Feb. 10, 1970 A. KLEIN 3,494,079

APPROACH CONTROL FOR GRINDING MACHINES

Filed July 10, 1967 5 Sheets-Sheet 1

Fig. 1

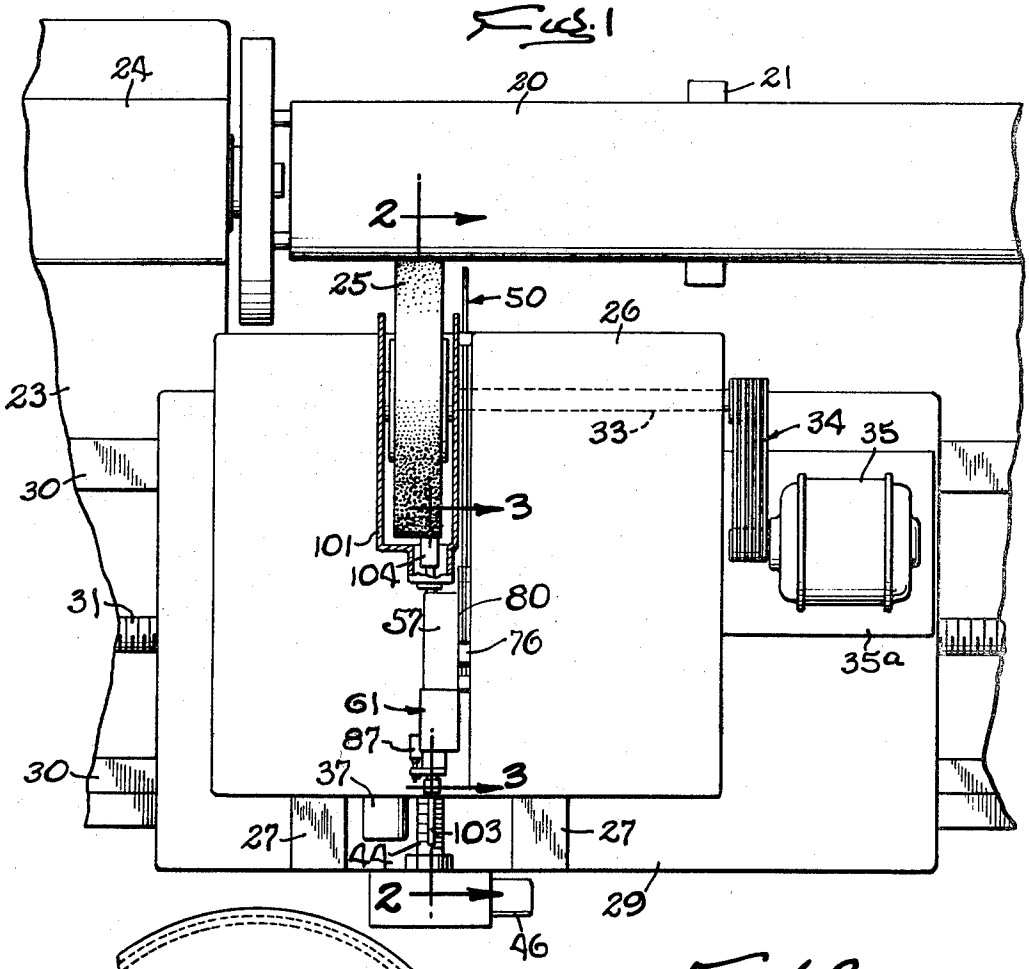
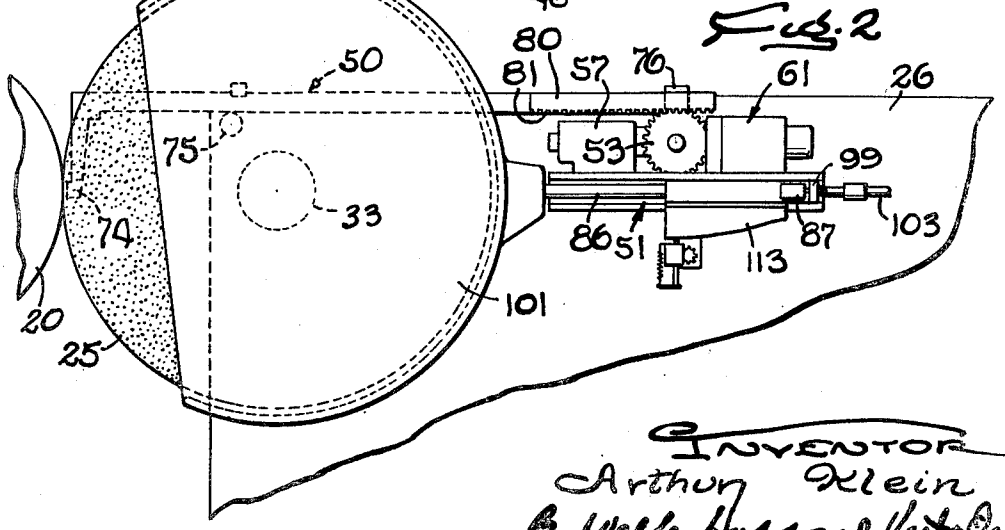


