United States Patent [19]

Schaller

[11] **3,859,755**

[45] **Jan. 14, 1975**

[54] **POWER PROGRAMMING SYSTEM FOR A CENTERLESS GRINDER**

[75] Inventor: **Robert L. Schaller,** Camillus, N.Y.

[73] Assignee: **Sundstrand Syracuse, Inc.,** Syracuse, N.Y.

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[52] **U.S. Cl.** .... **51/103 TF,** 51/165.92
[51] **Int. Cl.** **B24b 3/18**
[58] **Field of Search** .... 51/103 R, 103 TF, 135, 51/139, 165 R, 165.92

[56] **References Cited**

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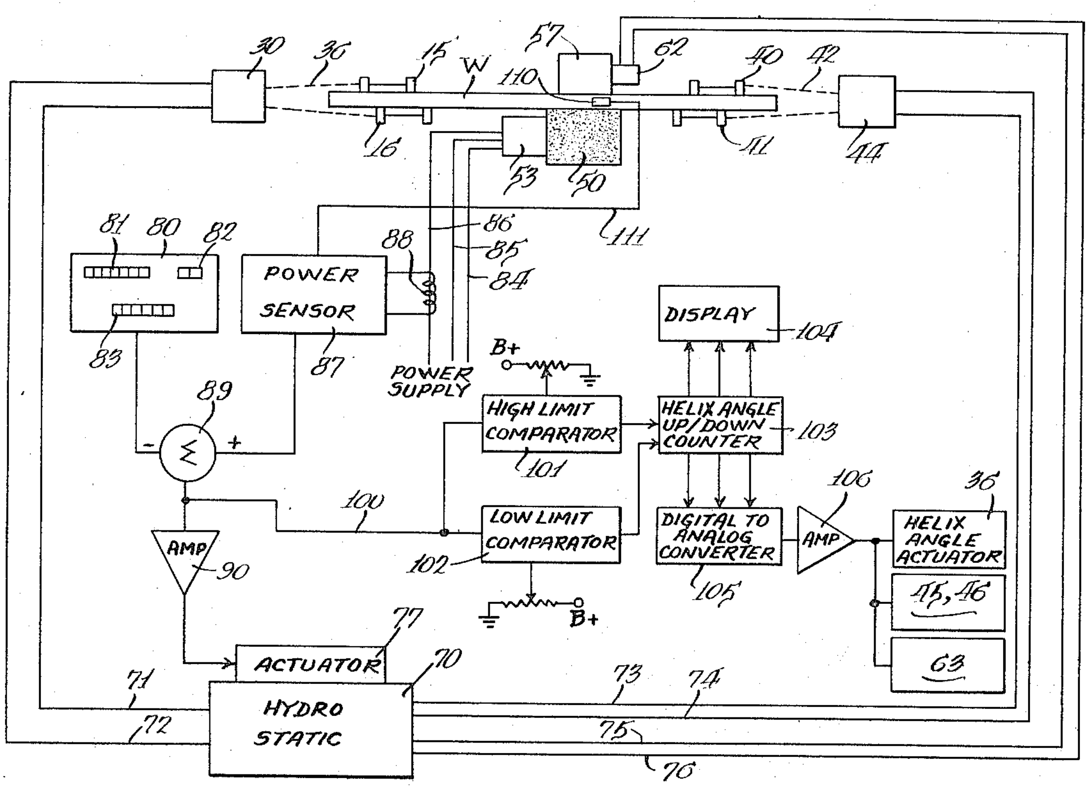
1,996,467	4/1935	Ernst	51/165.77
2,648,176	8/1953	Zimmerman	51/135
2,807,917	10/1957	Fuller	51/103 TF
2,818,688	1/1958	Swedmark	51/103 WH
2,961,808	11/1960	Dunigan	51/165.92
3,503,156	3/1970	Schaller	51/139
3,589,077	6/1971	Lenning	51/165.92
3,654,737	4/1972	Schmidt	51/165.92

Primary Examiner—Harold D. Whitehead
Attorney, Agent, or Firm—Wegner, Stellman, McCord, Wiles & Wood

[57] **ABSTRACT**

A power programming system for a centerless grinder which sets a reference input power consumption dependent upon the size of stock being ground, the depth of cut and the nature of the material and which measures or senses the power consumed and controls the rate of feed of the workpiece to have the power consumption equal the input value. The rate of feed of the workpiece may be varied within limits by varying the speed of the feeding mechanism for the workpiece and within greater limits by varying the helix angle of components of the feeding mechanism.

