United States Patent [19]

Fournier

[11] **3,855,734**

[45] **Dec. 24, 1974**

[54] **GRINDING MACHINE WITH WORKPIECE LOCATOR ASSEMBLY**

[75] Inventor: **Roger H. Fournier,** Millbury, Mass.

[73] Assignee: **The Warner & Swasey Company,** Cleveland, Ohio

[22] Filed: **Mar. 28, 1973**

[21] Appl. No.: **345,693**

[52] **U.S. Cl.** ..... **51/165 R,** 51/105 SP, 51/165.92

[51] **Int. Cl.** **B24b 49/00**

[58] **Field of Search** ..... 51/105 SP, 105 R, 165 R, 51/165.83, 165.92

[56] **References Cited**

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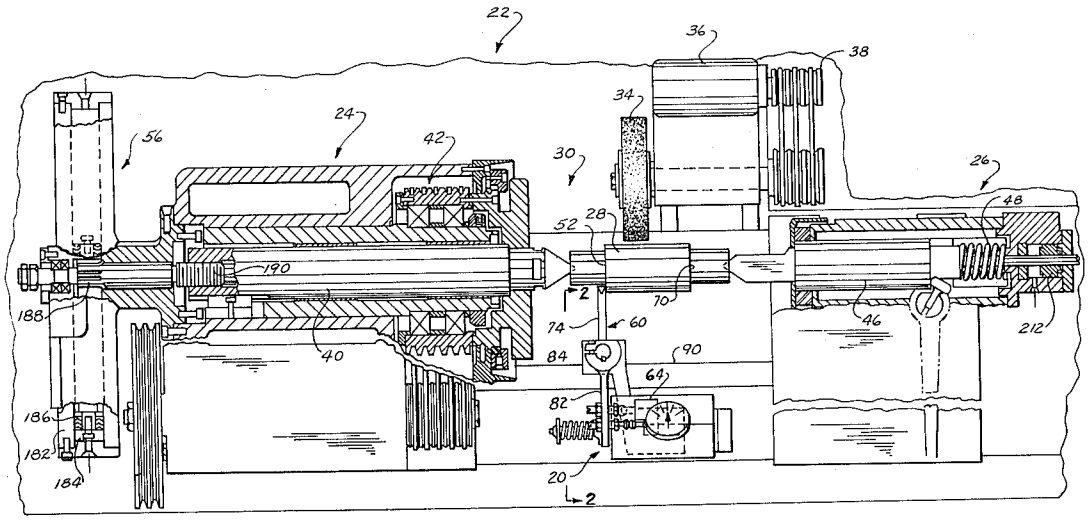
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Primary Examiner—Harold D. Whitehead

[57] **ABSTRACT**

An improved workpiece locator or sensor assembly is utilized in association with a grinding machine to detect when either a left or right reference surface on a workpiece has been moved to a predetermined position in a work area. The workpiece locator assembly includes a probe member which is moved by a double acting motor into engagement with either a right or left reference surface. The probe member is connected with the motor by a yieldable connection which includes two springs of the same free lengths. The workpiece locator assembly can be utilized to locate either a right or left reference surface. In addition, a selector valve can be associated with the motor to effect operation of the locator assembly to first locate a right reference surface on one workpiece and to subsequently locate a left reference surface on a second workpiece without disassembling the locator assembly.