Fig. 2

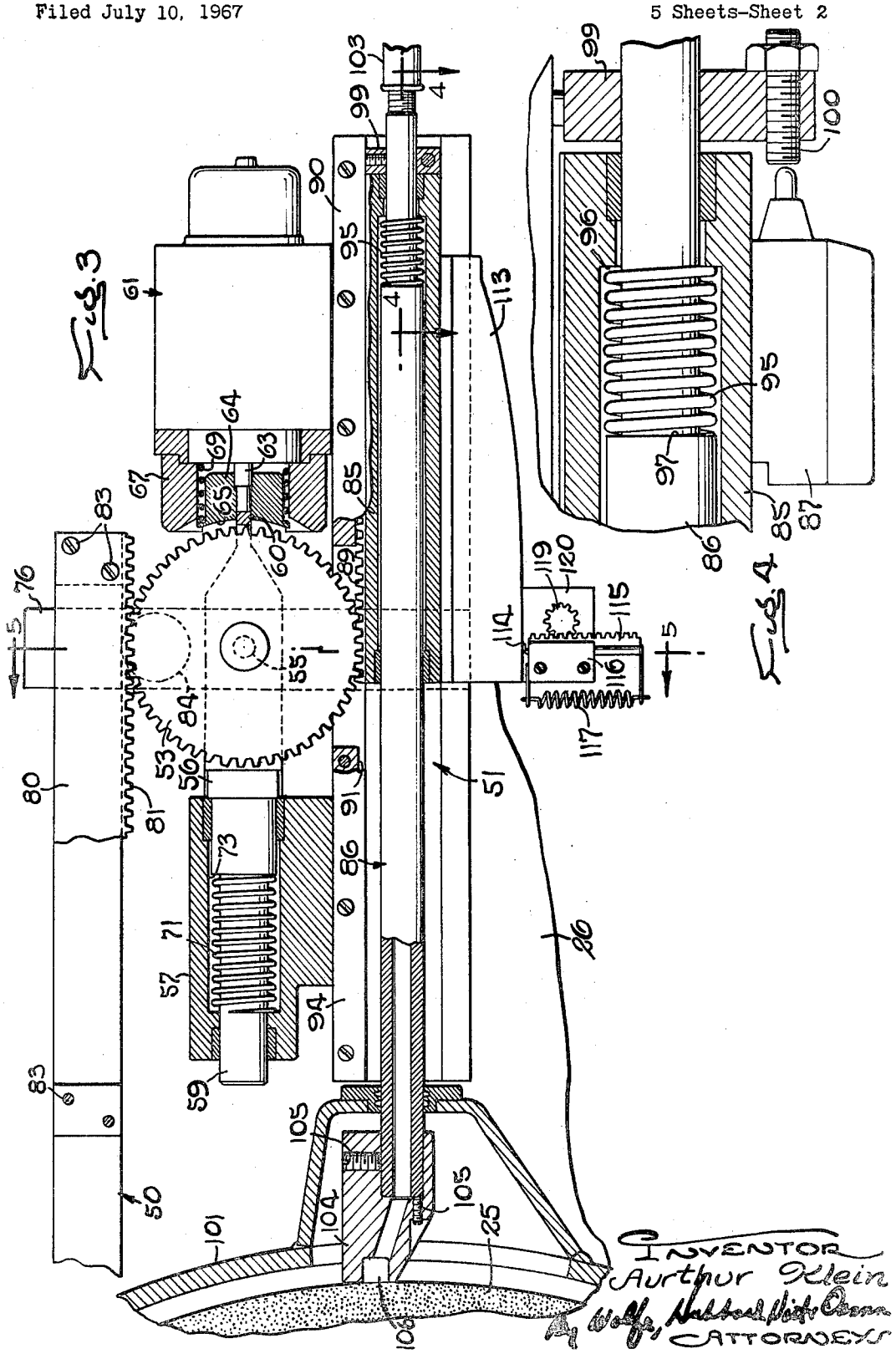


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APPROACH CONTROL FOR GRINDING MACHINES