11 Claims, 4 Drawing Figures



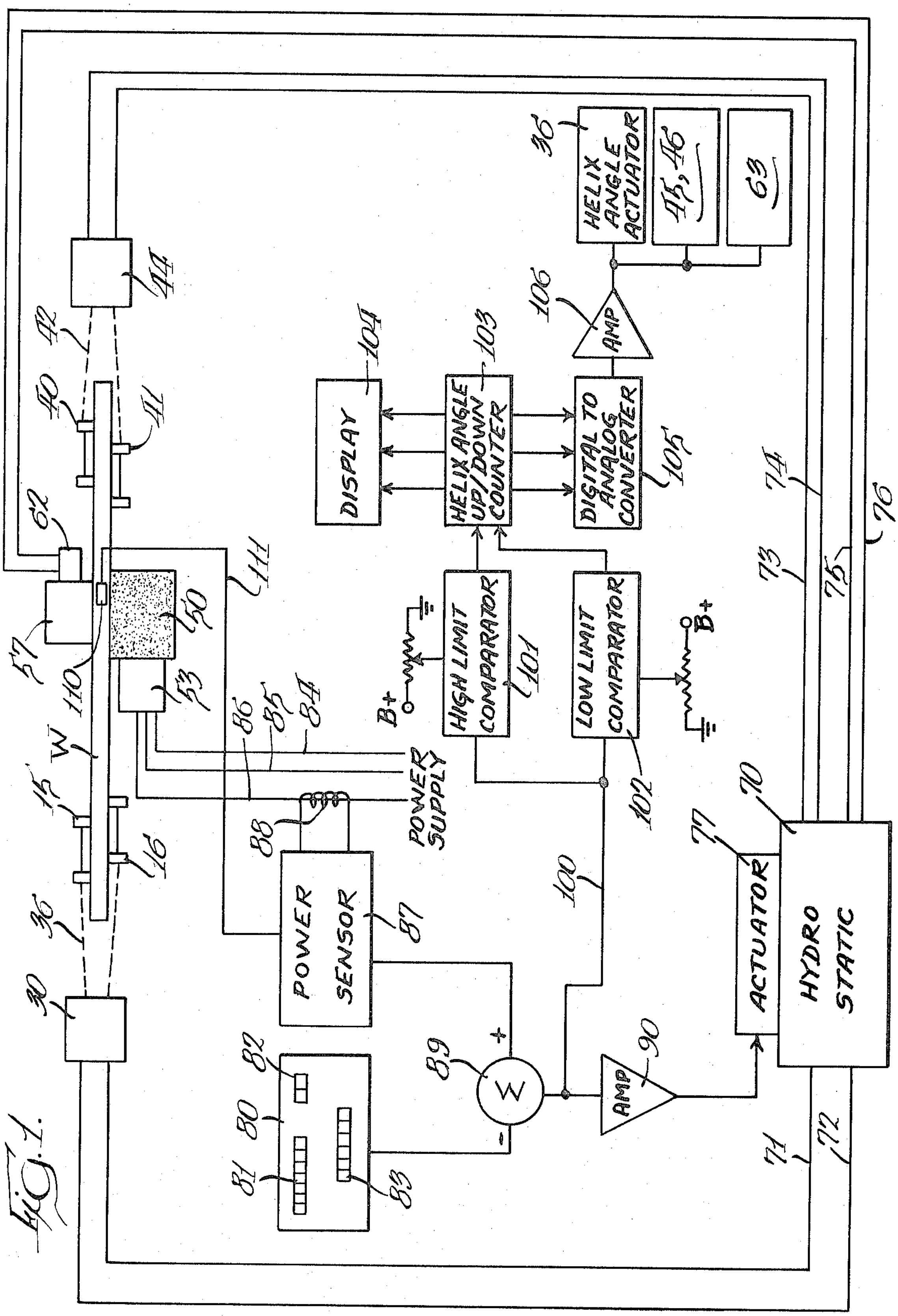

HELIX ANGLE ACTUATOR
45, 46
63
AMP
DISPLAY
HELIX ANGLE UP/DOWN COUNTER
DIGITAL TO ANALOG CONVERTER