18 Claims, 12 Drawing Figures



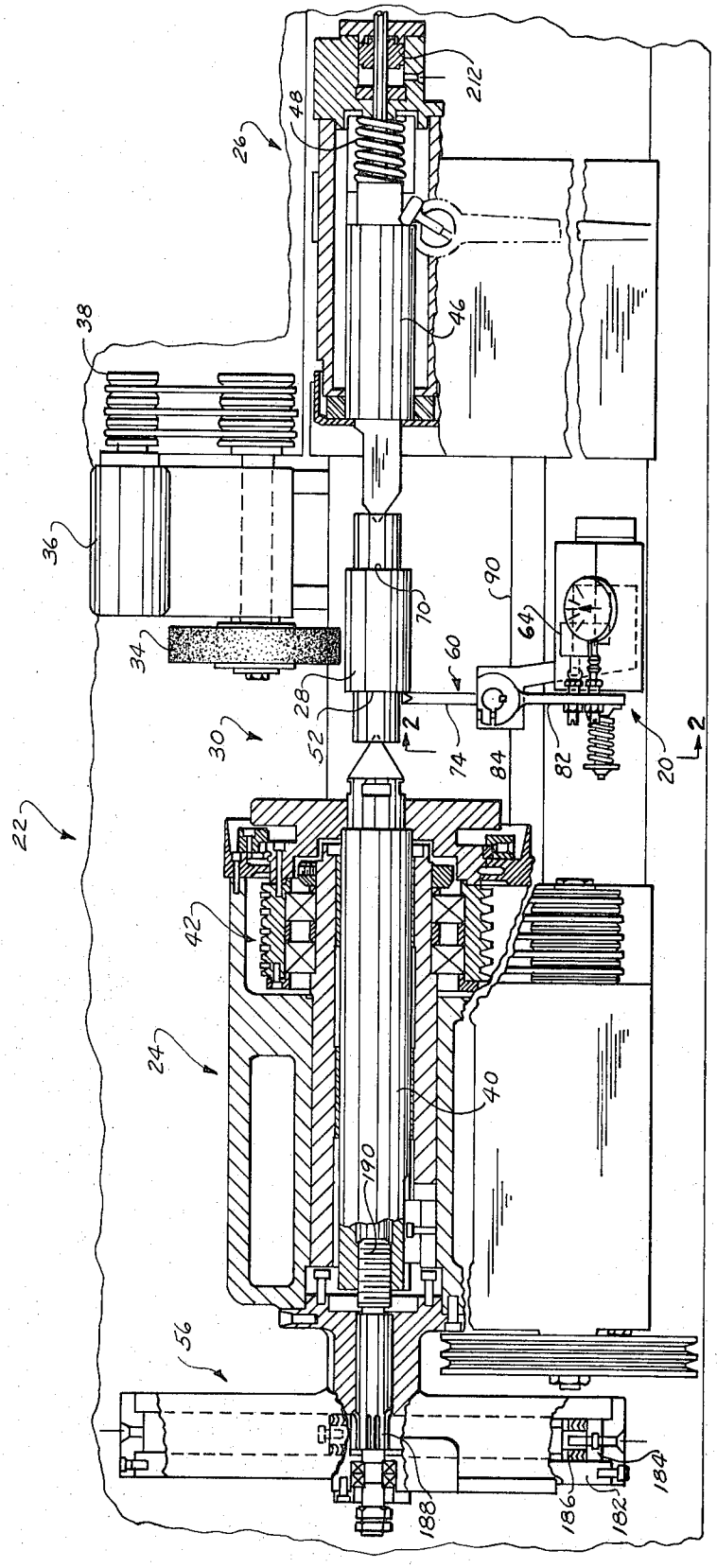

212
48
26
46
38
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70
90
64
34
60
28
30
52
74
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82
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FIG. 1

