3,494,079
APPROACH CONTROL FOR GRINDING MACHINES
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Filed July 10, 1967, Ser. No. 654,032
Int. Cl. B24B 49/02
U.S. Cl. 51—165
7 Claims

ABSTRACT OF THE DISCLOSURE

For automatically reducing the rate of advance of a grinding wheel toward a work roll when the periphery of the wheel is a predetermined distance short of the roll, a roll-feeler projecting in front of the wheel periphery engages the roll ahead of the wheel to detect the diameter and location of the roll, shifts rearwardly relative to the wheel as a result of such engagement, and acts through a floating differential lever to shift a wheel-feeler forwardly into feeling engagement with the wheel. In moving into feeling engagement, the wheel-feeler senses the prevailing diameter of the wheel and reduces the rate of advance of the wheel when the latter reaches a position determined both by the diameter of the wheel and the diameter of the roll.

BACKGROUND OF THE INVENTION

This invention relates to a grinding machine of the type in which a carriage supporting a rotatable grinding wheel is advanced at a rapid rate toward a work roll to bring the wheel into operative position for effecting grinding of the roll as the advance of the carriage is continued at a slow feed rate.

SUMMARY OF THE INVENTION

The present invention insures that, in spite of wearing down of the grinding wheel to a reduced diameter and regardless of the diameter of the roll to be ground, the rate of advance of the wheel always will be reduced when the periphery of the wheel is a fixed distance short of the roll. For this purpose, a roll-feeler projecting ahead of the periphery of the wheel engages and detects the diameter of the roll upon rapid advance of the carriage and acts through a floating differential lever mounted on the carriage to project a wheel-feeler into feeling engagement with the wheel. The latter feels, when in feeling engagement, detects the prevailing diameter of the wheel and delays the changeover in the advance rate until the distance between the wheel and the roll is correlated not only with the diameter of the roll but also with the diameter of the wheel. As a result, a wheel of any diameter may be rapidly approached to just short of a roll of any diameter and yet with no danger of the wheel hitting the roll while being rapidly advanced.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a fragmentary plan view of a grinding machine embodying the novel features of the present invention.

FIGS. 2 and 3 are enlarged fragmentary cross-sections taken along the lines 2—2 and 3—3 of FIG. 1.

FIG. 4 is an enlarged cross-section taken along the line 4—4 of FIG. 3 and showing parts in moved positions.

FIG. 5 is an enlarged fragmentary cross-section taken along the line 5—5 of FIG. 3.

FIG. 6 is an enlargement of part of FIG. 3 and showing the parts in moved positions.

FIGS. 7 to 12 are fragmentary views similar to FIG. 2 and schematically illustrating the parts on an exaggerated scale and in various moved positions.

FIG. 13 is a fragmentary circuit diagram.

DESCRIPTION OF THE PREFERRED EMBODIMENT

For purposes of illustration, the invention is shown in the drawings incorporated in a grinding machine of the type commonly used to rough and finish grind the surface of a generally cylindrical mill roll 20 (FIG. 1) while the latter is rotated about its longitudinal axis on steadyrests 21 upstanding from a supporting bed 23 by a motor (not shown) driving a headstock 24 attached to one end of the roll. Grinding of the roll is effected by a rotatable abrasive wheel 25 mounted on a carriage 26 for movement in a rectilinear path toward and away from the roll as the carriage is slid back and forth along ways 27 on a sub-carriage 29 which, in turn, slides along a second set of ways 30 on the bed. 23 to move the wheel along the face of the roll in response to turning of a lead screw 31 connected to the sub-carriage and rotated by a drive motor (not shown). The grinding wheel is fast on and rotated by a horizontal spindle 33 journaled in the carriage 26 and connected by drive belts 34 to an electric motor 35 which is supported on a platform 36 on one side of the carriage.

With an unfinished roll 20 in place on the steadyrests 21, a power operator 36 (FIG. 7) advances the grinding wheel 25 toward the roll in a two-step cycle including first advancing the wheel rapidly from a retracted position (FIG. 7) to a position shown in FIG. 10 in which the periphery of the wheel is just short of the roll and then continuing to advance the wheel at a slower feed rate into contact with the roll to effect grinding thereof. Herein, the power operator comprises a reversible rapid traverse motor 37 (FIG. 7) mounted on the carriage 26 and connected by reduction gearing 40 to a nut 41 journaled in a bearing (not shown) on the underside of the carriage and threaded onto a lead screw 44 rotatably supported in bearings 45 on the sub-carriage 29. Rapid advance of the wheel is effected by the rapid traverse motor 37 rotating the nut along the screw at the same time the screw itself is being rotated by a feed motor 46 supported on the sub-carriage and geared to one end of the screw. When the grinding wheel is a predetermined distance from the roll, the rapid traverse motor is stopped automatically while the feed motor continues to rotate the lead screw to advance the wheel at a slower rate and into contact with the roll. The rapid traverse motor 37 is driven reversely to return the wheel rapidly to the retracted position upon completion of grinding of the roll.