HIGH LIMIT COMPARATOR
LOW LIMIT COMPARATOR
B+
B+
POWER SUPPLY
POWER SENSOR
W
AMP
ACTUATOR
HYDRO STATIC

FIG. 1.

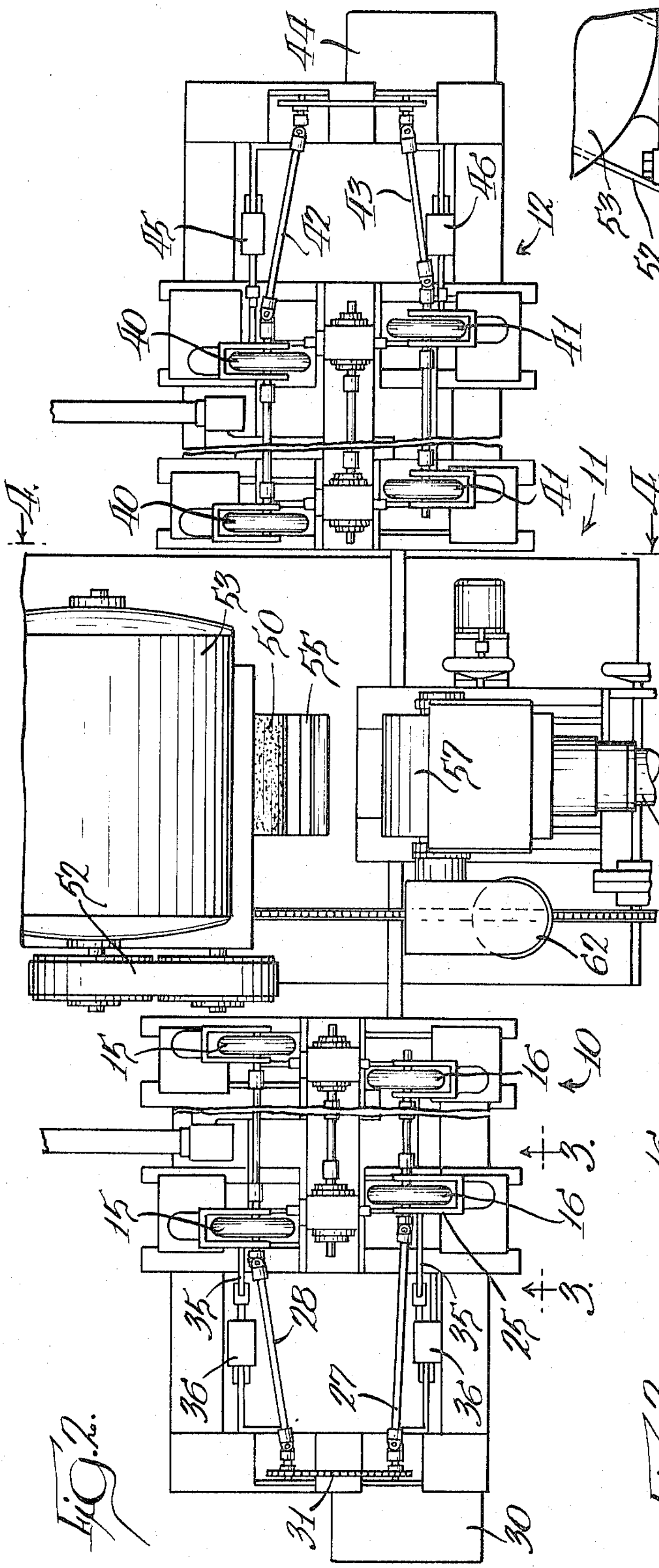


Fig. 2.