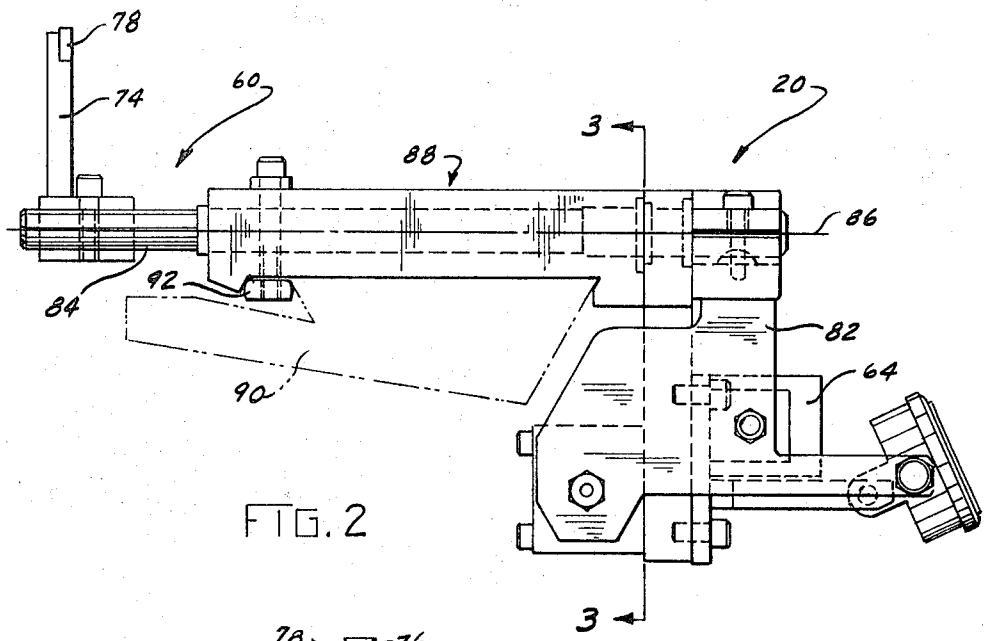


FIG. 2

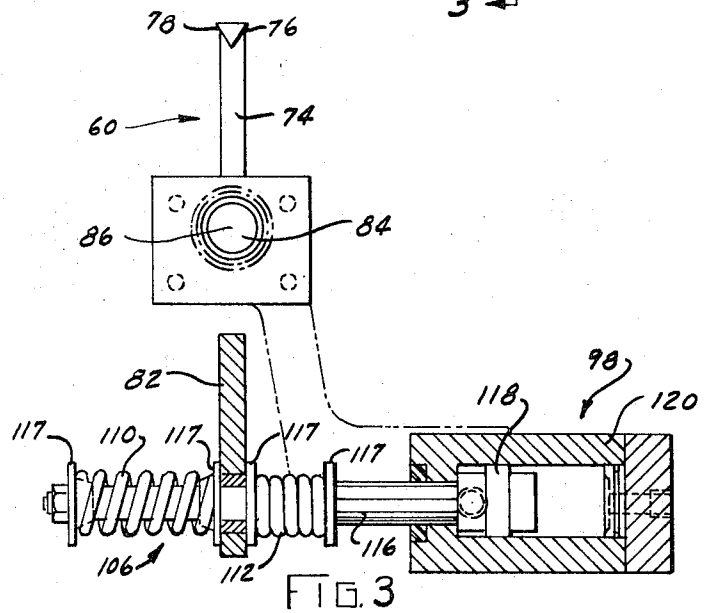


FIG. 3

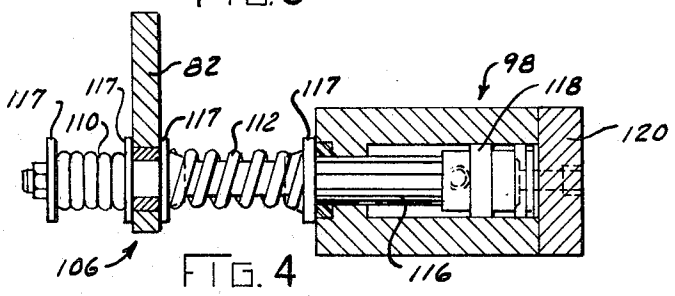


FIG. 4

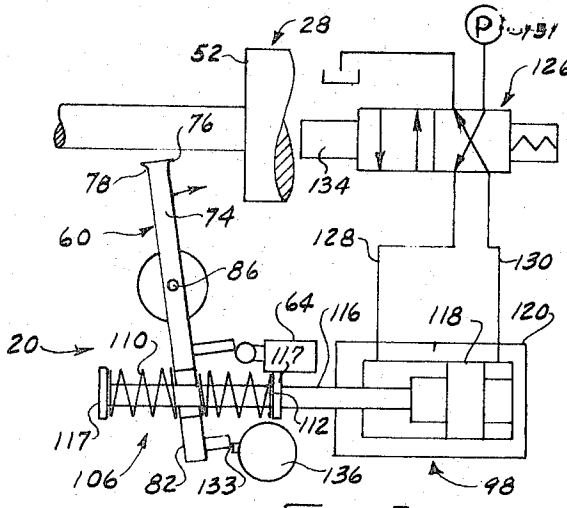


FIG. 5

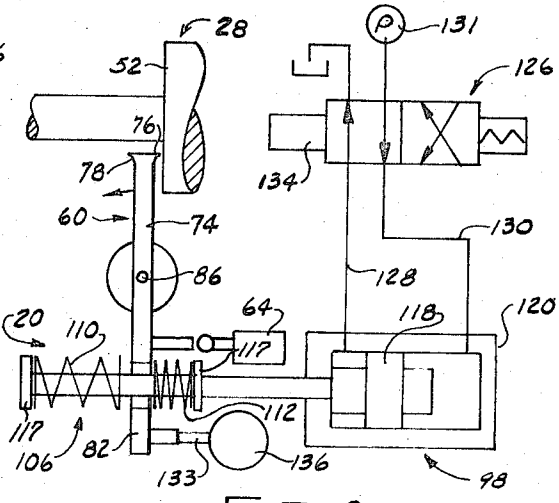


FIG. 6

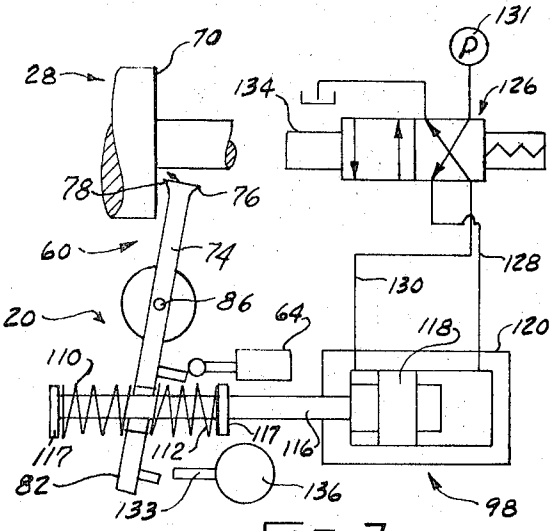


FIG. 7

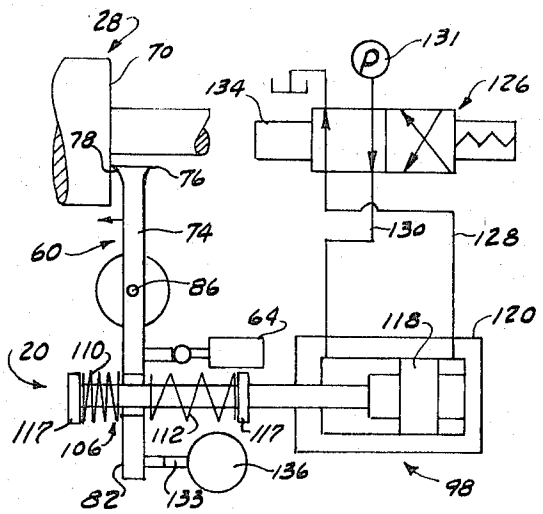


FIG. 8

FIG. 9

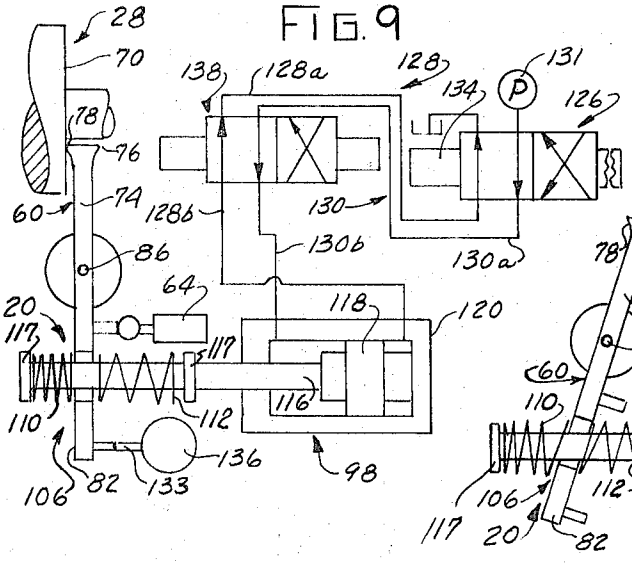
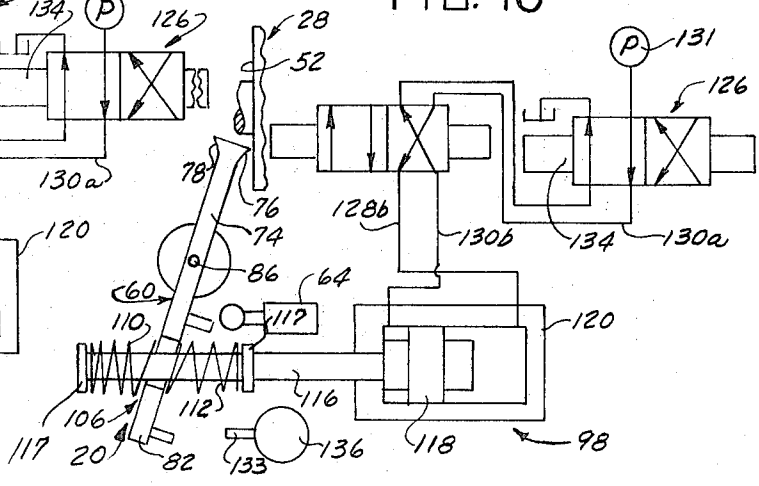