Filed July 10, 1967 5 Sheets-Sheet 2



Feb. 10, 1970 A. KLEIN 3,494,079

APPROACH CONTROL FOR GRINDING MACHINES

Filed July 10, 1967 5 Sheets-Sheet 3

Fig. 5

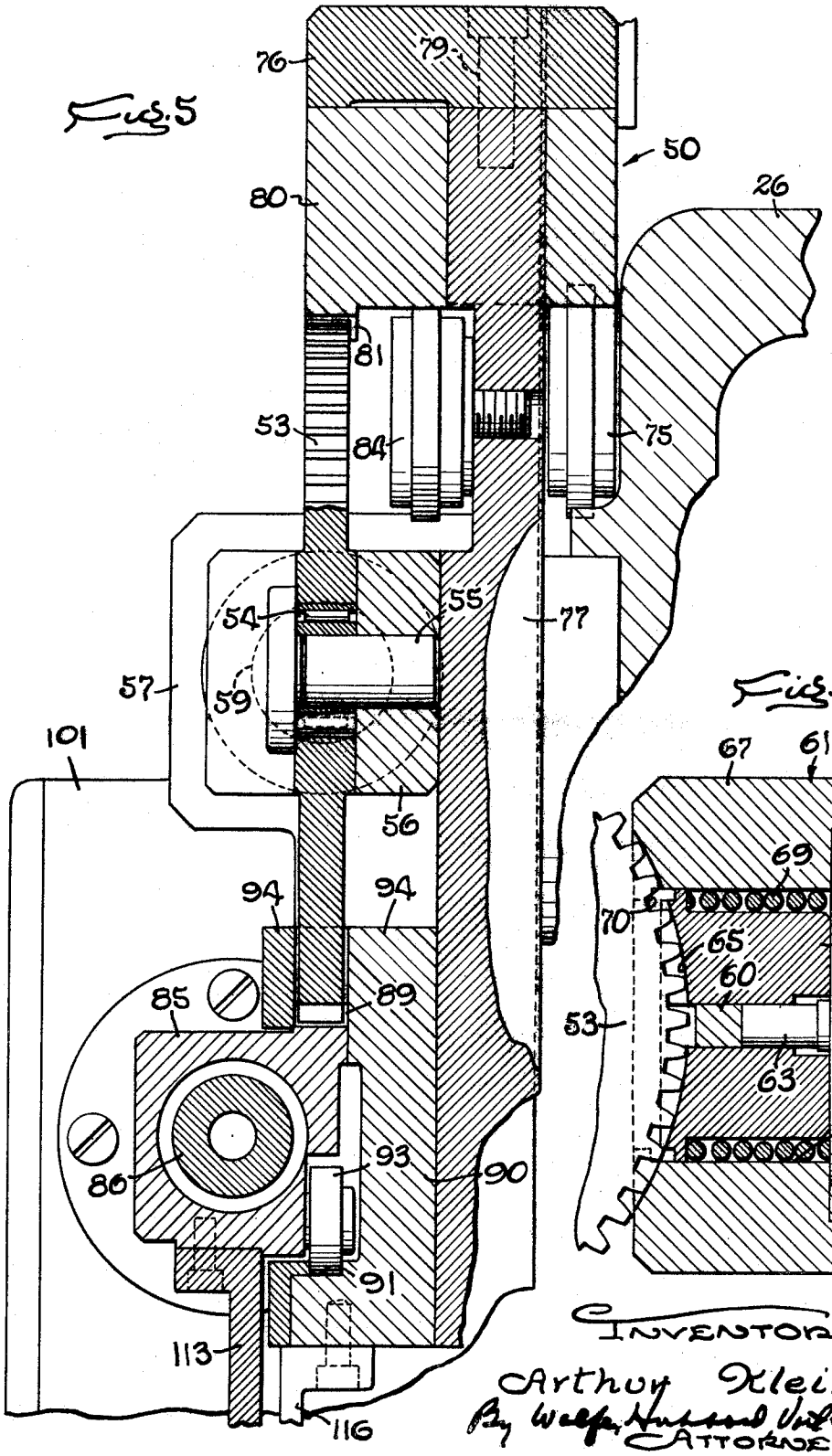


Fig. 6

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APPROACH CONTROL FOR GRINDING MACHINES