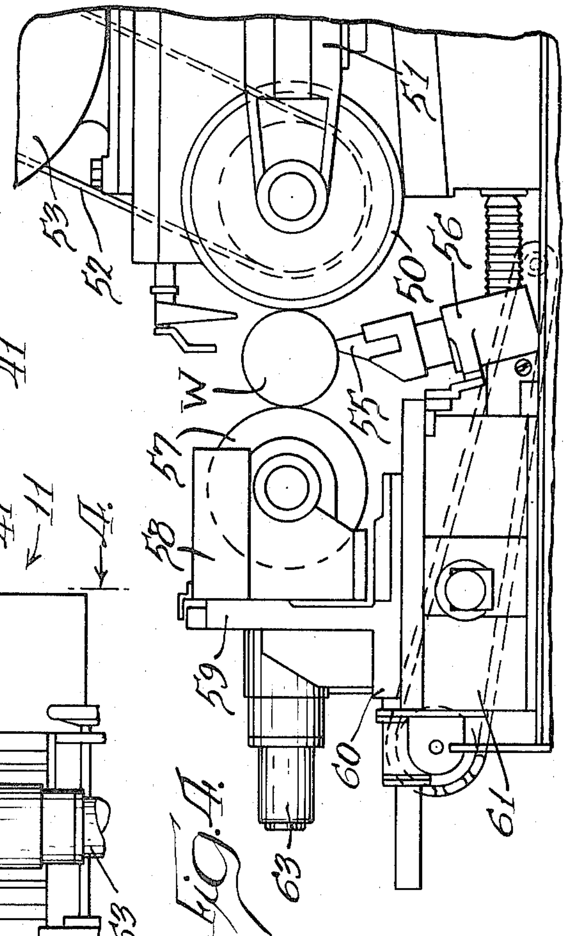


Fig. 4.

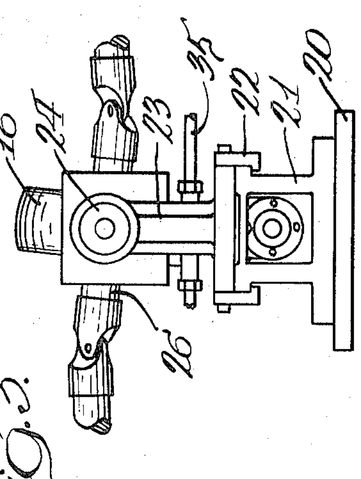


Fig. 3.

POWER PROGRAMMING SYSTEM FOR A CENTERLESS GRINDER

BACKGROUND OF THE INVENTION

This invention pertains to power programming systems for centerless grinders.

One type of centerless grinder which may have a power programming system associated therewith is shown in Schaller U.S. Pat. No. 3,503,156. This patent includes structure for feeding a workpiece relative to one or more grinding elements and with the rate of rotation and the helix angle of the feed elements being variable.

The control of inclination of input and outlet feed wheels for feeding a workpiece relative to a grinder is shown generally in Swedmark U.S. Pat. No. 2,818,688.

The Ernst U.S. Pat. No. 1,996,467 discloses a grinding machine with a workpiece supported on a travelling table. An electrical control system detects power consumption by a motor operating the machine and with changes in power consumption varying the rate of travel of the table which supports the workpiece. There is no disclosure in this patent of any selective setting of the power consumption rate nor of such control in a centerless grinding system.