In accordance with the present invention, a roll-feeler 50 (FIGS. 2 and 3) for sensing the diameter of the roll 20 coacts with a wheel-feeler 51 for sensing the prevailing diameter of the grinding wheel 25 to reduce automatically the rate of advance of the wheel toward the roll when the periphery of the wheel is a fixed distance short of the roll regardless of the diameter of the roll and roll diameters. The roll-feeler projects ahead of the periphery of the wheel during rapid advance of the wheel, engages the roll ahead of the wheel to detect the diameter of the roll, and thereafter shifts rearwardly relative to the wheel and acts through a floating differential lever 53 (FIG. 3) to project the wheel-feeler forwardly into feeling engagement with the periphery of the wheel. The latter feels, when in feeling engagement, detects the diameter of the wheel with the diameter of the roll and de-activates the rapid traverse motor 37 just prior to the wheel contacting the roll.

In the present instance, the floating differential lever 53 is a toothed pinion which is journaled in a roller bearing 54 (FIG. 5) for rotation about the axis of a horizontally disposed pin 55 fastened intermediate the ends of an arm 56. The latter lies alongside the pinion and is mounted for back and forth reciprocation along one side...
of the carriage 26 by a tubular guide 57 (FIG. 3) which is attached to the carriage and which slidably receives a cylindrical stem 59 rigid with the forward end of the arm 56 and guided laterally from the arm and behind the periphery of the pinion 53 so that, in response to energization of a reversible power actuator, herein an electrically operated solenoid 61 fastened to the carriage 26, the armature 63 of the solenoid abuts against the tongue to shift the pinion bodily and forwardly through a limited range from a retracted position (FIG. 7) to an advanced position (FIGS. 3 and 8). During the initial movement of the pinion to the advanced position, a pinister 64 formed with an arcuate face 65 concentric with the periphery of the pinion engages and prevents rotation of the latter. The pinister is telescoped slidably over the armature 63 and into a bore 66 in the casing 67 of the solenoid and is urged against the pinister by a coil spring 69 housed within the bore. Near the end of the forward stroke of the solenoid armature 70 extending around the open end of the bore stops further forward movement of the pinister with the pinion so that the pinister is left free to rotate when disposed in the advanced position. De-energization of the solenoid results in the return of the pinion to the retracted position through the action of a spring 71 (FIG. 3) telescoped over the stem 59 and into a bore 73 formed in the guide 57.

Guided for back and forth reciprocation above the pinion 53 in response to bodily shifting of the axis 55 thereof is the roll feeler 50 which herein is an elongated bar extending alongside the grinding wheel 25 and formed at its outer or free end with a depending finger 74 (FIG. 2) engageable with the work roll 20. Near its free end, the finger is guided by a roller 75 (FIG. 2) journalred on the carriage while, at its rear end, the feeler slides between a cap 76 (FIG. 5) and along one side of a post 77 upstanding from the carriage, the cap 76 being fastened to the upper end of the post by a screw 79. The motion of the pinion is transmitted to the roller feeler 50 by a rack 80 (FIGS. 3 and 5) which is formed on its lower side with teeth 81 meshing with the teeth of the pinion. The rack slides parallel to the feeler 50 along the opposite side of the post 77 and is fastened at opposite ends to the feeler by screws 83 (FIG. 3). A roller 84 (FIG. 5) is mounted for rotation on the post and underlies the rack 80 to guide the latter.

As the pinion 53 is shifted from its retracted position (FIG. 7) to its advanced position (FIG. 8), the rack 80 moves bodily with the pinion and projects the roll feeler 50 outwardly from its retracted position in which the finger 74 is disposed behind the periphery of the wheel 25 to an advanced position in which the finger is disposed approximately 3/4 of an inch ahead of the wheel periphery. Starting with the roll feeler in its advanced position, the wheel is advanced rapidly toward the roll 20 and thus the feeler engages and stops against the roll while the wheel is still a short distance away from the roll (see FIG. 9). With continued advance of the wheel, the feeler, in effect, shifts rearwardly relative to the carriage 26 and rotates the pinion about the axis of the pin 55.