FIG. 10



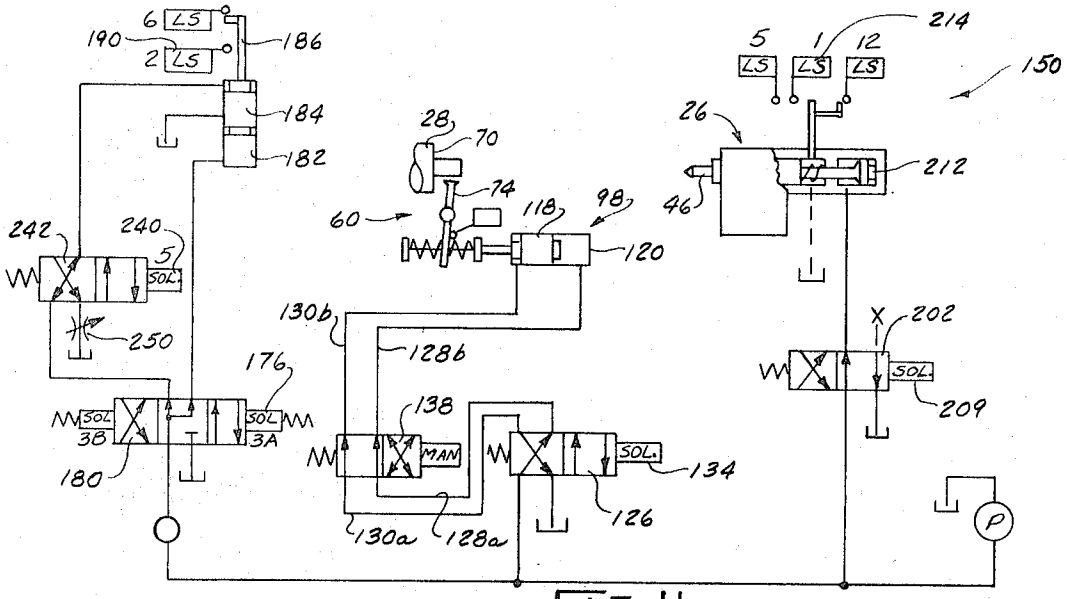

6 LS
190
2 LS
186
184
182
242
240
5
SOL
250
176
SOL 3B
SOL 3A
180
28
70
74
60
118
98
120
130b
128b
138
MAN
SOL.
134
126
130a
128a
5
1
12
LS
214
150
26
212
46
202
X
SOL.
209
P