SUMMARY

At the present time, an operator can set up a centerless grinder and it is desirable to take the production capability of such a machine away from an operator and provide for automatic control. The horsepower now available in centerless grinders exceeds the amount of horsepower that can be utilized in certain instances. For example, a centerless grinder, as commercially available, can be used through a very broad range of workpiece diameters, such as bar diameters, from a diameter of approximately ⅝ inch to as large as 7 or 8 inches. Correspondingly, the through-feed rates may vary from 3 fpm to 200 fpm. If the centerless grinder has a two hundred horsepower capability, such horsepower is not usable with a small diameter workpiece because of such bars not being perfectly straight and tending to whip if the through-feed rate is not restricted. Additionally, the grindability is a variable, since differing materials, or the same material with different hardness, require different horsepower. The grinding of stainless steel bars requires more horsepower than that required for low carbon steel such as 1,020 low carbon steel. The power programming system predetermines the horsepower that can be utilized on various diameter bars with various depth of cuts and grindability ratios. This establishes a value of desired power consumption. The power consumed by the motor for the grinding element is sensed and any variation therebetween is used to modify the through-feed rate of a workpiece to bring the consumed power into match with the set desired power consumption. This variation in the through-feed rate may be accomplished by varying the speed of rotation of the regulating wheel as well as the input and outlet feed wheels for the workpiece, or the helix angles thereof which are set to provide for feed of the workpiece resulting from rotation of the wheels.

A primary feature of the invention is in a power programming system for a centerless grinder having a grinding element and means for feeding a workpiece relative to the grinding element, wherein variable means are provided for setting the desired power consumption in grinding, dependent upon the size of the workpiece, the depth of cut, and the grindability thereof along with means for sensing the actual power consumed in grinding and with means for controlling the feed of the workpiece to have the workpiece travel at a rate whereby the consumed power is at the set rate.

The centerless grinder includes a regulating wheel coacting with the grinding element as well as input and outlet feed wheels, with all of said wheels being set at a helix angle whereby their rotation results in feeding of a workpiece and with control of the feed rate of the workpiece being provided by either varying the rate of rotation of said wheels or the helix angle thereof, or both.

An object of the invention is to provide a power programming system for a centerless grinder having a grinding element and a coacting regulating wheel, drive means for the grinding element including a motor, input feed wheels for feeding a workpiece toward the grinding element, outlet feed wheels for feeding a workpiece from the grinding element, a series of motors for said wheels, means for operating said series of motors, comprising, settable means for setting the desired power to be utilized by said motor in grinding a workpiece, means for sensing the power consumed by the motor for the grinding element, and means for detecting a difference between the consumed power and desired power utilization and for modifying the operating means for the series of motors to feed the workpiece at a rate to have the consumed power match the desired power utilization.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a schematic view of the power programming system for a centerless grinder;

FIG. **2** is a fragmentary plan view of a centerless grinder;

FIG. **3** is a fragmentary elevational view taken generally along the line **3—3** in FIG. **2**; and

FIG. **4** is a side elevational view of the structure at a grinding station of a centerless grinder and taken generally along the line **4—4** in FIG. **2.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

A schematic view of the power programming system is shown in FIG. **1,** with the structure of a centerless grinder shown more particularly in FIGS. **2–4.**

A centerless grinder which may incorporate the power programming system has three major components, as shown generally in FIG. **2.** There is an input feed section for the workpiece, indicated generally at **10,** one or more grinding stations, with one station being indicated generally at **11,** and an outlet feed section for a workpiece, indicated generally at **12.** The structure of a centerless grinder, shown in FIGS. **2–4,** is of the type disclosed in the Schaller U.S. Pat. No. 3,503,156 and the disclosure of said patent is incorporated herein by reference.

The input feed section includes opposed pairs of feed wheels **15** and **16** with the mounting of each being of the same construction and the mounting for one of the feed wheels **16** being shown in FIG. **3.** The main frame of the centerless grinder input or outlet feed section includes a plate **20** mounting a base member **21** which mounts a slidable member **22** having an upstanding flange **23** with an apertured end receiving a trunnion **24** which supports the feed wheel **16** by means of a yoke member **25** rotatably mounting a shaft **26** carrying the feed wheel **16.** With the mounting provided by the slidable member **22,** the spacing between the feed wheels **15** and **16** may be varied. The shaft **26** of each of the feed wheels is driven from a drive shaft **27** with suitable universal joint connections and with an additional drive shaft **28** driving the feed wheels **15.** A motor **30** connects to the drive shaft **27,** with a connecting chain **31** driving a jack shaft which connects to the drive shaft **28.** In order for the feed wheels **15** and **16** to feed a workpiece, they are set at a helix angle whereby rotation thereof imparts linear movement to a workpiece. This helix angle is set by a rod **35** connected to each of the yoke members **25** by a swivel connection and with the rods **35** being connected to linear motors **36,** such as hydraulic cylinders, for linear movement and resulting establishment of helix angles for the wheels **15** and **16.**