Both the floating and the rotational movements of the pinion 53 are transmitted to the wheel feeler 51 (FIG. 3) which herein comprises a supporting part or member 85 slidably mounted on the carriage 26 and a feeling part 86 slidably mounted on the supporting part. Generally stated, the two parts are shifted in unison from a retracted position (FIG. 7) to an advanced position (FIG. 8) when the solenoid 61 is energized to shift the axis of the pinion forwardly. Thereafter and as the roll feeler 50 engages the roll 20 and rotates the pinion, the two parts 85, 86 continue to move as a unit from the advanced position and toward the periphery of the wheel 25 until the feeling part 86 moves into feeling engagement with the wheel as shown in FIG. 9. Such feeling engagement may be achieved mechanically, as by means of a roller on the free end of the feeling part engaging the wheel, or hydrostatically as by a cone or pin to lie in the manner of the pinion 53. Formed on the rear end of the arm 56 is a tongue 60 (FIGS. 3 and 6) projecting laterally from the arm and behind the periphery of the pinion 53 so that, in response to energization of a reversible power actuator, herein an electrically operated solenoid 61 fastened to the carriage 26, the armature 63 of the solenoid abuts against the tongue to shift the pinion bodily and forwardly through a limited range from a retracted position (FIG. 7) to an advanced position (FIGS. 3 and 8).

More specifically, the supporting part 85 is a rack in the form of an elongated sleeve (see FIG. 3) which is disposed below the axis of the pinion 53 and which is formed along its upper side with a row of teeth 89 meshing with the teeth of the pinion. Slidably mounting the sleeve 85 for back and forth reciprocation in a path parallel to the carriage in response to shifting and rotation of the pinion is a guideway 90 (FIG. 5) attached to the side of the carriage and formed along its lower side with a horizontally flange or track 91 along which rides a roller 93 journaled on the sleeve. As shown most clearly in FIG. 5, the upper side of the guideway includes a pair of laterally spaced rails 94 extending along and guiding opposite sides of the rack teeth 89.

Preferably, the supporting part 85 is an elongated tube which is telescoped into the sleeve 85. A coil spring 95 (FIGS. 3 and 4) surrounding the rear end portion of the tube 86 and compressed between opposing shoulder 96 and 97 (FIG. 4) on the sleeve and the tube normally couples the two for movement axially in unison but yields to allow sliding of the sleeve on the tube when the latter is stopped as a result of moving into feeling engagement with the wheel 25. The spring 95 urges the tube forwardly in the sleeve and to a position limited by engagement of the rear end of the sleeve with a collar 99 (FIGS. 3 and 4) fastened to the rear end of the tube. The collar carries a switch operator 100 which normally is urged against the control switch 87 to hold the latter open, the control switch being attached to one side of the sleeve 85 near the rear end thereof.

The forward end of the tube 86 projects beyond the forward end of the sleeve 85 and is slidably housed in an arcuate hood 101 (FIG. 3) which encircles and covers a substantial arc of the grinding wheel 25. Herein, liquid coolant under high pressure, for example 100 p.s.i., is admitted into the rear end of the tube through a conduit 103 communicating with a coolant source (not shown) and is conducted to a nozzle 104 which is fastened to the forward end of the tube by screws 105. Formed in the nozzle and communicating with the tube is a recess or hydrostatic pad 106 which directs a high velocity jet of the coolant toward the periphery of the wheel. As the rotating pinion moves the sleeve and the tube in unison from their advanced positions (FIG. 8) and progressively closer toward the wheel, the jet of coolant impinges against the wheel periphery and creates an incrementally high back pressure between the pad 106 and the wheel. When the pad is in feeling engagement with and about .010 of an inch from the wheel (FIG. 9), the force of the developed back pressure overcomes the force of the spring 95 coupling the tube 86 and the sleeve 85 and, as a result, the pad 106 stops short of the wheel while the spring 95 yields to permit relative sliding of the sleeve along the tube (see FIG. 10) upon continued rotation of the pinion. Such relative sliding moves the control switch 87 away from the switch operator 100 and thus de-activates the rapid traverse motor 37.