FIG. 11

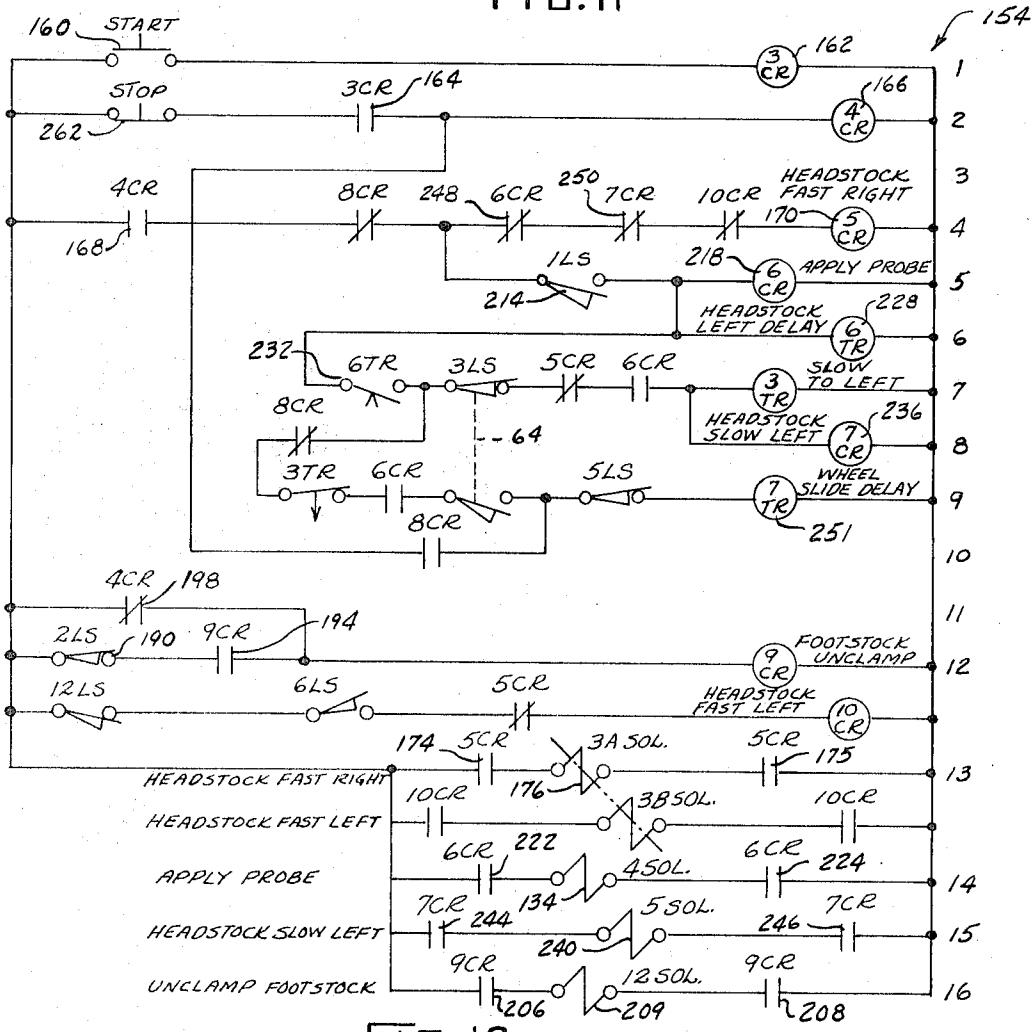

160 START
STOP
262
3CR 164
3 CR 162
4 CR 166
4CR
168
8CR
248
6CR
250
7CR
10CR
HEADSTOCK FAST RIGHT
170
5 CR
1LS
214
218
6 CR
APPLY PROBE
HEADSTOCK LEFT DELAY
6 TR 228
232
6TR
3LS
5CR
6CR
3 TR
SLOW TO LEFT
8CR
64
HEADSTOCK SLOW LEFT
7 CR 236
3TR
6CR
5LS
WHEEL SLIDE DELAY
7 TR
251
8CR
4CR 198
2LS
190
9CR
194
9 CR
FOOTSTOCK UNCLAMP
12LS
6LS
5CR
HEADSTOCK FAST LEFT
10 CR
174
5CR
3A SOL.
5CR
175
HEADSTOCK FAST RIGHT
10CR
176
3B SOL.
10CR
HEADSTOCK FAST LEFT
6CR
222
4 SOL.
6CR
224
APPLY PROBE
7CR
244
134
5 SOL.
7CR
246
HEADSTOCK SLOW LEFT
240
9CR
12 SOL.
9CR
UNCLAMP FOOTSTOCK
206
209
208
154
1
2
3
4
5
6
7
8
9
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11
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FIG. 12

GRINDING MACHINE WITH WORKPIECE LOCATOR ASSEMBLY

BACKGROUND OF THE INVENTION

This invention relates generally to a workpiece locator assembly and more specifically to the workpiece locator assembly which can be utilized to detect when either a right or a left reference surface on a workpiece is in a desired position.

There are many known workpiece locator assemblies which are utilized to determine when a reference surface is in a predetermined position relative to a grinding wheel or a cutting tool. Generally speaking, these workpiece locator assemblies are constructed so that they can be utilized to detect the position of either a right reference surface or a left reference surface relative to the work area. These known workpiece locator assemblies cannot be utilized, without extensive modifications or changes, to sequentially locate a right reference surface relative to the work area and then to locate a left reference surface relative to the work area. Thus, these known workpiece locator assemblies are utilized to locate reference surfaces which face the same direction relative to the work area, that is for the purpose of locating only right reference surfaces or only left reference surfaces relative to the work area. One of those knownn workpiece locator assemblies is disclosed in U.S. Pat. No. 3,064,395.

Another known workpiece locator assembly is utilized to determine when two reference surfaces which face toward each other are in a desired position in a work area. This known locator assembly includes a rotatable cam which is disposed on the outer end of a probe member. This cam is rotated so that opposite side surfaces on the cam simultaneously engage the two reference surfaces. The construction of this known locator assembly is disclosed on U.S. Pat. No. 3,098,328.

SUMMARY OF THE PRESENT INVENTION

A workpiece locator assembly constructed in accordance with the present invention can be utilized to detect when a right or left reference surface is in a predetermined position in a work area. To facilitate sequential operation on workpieces having different shapes, the locator assembly can be utilized to locate a right reference surface on one workpiece relative to the work area and to subsequently locate a left reference surface without disassembling the locator assembly. The locator assembly includes a probe member having a first side surface for engaging a left reference surface on a workpiece during the locating of this workpiece in a predetermined position in a work area. The probe member also has a second side surface which engages a right reference surface on another workpiece as it is being positioned in the work area.

The probe member is connected with a double acting motor by a yieldable connection which enables the probe member to move relative to the motor. This yieldable connection includes a pair of springs of the same free length. The springs press the probe member against the workpiece so that the probe member will follow the workpiece as it moves to the predetermined position. Thus, if the locator assembly is to be utilized to detect when workpieces having a right reference surface are disposed in a predetermined position in a work area, one of the two springs presses one side of the probe member against the right reference surface. If the locator assembly is utilized to determine when a left reference surface is in a predetermined position in the work area, the other spring presses the opposite side of the probe member against the left reference surface.

To enable the locator assembly to be utilized to sequentially locate a right reference surface on a first workpiece relative to a work area and to thereafter locate a left reference surface on another workpiece relative to the work area, a selector valve is associated with the motor. Actuation of this selector valve to a first position enables the motor to pivot the probe member in a first direction from an inactive condition to an active condition when the probe member is to be utilized to locate the right reference surface. Similarly, actuation of the selector valve to a second position enables the motor to pivot the probe member in a second direction from an inactive condition to an active condition when the probe member is to be utilized to locate a left reference surface.

Accordingly, it is an object of the present invention to provide a new and improved workpiece locator assembly which can be utilized to detect when either a right or a left reference surface on a workpiece is in a predetermined position in a work area.

Another object of this invention is to provide a new and improved workpiece locator assembly which can be utilized to detect when a right reference surface on a first workpiece is in a predetermined position in a work area and to subsequently detect when a left reference surface on a second workpiece is in a predetermined position relative in the work area.