The outlet feed section for a workpiece includes opposed pairs of feed wheels **40** and **41** which are mounted in the same manner as the feed wheels **15** and **16** and as shown in FIG. **3.** Rotation thereof is through a pair of drive shafts **42** and **43** driven by a motor **44** in the same manner as the motor **30** drive the drive shafts **27** and **28.** The helix angles thereof are set by linear motors **45** and **46** in the same manner as described in connection with the linear motors **36.**

A typical structure at the grinding station is shown in FIGS. **2** and **4** wherein a grinding element, in the form of a wheel **50,** is supported by a mounting **51** and driven through a belt **52** from a motor **53.** Alternatively, the grinding element may be an endless belt supported by a back-up member, rather than the grinding wheel shown. A workpiece W is shown in position (FIG. **1**) against the grinding element **50** and is supported by a work-engaging blade **55** mounted in a conventional manner for movement in a frame **56.** A regulating wheel **57** is mounted on a support **58** for angular movement relative to a column **59** and with the column being on a slide **60** which is adjustable relative to a base **61.** The regulating wheel **57** is driven through a gear box by a motor **62** and with the supporting mounting for the regulating wheel **57** being tiltable by power from a motor **63** in order to adjust the helix angle of the regulating wheel.

The foregoing structure is shown schematically in FIG. **1.** The motors **30** and **44** for driving the input and outlet feed wheels as well as the motor **62** for driving the regulating wheel may be hydraulic motors as part of a hydrostatic transmission with the hydraulic power source being indicated at **70.** A pair of hydraulic lines **71** and **72** connect the power source **70** with the motor **30.** A pair of hydraulic lines **73** and **74** connect the power source **70** with the motor **44.** A pair of hydraulic lines **75** and **76** connect the power source with the motor **62.** Hydrostatic transmissions of this type are known and include an actuator **77** which may vary the output of the hydrostatic power source **70** to resultingly vary the speed of operation of the motors **30, 44** and **62** and the wheels driven thereby.

An input computer unit **80** has dial-in units **81, 82,** and **83** for setting into the unit the diameter of the workpiece W, the grindability ratio thereof, and the desired depth of cut, respectively. This unit, in a known manner, provides an analog output signal which is an indication of the desired power consumption to be utilized in grinding the workpiece W, taking into account the above variables. The motor **53** for driving the grinding element **50** is shown as an electric motor, with a three line supply having lines **84, 85,** and **86,** and with a power sensor **87** having a sensing coil **88** around the line **86** to sense the actual power consumed by the motor **53** in operating the grinding element **50.**

The power sensor **87** emits an analog signal which is summed with the analog signal from the input computer unit **80** by the summing unit **89** to produce an error signal which is applied via an amplifier **90** to cause the actuator **77** to adjust the hydrostatic power source **70** in one direction or the other to either increase or decrease the speed of the various wheels engaging the workpiece to obtain a match between the desired power consumption and the actual power consumed.

A secondary loop provides for control of the helix angle of the feed wheels **15** and **16** of the input section, the feed wheels **40** and **41** of the outlet section and the regulating wheel **57.** The secondary loop includes a line **100** connected to the outlet side of the summing unit **89** and inputting to a high limit comparator **101** and a low limit comparator **102,** each of which has an adjustable setting to determine a high limit and a low limit respectively for the value of horsepower error. A signal derived from either of the comparators **101** and **102** is supplied to a helix angle up/down counter **103** with an output to a numeric read-out display unit **104** and with a digital to analog converter **105** converting an output from the counter **103** to an analog value which passes through an amplifier **106** and is applied to the motors **36, 45, 46** and **63** which adjust the helix angle of the various wheels in engagement with the workpiece to vary the through-feed rate of the workpiece W. The helix angle control is disclosed as based on minimum and maximum values of horsepower error. If the error becomes very negative, indicating a low load on the motor **53** for the grinding element, the low limit is exceeded as determined by comparator **102** which emits the signal to adjust the helix angle actuating motors. Conversely if the error becomes very positive, indicating high load on the motor **53,** the high limit is exceeded as determined by comparator **101** and the helix angle of the wheels is changed in the opposite direction until the error is below the high limit.