**SUMMARY OF OPERATION**

Assume at the start of a cycle that the wheel 25 is retracted away from the roll 20 and that the pinion 53 and the two feelers 50, 51 are disposed in their retracted positions as shown in FIG. 7. Upon manual closure of
start-stop switch contacts 107 and 108 (FIG. 13), the rapid traverse and feed motors 37, 46 are started to advance the wheel rapidly toward the roll. At the same time, the solenoid 61 is energized through switch contacts 107 to shift the pinion 53 and the two feelers all as a unit to their advanced positions (FIG. 8). The roll feeler 50, projecting ahead of the wheel during advance of the carriage 26, engages and stops against the roll (FIG. 9) while the wheel is still about 14 of an inch short of the roll and, with continued advance of the carriage, slides rearward relative to the carriage and acts through the rack 80 to rotate the pinion 53. Through the rack teeth 89, the rotating pinion 53 lifts the sleeve 85 and tube 86 toward the wheel, the two initially moving in unison due to the coupling spring 95 (see FIG. 9). Approach of the pad 106 into feeling engagement with the wheel causes the back pressure between the two to increase sufficiently high to overcome the force of the spring 95 and to stop the tube 85 so that, with continued movement of the carriage 26 and rotation of the pinion produced by continued advance of the carriage with the roll feeler 50 contacting the roll, the sleeve 85 slides forwardly on the tube 86 by yielding of the spring 95 and moves the control switch 87 away from the switch operator 100 to close the switch 87, energize a relay 109, and de-activate the rapid traverse motor 37 through a switch 110 which is opened by energization of the relay.

Opening of the switch 110 also de-energizes the solenoid 61 which allows the spring 71 to retract the roll feeler 50 behind the periphery of the wheel 25 (FIG. 11) and out of contact with the roll 20 and to retract the pad 106 away from the wheel. During retraction of the pad, the spring 95 relaxes and slides the sleeve 85 rearwardly on the tube 86 to move the control switch 87 back into contact with the switch operator 100 preparatory to the next advance of the wheel. The control switch 87 re-opens but the relay 109 remains energized to hold switch 110 open through a holding circuit set up by start-stop switch contacts 108 and relay-actuated switch contacts 111. Accordingly, the solenoid 61 and the rapid traverse motor 37 are held de-energized during gridding of the roll. The relay 109 is de-energized at the completion of a gridding cycle when start-stop contacts 108 are opened.

The advantages of the foregoing arrangement are apparent. The wheel feeler 51 is not moved from its advanced position and toward feeling engagement with the wheel 25 until the roll feeler 50 engages and detections the rear of the roll 20. While moving forwardly as directed by the roll feeler, the wheel feeler does not actuate the control switch 87 until the pad 106 actually moves into feeling engagement with and detects the prevailing diameter of the wheel. Thus, regardless of the diameters of the wheel and the roll, the reduction in the advance rate always will occur when the wheel periphery is a fixed distance short of the roll. During service use, the wheel wears down and decreases in diameter so that, when the roll feeler is shifted to its extended position between successive advances of the wheel toward the roll, the extent of projection of the finger 74 ahead of the wheel periphery, in effect, advances in steps of the roll. As the roll feeler is advanced to detect the roll edge, the roll is advanced to detect the roll edge.

Moreover, the roll feeler will shift the sleeve 85 and the tube 86 in unison relative to the carriage through a greater distance before the pad moves into feeling engagement with the worn wheel and before the back pressure stops the tube. As a result, the position of the tube and the sleeve shifts forwardly in small increments between successive advances to delay the changeover to the advance rate in accordance with the diameter of the wearing wheel. This is illustrated schematically in FIG. 12 which shows a wheel 25 worn down to a diameter considerably smaller than its original diameter. As is apparent, the sleeve 85 and the tube 86 have moved to positions considerably farther forward on the carriage than was the case with the wheel 25. Thus, each time the two feelers 50, 51 are returned to their retracted positions by the solenoid between successive advances of the carriage, they assume positions which are spaced short and far apart, respectively, of their corresponding positions before the advance of the carriage. The length of the increments is equal to the amount of wheel wear during gridding, that is, equal to the decrease in the radius of the wheel.

The incremental shifting of the sleeve 85 along the carriage 26 as the wheel 25 wears is used separately to increase the rotational speed of the wheel automatically in response to wheel wear thereby to maintain constant the peripheral speed of the wheel. For this purpose, a cam 113 (FIG. 3) is carried by the lower side of the sleeve 85 and rides along a pointed follower 114 which is carried at the upper end of a rack 115 guided for up and down sliding in a bracket 116 fastened to the carriage 26. As the cam and the sleeve shift forwardly in small increments, the follower and the rack are released to the action of a spring 117 stretched between the bracket and the lower end of the rack and, as a result, the rack slides upwardly and turns a pinion 119 which is fasted on the operating shaft of a potentiometer 35 in the control circuit of the grinding wheel motor 35. Turning of the pinion 119 adjusts the potentiometer in accordance with the amount of wheel wear, and the potentiometer increases the speed of the wheel motor 35 to maintain the peripheral speed of the wheel at a constant value in spite of such wear.