Filed July 10, 1967 5 Sheets-Sheet 4

Fig. 7

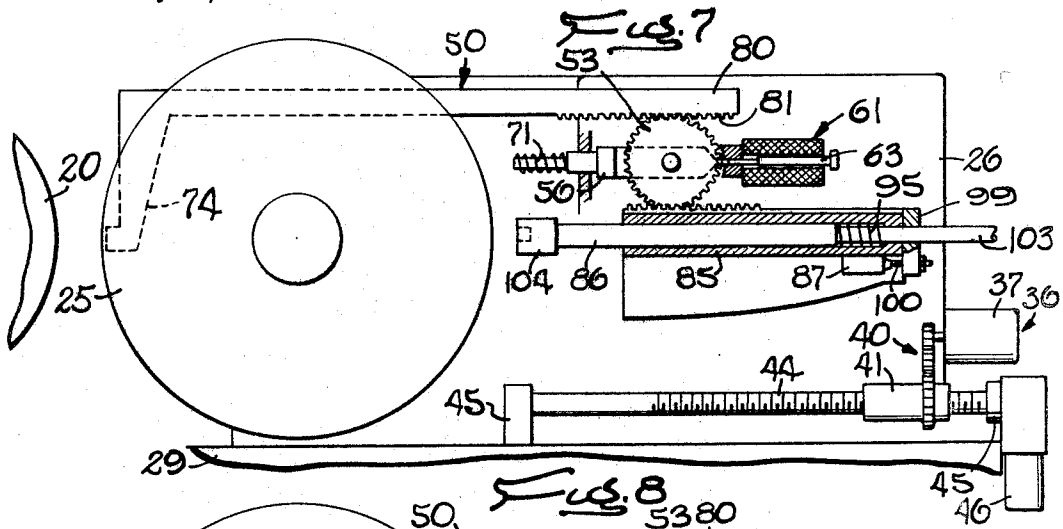


Fig. 8

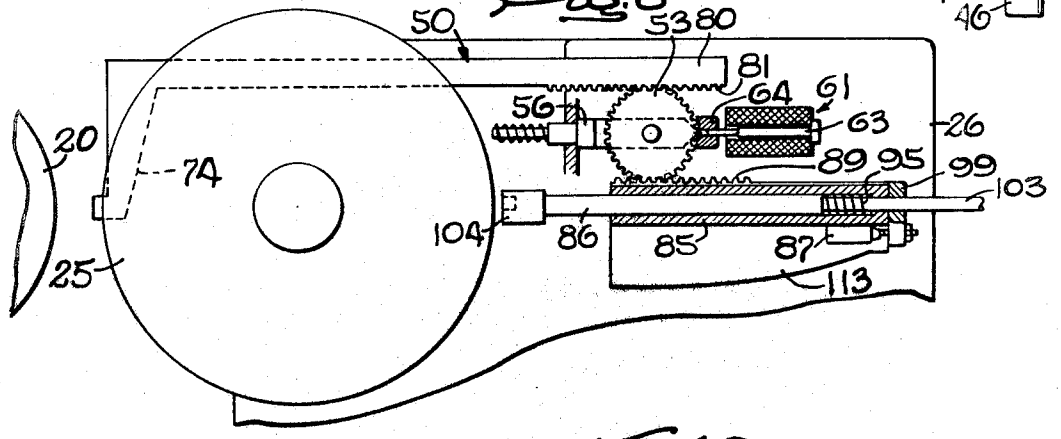
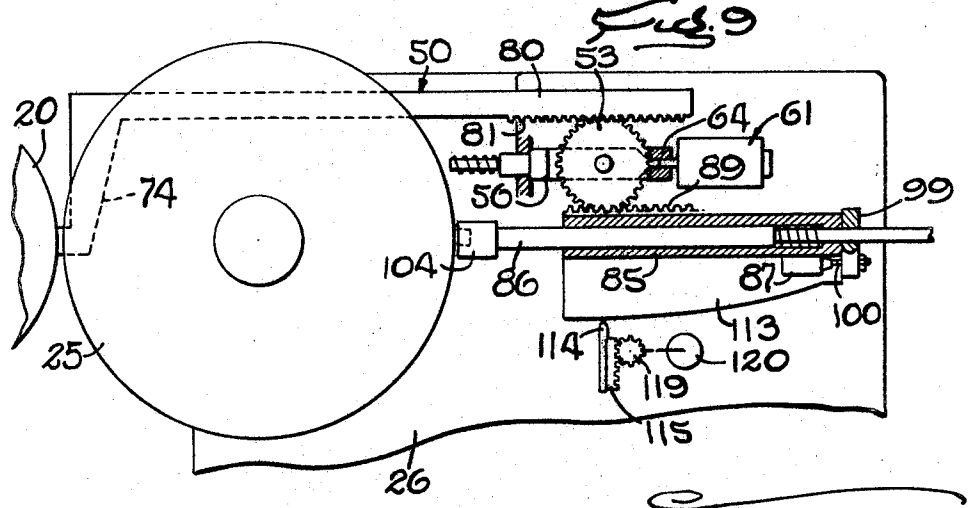