The power programming system through the setting of a desired power consumption in input computer unit **80** sets a predetermined speed for the input and outlet feed wheels and the regulating wheel **57** and with the helix angle of these wheels being at some predetermined value. A workpiece W is then started through the system. In order to avoid premature sensing of the consumed power a probe **110** is interlocked with the power sensor **87** through a line **111.** This probe detects the presence of a workpiece near the exit end of the grinding element **50.** When the presence of a workpiece is sensed, the power sensor **87** then determines the power consumed, with the summing unit **89** comparing the analog output from the power sensor **87** with the set rate of desired power consumption from unit **80** to operate the control as previously described.

All of the wheels for feeding of a workpiece have a trimming (speed) control (not shown) to provide for synchronization therebetween and compensate for wheel wear.

I claim:

1. A power programming system for a centerless grinder having a grinding element, means for feeding a workpiece relative to the grinding element at a selected rate of speed within a variable range of speeds including a regulating wheel and a variable speed drive unit, drive means for the grinding element including a motor, variable means for setting the desired power consumption, means for sensing the power consumption of said motor, and means for continuously comparing the desired power consumption and the actual power consumption and controlling said variable speed drive unit of the workpiece feeding means to have the workpiece travel at a rate to cause the motor to consume power at the set rate during the entire grinding operation.

2. A power programming system as defined in claim **1** wherein the variable means for setting desired power consumption has inputs for grindability, workpiece diameter and depth of cut.

3. A power programming system as defined in claim **1** wherein said workpiece feeding means includes input feed wheels and outlet feed wheels which are disposed at a helix angle similarly to the regulating wheel in order to feed a workpiece by rotation thereof, and means for varying the helix angles of said wheels to have said consumed power equal said desired power consumption.

4. A power programming system as defined in claim **1** wherein said power sensing means is interlocked with a workpiece sensing probe at the grinding element whereby the power is not sensed until a workpiece is being ground by the grinding element.

5. A power programming system as defined in claim **1** wherein said workpiece feeding means includes input feed wheels and outlet feed wheels which are disposed at a helix angle in order to feed a workiece by rotation thereof, and said variable speed drive unit driving all of said wheels.

6. A power programming system as defined in claim **5** wherein the means for controlling the workpiece feeding means includes means to vary the helix angle of said wheels.

7. A power programming system for a centerless grinder having a grinding element and a coacting regulating wheel, drive means for the grinding element including a motor, input feed wheels for feeding a workpiece toward the grinding element, outlet feed wheels for feeding a workpiece from the grinding element, a series of motors for said wheels, variable speed drive means for operating said series of motors, settable means for setting the desired power to be utilized by said motor in grinding a workpiece, means for sensing the power consumed by said motor for the grinding element, and means for continuously detecting a difference between the consumed power and desired power utilization and for continuously modifying the operating means for the series of motors to feed the workpiece at a rate to have consumed power match the desired power utilization.

8. A power programming system as defined in claim **7** wherein said means for operating said series of motors includes a variable master power source connected to each of said series of motors.

9. A power programming system as defined in claim **8** wherein said wheels are all disposed at a helix angle whereby rotation of the wheels feeds a workpiece, and said series of motors adjusting the helix angle of said wheels.

10. A power programming system as defined in claim **7** wherein said settable means for setting the desired power includes inputs for grindability and diameter of a workpiece and desired depth of cut.

11. A power programming system as defined in claim **10** wherein said power sensing means is interlocked with a workpiece sensing probe at the grinding element whereby the power is not sensed until a workpiece is being ground by the grinding element.

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