I claim as my invention:

1. In a grinding machine, the combination of, a support for mounting a horizontally disposed work roll to turn about its longitudinal axis, carriage mounted on said support to move toward and away from the roll along a path extending generally transversely of said roll axis, a power driven grinding wheel mounted for rotation on said carriage and engageable with the roll along a surface thereof, a power operator selectively operable to advance said carriage along said path toward the roll at rapid and slow rates, a differential lever mounted on said carriage for turning about an axis and also for bodily floating toward and away from the roll, a reversible power actuator energizable selectively to shift said level axis relative to said carriage and toward and away from said roll through a limited range between advanced and retracted positions, an elongated roll feeler coupled to said lever on one side of the axis thereof and mounted on said carriage for end-wise movement in support of said lever, said lever having a free end disposed respectively ahead and behind the periphery of said wheel in said advanced and retracted positions of said lever axis, an elongated wheel feeler coupled to said lever on the opposite side of said lever axis and comprising a supporting part slidably back and forth on said carriage parallel to said path, said wheel feeler further comprising a feeling part slidable on said supporting part parallel to said path and having a free end movable forwardly into feeling engagement with the periphery of said wheel on the side thereof opposite said roll, means yieldably biasing said feeling part relative to said supporting part and toward said wheel periphery, said roll feeler, when held ahead of the wheel by said actuator and with said wheel feeler retracted out of feeling engagement with said wheel, acting, during the rapid advance of said carriage toward the roll and after engaging the roll, the roll feeler and the sleeve of said carriage, turn said lever about said lever axis and thereby shift said supporting and feeling parts in unison toward the wheel periphery and then, after feeling engagement of said feeling part with said wheel, to continue to shift said supporting part relative to said feeling part by yielding of said biasing means, and thereby to reverse relative to said carriage, turn said lever about said lever axis and thereby shift said supporting and feeling parts to control said operator and change the advance of said carriage from said rapid rate to said slow rate.
2. A grinding machine as defined in claim 1 in which said differential lever comprises a pinion rotatable about said lever axis and meshing with rack teeth carried by said roll and wheel feelers.

3. A grinding machine as defined in claim 1 in which said actuator is energized and de-energized to shift said lever to said advanced and retracted positions, respectively.

4. A grinding machine comprising, in combination, a support rotatably mounting a roll to be ground, a carriage mounted for movement back and forth along a path extending generally transversely of said roll, an abrasive wheel for grinding said roll mounted on said carriage and power rotated about an axis extending generally transversely of said path, a power operator selectively controllable to advance said carriage along said path, and toward said roll at rapid and slow rates, a feeler projecting along said path ahead of the periphery of said wheel for engagement with said roll and mounted on said carriage for movement relative thereto along said path so as to be retracted progressively in the advance of said carriage following engagement of the feeler with said roll, a wheel feeling part, a member mounted on said carriage for movement relative thereto and supporting said feeling part for feeling engagement with the wheel periphery, means biasing said feeling part relative to said member toward said wheel to a predetermined normal position relative to the member, mechanism coupling said roll feeler and said member and operable during retraction of the roll feeler in the rapid advance of the carriage after the roll feeler engages said roll to advance said member and feeling part toward said wheel and after feeling engagement therewith to permit continued movement of the member in the continued retraction of the roll feeler, and means responsive to said continued movement of said member to control said power operator and change the advance of said carriage from said rapid rate to said slow rate.

5. A grinding machine as defined in claim 4 in which said coupling mechanism includes a device mounted on said carriage for bodily movement back and forth along said path and coupled to said roll feeler and said member for movement of the two back and forth in the same direction and in unison.

6. A grinding machine as defined in claim 5 including a power actuator selectively operable to shift said device back and forth along said path through a limited range sufficient to retract said roll feeler behind said wheel periphery after termination of the advance of said carriage at said slow rate.

7. A grinding machine as defined in claim 4 further including a motor on said carriage for rotating said abrasive wheel, a cam carried by and movable with said member, and means on said carriage and engageable with said cam and responsive to movement thereof to increase the speed of said motor and the rotational speed of said abrasive wheel as the latter wears down and decreases in diameter.

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