and a trip cam carried by said slide to be displaceable therewith, said trip cam serving to actuate said third switch to stop said feed.

10. Means according to claim 9, further comprising a differential gear means, an element in said gear means connected with said auxiliary motor, a manually operable rotary member connected with another element in said gear means, and a driving member of said slide displacing means connected with a third element in said gear means.

11. In a surface grinding machine comprising a work table, a fixed column, a wheelhead mounted in and axially displaceable relative to said column, a motor and feed means associated with said motor for displacing said wheelhead towards and away from said work table, and a grinding wheel mounted in said wheelhead, the combination of means for automatically terminating the feed displacement of said wheelhead, with regard to the progress of wear of the working surface of said grinding wheel, when said working surface is at a predetermined distance from the work table, said means comprising a slideway fixed to the wheelhead, a slide displaceable in said slideway in the direction of movement of the wheelhead, a probe pivotally mounted on said slide and projecting towards the work table, a magnifying lever engaged with said probe and displaceable when the probe engages a workpiece, a control switch actuable by said magnifying lever, means for displacing said slide with respect to the slideway, an auxiliary motor operable by said control switch when actuated to move said displacing means to displace said slide away from said work table, a first switch in circuit with said motor, when operative to displace said wheelhead towards the work table at a grinding feed rate, a second stop switch in circuit with said motor when operative to displace said wheelhead away from the work table, first and second trip cams carried by said slide to be displaceable therewith, said first trip cam serving to actuate said first stop switch and said second trip cam serving to actuate said second stop switch.

12. Means according to claim 11, further comprising a nut secured to said slide, a displacing screw engaged in said nut and rotatably mounted in the end of said channel member remote from said probe, a driven gear wheel secured to said screw, a differential gear means, one element in said gear means connected with said auxiliary motor, a manually operable rotary member connected with another element in said gear means, and a driving gear wheel in mesh with said driven gear wheel and connected with a third element in said differential gear means.

13. Means according to claim 11, further comprising a channel member as a component of said slideway, linear bearing means within said channel, said slide being displaceable in said bearing means, a cover for the open side of said channel member, a plate wherein said probe is mounted at an end of said channel, a bracket projection on said plate, a post mounted in said projection, first and second bodies securable in positions of relatively coarse adjustment on said post, two micrometer screw means supported one by each of said bodies, and said first and second trip cams supported for fine adjustment each by one of said micrometer screw means.

14. In a surface grinding machine comprising a work table, a fixed column, a wheelhead mounted in and axially displaceable relative to said column, a motor and feed means associated with said motor for displacing said wheelhead towards and away from said work table, and a grinding wheel mounted in said wheelhead, the combination of means for automatically terminating the feed displacement of said wheelhead, with regard to the progress of wear of the working surface of said grinding wheel, when said working surface is at a predetermined distance from the work table, said means comprising a slideway fixed to the wheelhead, a slide displaceable in said slideway in the direction of movement of the wheelhead, a probe pivotally mounted on said slide and projecting towards the work table, a magnifying lever engaged with said probe and displaceable when the probe engages a workpiece, a first switch actuable by said magnifying lever, means for displacing said slide with respect to the slideway, an auxiliary motor operable by said first switch when actuated to move said displacing means to displace said slide away from said work table, a second switch actuable by said magnifying lever, means operable by said second switch when actuated to limit the dis-

placement of said wheelhead to a grinding feed rate, said second switch being automatically resetting after actuation thereof, a third stop switch in circuit with said motor when operative to displace said wheelhead at said grinding feed rate, a fourth, stop switch in circuit with said feed motor when operative to displace said wheelhead away from the worktable, first and second trip cams carried by said slide to be displaceable therewith, said first trip cam serving to actuate said third switch to stop said displacement of the wheelhead at said grinding feed rate, and said second trip cam serving to actuate said fourth switch to stop said motor.

15. Means according to claim **14**, further comprising a bracket projection on said slide, a post mounted in said projection, first and second bodies securable in positions of relatively coarse adjustment on said post, two micrometer screw means supported one by each of said bodies, and said first and second trip cams supported for fine adjustment each by one of said micrometer screw means.

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