Fig. 9



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APPROACH CONTROL FOR GRINDING MACHINES

Filed July 10, 1967 5 Sheets-Sheet 5

Fig. 10

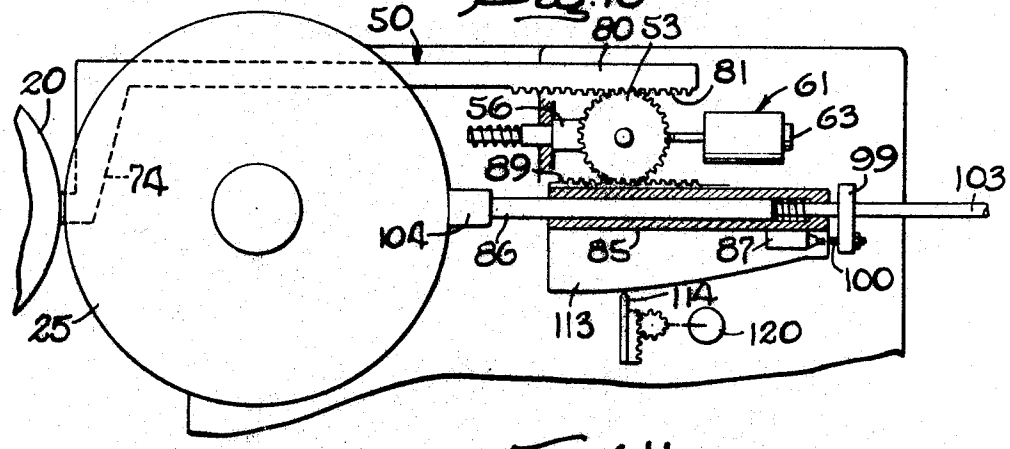


Fig. 11

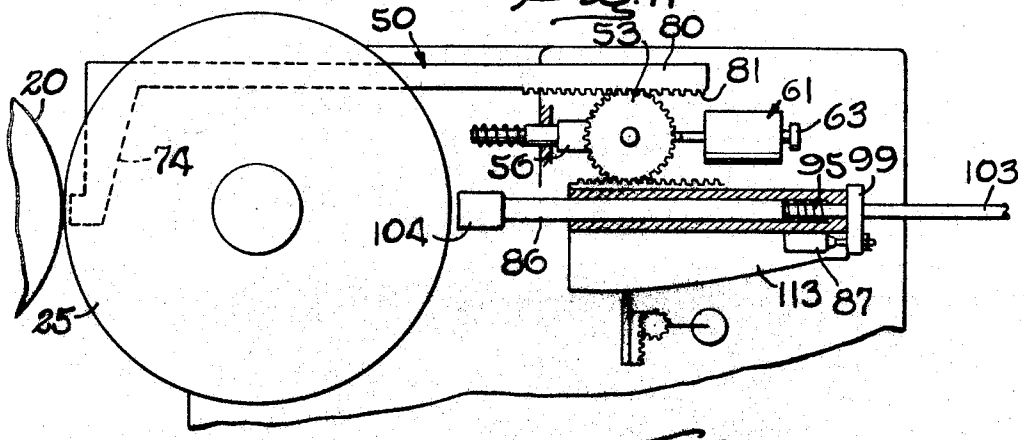


Fig. 12

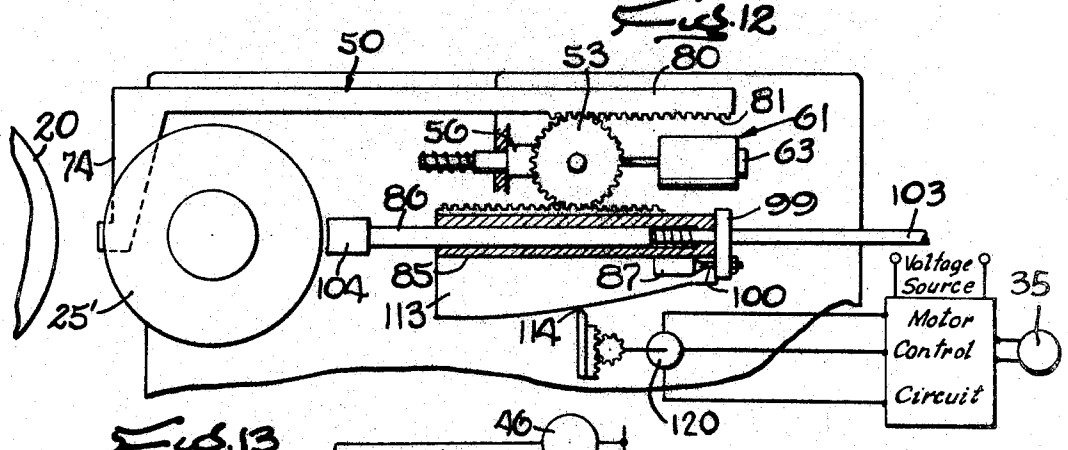
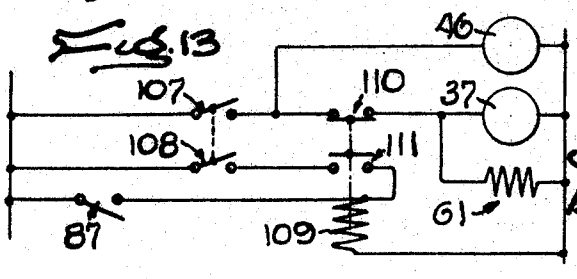


Fig. 13



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United States Patent Office 3,494,079
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3,494,079

APPROACH CONTROL FOR GRINDING MACHINES

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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 feeler, 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** chucked 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 **35***a* 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 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 wheel 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 feeler senses and correlates 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 by 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 but offset laterally therefrom so as to lie in the plane 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). During the initial movement of the pinion to the advanced position, a piston **64** (FIG. 6) formed with an arcuate face **65** concentric with the periphery of the pinion engages and prevents rotation of the latter. The piston is telescoped slidably over the armature **63** and into a bore **66** in the casing **67** of the solenoid and is urged against the pinion by a coil spring **69** housed within the bore. Near the end of the forward stroke of the solenoid, a shoulder **70** extending around the open end of the bore stops further forward movement of the piston with the pinion so that the pinion 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 feeler is guided by a roller **75** (FIG. 2) journaled on the carriage while, at its rear end, the feeler slides beneath 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 roll 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 a 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 ¼ 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 illustrated herein and as later to be described. Upon moving into feeling engagement with and detecting the prevailing diameter of the wheel, the feeling part stops while continued rotation of the pinion shifts the supporting part **85** relative to the feeling part (see FIG. 10). Such relative shifting between the two parts is utilized to operate a control switch **87** (FIGS. 4, 7 and 10) which de-activates the rapid traverse motor **37** to slow the advance of the wheel toward the roll.

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 horizontal 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 feeling part **86** 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 shoulders **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 bushed 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 ahe 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 increasingly 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 ¼ of an inch short of the roll and, with continued advance of the carriage, slides rearwardly relative to the carriage and acts through the rack **80** to rotate the pinion **53**. Through the rack teeth **89**, the rotating pinion **53** shifts 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** reopens 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 grinding of the roll. The relay **109** is de-energized at the completion of a grinding 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 detects the diameter and location of the roll. Even when moved 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, will be just slightly greater than on the last previous advance. 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 in 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 increments rearwardly and forwardly, 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 grinding, 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 to advantage 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 fast on the operating shaft of a potentiometer **120** connected in the control circuit of ahe 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 endwise movement in response to shifting of said lever axis, said feeler having a free end disposed respectively ahead of 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 slidable 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, to shift rearwardly relative to 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 mechanism operable in response to such relative shifting of 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 and 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 increse 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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HAROLD D. WHITEHEAD, Primary Examiner

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51—134.5