Another object of the invention is to provide a new and improved workpiece locator assembly having a probe member which is connected with a motor by a yieldable connection which is formed by a pair of springs which are disposed on opposite sides of the probe member in a coaxial relationship with each other.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and features of the present invention will become more apparent upon a consideration of the following description taken in connection with the accompanying drawings wherein:

FIG. **1** is a partially broken away illustration of a grinding machine having a workpiece locator assembly constructed in accordance with the present invention;

FIG. **2** is an enlarged elevational view, taken along the line **2—2** of FIG. **1**, further illustrating the construction of the workpiece locator assembly;

FIG. **3** is a sectional view, taken generally on the line **3—3** of FIG. **2**, illustrating the condition of a pair of springs in a yieldable connection which interconnects a probe member and double acting motor in the locator assembly as a right reference surface moves to a predetermined position in a work area;

FIG. **4** is a fragmentary sectional view, generally similar to FIG. **3**, illustrating the condition of the pair of springs as a left reference surface moves to a predetermined position in the work area;

FIG. **5** is a schematic illustration of the locator assembly in an inactive condition with the springs in an initial condition in which they are compressed to the same length;

FIG. **6** is a schematic illustration of the locator assembly of FIG. **5** in an active condition in which the

springs are in the condition shown in FIG. 3 and the locator assembly is effective to detect when a right reference surface is in a predetermined position;

FIG. 7 is a schematic illustration of the locator assembly in an inactive condition with the springs in the initial condition;

FIG. 8 is a schematic illustration of the locator assembly of FIG. 7 in an active condition in which the springs are in the condition shown in FIG. 4 and the locator assembly is effective to detect when a left reference surface is in a predetermined position;

FIG. 9 is a schematic illustration of a second embodiment of the locator assembly in an active condition in which it is effective to detect when a left reference surface on a workpiece is in a predetermined position;

FIG. 10 is a schematic illustration of the locator assembly of FIG. 9 being utilized to detect when a right reference surface on another workpiece is in a predetermined position;

FIG. 11 is a schematic illustration of hydraulic control circuitry which is utilized in association with the grinding machine of FIG. 1; and,

FIG. 12 is a schematic illustration of electrical control circuitry of FIG. 11.

DESCRIPTION OF SPECIFIC PREFERRED EMBODIMENTS

A workpiece locator or sensor assembly **20** is illustrated in association with a known grinding machine **22** having a headstock **24** and a tailstock **26** which cooperate to support and rotate a workpiece **28** in a work area **30.** During operation of the grinding machine **22,** a grinding wheel **34** is rotated by a motor **36** through a drive train **38** to cut material from the workpiece **28** as it is rotated about its central axis under the influence of forces transmitted to a headstock spindle **40** by a multi-sheave pulley arrangement **42.** A tailstock spindle **46** is pressed against the workpiece **28** under the influence of a biasing spring **48.**

To locate a shoulder or reference surface **52** in a desired position, the headstock **24** and tailstock **26** are first adjusted to locate the workpiece **28** in a position in which the reference surface is to the right of the desired position. A drive arrangement **56** is then activated to move the headstock spindle **40** toward the left (as viewed in FIG. **1**). The spring biased spindle **46** of the tailstock **26** presses the workpiece **28** toward the left as the headstock spindle **40** is moved leftwardly.

When the workpiece **28** has been moved axially toward the left through a distance sufficient to move the reference surface **52** into the desired position relative to the work area **30,** a probe assembly **60** is pivoted in a counter clockwise direction (as viewed in FIG. **1**) to actuate a detector switch **64.** Actuation of the detector switch **64** interrupts operation of the drive arrangement **56** with the reference surface **52** in the desired position relative to the grinding wheel **34.** The construction and general mode of operation of the grinding machine **22** is the same as is disclosed in U.S. Pat. No. 3,171,234 and to avoid prolixity of description, the disclosure in that patent is to be considered as being incorporated herein in its entirety by this reference thereto.

In accordance with the present invention, the workpiece locator assembly **20** can be utilized to detect when either the right reference surface **52** or a left reference surface **70,** is in a predetermined position in the work area **30.** Accordingly, the probe assembly **60** includes a probe member **74** (see FIGS. **2** and **3**) having a first side or locating surface **76** (FIG. **3**) which engages the right shoulder or reference surface **52** and a second side or locating surface **78** which engages the left shoulder or reference surface **70.** Regardless of which locating surface on the probe member is being utilized, an actuator arm **82** and support shaft **84** (FIGS. **2** and **3**) are rotated about a central axis **86** to actuate the detector switch **64** (FIG. **1**) when a reference surface **52** or **70** engaged by a side or locating surface **76** or **78** on the probe member **74** is moved to the predetermined position in the work area **30.** To enable the locator assembly **20** to be utilized with different lengths of workpieces, the locator assembly includes a carriage **88** (FIG. **2**) which is slidably mounted on a bedway **90.** A suitable clamping arrangement **92** is provided to lock the carriage **88** in a position such that the actuator arm **82** will actuate the limit switch **64** when a reference surface engaged by the probe member **74** is in a desired position in the work area **30.**

A double acting fluid motor **98** is utilized to pivot the probe member **74** about the axis **86** from an inactive position in which the side or locating surfaces **76** and **78** are spaced apart from the reference surfaces **52** and **70** (FIGS. **5** and **7**) and an active position in which one of the locating surfaces **76** or **78** is engaged by one of the reference surfaces **52** or **70** (FIGS. **6** and **8**). Thus, when the locator assembly **20** is to be utilized to detect when a right shoulder or reference surface **52** is in a predetermined position in the work area **30,** the double acting motor **98** pivots the probe member **74** in a clockwise direction from the inactive condition of FIG. **5** to an active condition. When the probe member **74** is in the active condition, leftward movement of the workpiece brings the reference surface **52** into engagement with the side surface **76** on the probe member **74.** Continued leftward movement of the workpiece **28** under the influence of the head and tailstocks **24** and **26** causes the probe member **74** to be pivoted in a counterclockwise direction (as viewed in FIGS. **5** and **6**) to actuate the limit switch **64** when the reference surface **52** has been moved to the desired position in the work area **30** (as illustrated in FIG. **6**).

Similarly, when the workpiece locator assembly **20** is to be utilized to detect when the left reference surface or shoulder **70** is in a predetermined position in the work area **30,** the motor **98** is activated to move the probe member **74** from an inactive condition (FIG. **7**) in which the side or locating surface **78** is spaced from the reference surface **70** to an active condition in which the side locating surface **78** engages the reference surface **70** (FIG. **8**). Thus, the motor **98** is actuated to pivot the probe member **74** in a counterclockwise direction about the axis **86** toward the active condition of FIG. **8.** As the probe member **74** is pivoted toward the active condition, the side surface **78** on the probe member **74** moves into abutting engagement with the left reference surface **70.**

After the probe member **74** has engaged the left reference surface **70,** the workpiece **28** is then moved towards the left (as viewed in FIG. **1**) under the influence of the head and tailstocks **24** and **26.** When the reference surface **70** is located in the desired position in the work area **30,** the actuator arm **82** actuates the detector switch **64** (FIG. **8**) to interrupt the leftward axial movement of the workpiece **28** under the influence of the head and tailstocks **24** and **26.**

The probe member 74 and actuator arm 82 are in the same orientation when the detector switch 64 is actuated to indicate that a right reference surface 52 is in a predetermined position (see FIG. 6) as when the detector switch is actuated to indicate that a left reference surface 70 is in its predetermined position (see FIG. 8). However, the probe member 74 is pivoted in one direction from an inactive condition to engage the right reference surface 52 and is pivoted in the opposite direction from an inactive condition to engage the left reference surface 70. This requires that the motor 98 be operated in one direction to move the probe member 74 into engagement with a right reference surface 52 and in the opposite direction to move the probe member into engagement with a left reference surface 70.

To enable the motor 98 to be utilized to pivot the probe member in opposite directions from inactive conditons to active conditions, the probe assembly 60 is connected with the double acting motor by a yieldable connection 106. The yieldable connection 106 (FIG. 3) includes two identical springs 110 and 112 which have the same free length and are disposed in a coaxial relationship with each other. The springs 110 and 112 are mounted on a piston rod 116 with washers 117 and are compressed to about three-quarters of their free length when the springs are in the initial condition of FIGS. 5 and 7. The piston rod 116 is connected with a piston 118 in a cylinder 120 of the double acting motor 98.

Since the springs 110 and 112 have the same free length and spring rate, they are both compressed to the same length between washers 117 when the probe member 74 is in the inactive condition of FIG. 7. In the inactive condition of FIG. 5, the spring 110 is compressed somewhat due to engagement of the probe member 74 with switch 64. Upon operation of the motor 98 to move the probe member 74 from the inactive conditon to the active condition of either FIG. 6 or 8, the probe member 74 moves into engagement with the reference surface 52 or 70 and continued operation of the motor 98 compresses one of the springs 110 or 112 and at least parially relaxes the other spring.

Thus, when the motor 98 is operated from the condition shown in FIG. 5 to the condition shown in FIG. 6, the probe member 74 is pivoted from the inactive condition to the active condition. During this pivoting movement of the probe member, the side surface 76 on the probe member moves in abutting engagement with the reference surface 52. Continued operation of the motor 98 results in the spring 112 being compressed while the spring 110 is partially relaxed. At this time, the right reference surface 52 is to the right of the position shown in FIG. 6 and the spring 112 presses the side surface 76 firmly against the reference surface 52.

As the workpiece 28 is moved toward the left from the position shown in FIG. 5 to the position shown in FIG. 6 under the influence of the head and tailstocks 24 and 26, the probe member 74 is pivoted in a counterclockwise direction about the axis 86 to further compress the spring 112. When the reference surface 52 reaches the position shown in FIG. 6, the probe member 74 will have been pivoted through a sufficient distance to actuate the detector switch 64 to interrupt operation of the head and tailstocks 24 and 26. At this time the springs 110 and 112 are in the condition shown in FIG. 3 with the spring 110 at least partially relaxed and the spring 112 almost fully compressed.

Similarly, when the locator assembly 20 is to be utilized to detect when a left reference surface 70 is in a predetermined position relative to the work area, the motor 98 is operated from the condition shown in FIG. 7 to the condition shown in FIG. 8 to swing the probe member in a counterclockwise direction from the inactive position in FIG. 7. When the probe member 74 is in the inactive position of FIG. 7, the springs 110 and 112 have the same length. However, as the probe member 74 pivots in a counterclockwise direction, the side surface 78 moves into abutting engagement with the reference surface 70. Continued operation of the motor 98 moves the piston rod 116 relative to the probe member 74 to compress the spring 110 and partially relax the spring 112. The compressed spring 110 holds the side surface 78 of the probe member 74 firmly against the reference surface 70.

As the workpiece 28 is moved toward the left (as shown in FIGS. 7 and 8), under the influence of the head and tailstocks 24 and 26, the spring 110 pivots the probe member 74 in a counterclockwise direction. As the reference surface 78 reaches the predetermined position in the work area 30, the probe member 74 moves into the position shown in FIG. 8 and the detector switch 64 is actuated to interrupt movement of the workpiece 28. It should be noted that at this time the springs 110 and 112 will be in the condition shown in FIG. 4.

When the workpiece locator assembly 20 is to be utilized to detect the right reference surface 52 is in a predetermined position relative to the work area 30, the main control valve 126 is connected with the cylinder 120 of the motor 98 by conduits 128 and 130 in the manner illustrated in FIG. 5. When the main control valve 126 is in its normal or unactuated condition, fluid under pressure is ported to the conduit 128 and the rod end of the cylinder 120 from a pump 131 and the head end of the cylinder 120 is connected with drain through the conduit 130. Since the springs 110 and 112 are arranged as shown in FIG. 5, the spring 110 is compressed somewhat since the actuator arm 82 will engage an input member 133 to a pressure gauge 136 (FIG. 5).

Actuation of the main control valve 126 (FIG. 6) results in fluid under pressure being ported to the conduit 130 which is connected with the head end of the cylinder 120. This results in movement of the piston 118 to swing the probe member 74 in a clockwise direction from the inactive condition of FIG. 5 to the active condition.

When the probe member 74 is initially moved to the active position, the right reference surface 52 is disposed to the right of the position shown in FIG. 6 and, the actuator arm 82 is ineffective to actuate the switch 64. As the workpiece 28 is moved toward the left (as viewed in FIG. 5) under the influence of the head and tailstocks 24 and 26, the right reference surface 52 pivots the probe member 74 in a counter clockwise direction about the axis 86. This pivotal movement of the probe member 74 causes the actuator arm 82 to further compress the spring 112 and actuate the detector switch 64 when the right reference surface 52 is in a predetermined position relative to the work area 30 (FIG. 6). It should be noted that the actuator arm 82 and probe member 74 are movable relative to the pis-

ton rod **116** against the influence of the springs **110** and **112.** The springs **110** and **112** will be in the condition shown in FIG. **3** when the reference surface **52** reaches the predetermined position.

When the workpiece locator assembly **20** is to be used to detect when a left reference surface or shoulder **70** on a workpiece **28** is in a predetermined position relative to the work area **30,** the conduit **130** is connected with the rod end of the cylinder **120** and the conduit **128** is connected with the head end of the cylinder **120** in the manner shown in FIG. **7.** Therefore, when the main control valve **126** is in the normal or unactuated position, fluid under pressure is conducted to the head end of the cylinder **120** to extend the piston rod **116** in the manner shown in FIG. **7.** The springs **110** and **112** hold the probe member **74** in the inactive condition in FIG. **7** and the piston **118** at the left end of the cylinder **120.**

Upon actuation of the main control valve **126,** high pressure fluid is ported to the conduit **130** and the rod end of the cylinder **120.** This results in rightward movement of the piston **118** to pivot the probe member **74** in a counterclockwise direction. This moves the side or locating surface **78** on the probe member **74** into abutting engagement with the left reference surface **70.** At this time the reference surface **70** will be to the right of the position shown in FIG. **8.** Therefore, the piston rod **116** will continue to move relative to the probe member **74** and the spring **110** will be compressed.

As the workpiece **28** is moved toward the left from the position shown in FIG. **7** to the position shown in FIG. **8** under the influence of the head and tailstocks **24** and **26,** the spring **110** urges the probe member **74** in a counterclockwise direction about the axis **86** to maintain the locating surface **78** in abutting engagement with the left reference surface **70.** As the reference surface **70** reaches a predetermined position in the work area **30,** the probe member **74** moves to the position shown in FIG. **8** under the influence of spring **110.** The spring **110** is then effective to press the actuator arm **82** against the detector switch **64** and pressure gauge **136** to positively actuate the detector switch. Actuation of the detector switch **64** effects the operation of cylinder control circuitry to interrupt movement of the workpiece **28** by the head and tailstocks **24** and **26.** It should be noted that the springs **110** and **112** are in the condition shown in FIG. **4** when the actuator arm **82** is effective to actuate the switch **64.**

In the embodiment of the invention disclosed in FIGS. **5–8,** the main control valve **126** is spring biased to the normal position illustrated of FIGS. **5** and **7** and is actuated from this normal position by an energization of a solenoid **134.** Since the solenoid **134** is energized to effect operation of the probe assembly **60** from the inactive position of either FIG. **5** or FIG. **7** to the active position of either FIG. **6** or FIG. **8,** the main control valve **126** can be utilized with the same machine control circuitry regardless of whether the probe assembly **60** is to be used to detect a right or left reference surface. However, it is necessary to reverse the connections of the conduits **128** and **130** with the fluid motor **98.** Of course, if desired, the main valve **126** could be changed rather than changing the connections for the conduits **128** and **130.**

It is contemplated that under certain circumstances the grinding machine **22** may be utilized to sequentially operate on workpieces having reference surfaces facing in opposite directions. Thus, the grinding machine **22** may be utilized to shape a workpiece having a right reference surface or shoulder **52** and then subsequently utilized to shape a workpiece having a left reference surface or shoulder **70.** The conduits **128** and **130** could be changed from the condition shown in FIG. **5** to the condition shown in FIG. **6** when the machine is to be changed from operating on a workpiece having a right reference surface **52** to the workpiece having a left reference **70.** However, changing the conduits **128** and **130** contributes to the down-time of the grinding machine **22.**

Accordingly, a selector valve **138** is connected with the conduits **128** and **130** in the manner shown in FIGS. **9** and **10** to enable the probe assembly **60** to be quickly changed from a condition locating a left reference surface **70** (FIG. **9**) to a condition locating a right reference surface **52** (FIG. **10**). The selector valve **138** is connected with the main control valve **126** by a conduit **128***a* and is connected with the head end of the cylinder **120** by a conduit **128***b*. The selector valve **138** is also connected with the main control valve **126** by conduit **130***a* and is connected with the rod end of the cylinder **120** by a conduit **130***b*. Actuation of the selector valve **138** between the condition shown in FIG. **9** and the condition shown in FIG. **10** merely reverses the flow of fluid to the motor **98.**

When the probe assembly **60** is to be utilized to locate a left reference surface **70,** the selector valve **138** connects the conduit **128***a* with the conduit **128***b* and the conduit **130***a* with the conduit **130***b*. Acutation of the main control valve **126** from the position shown in FIG. **7** to the position shown in FIG. **9** effects operation of the motor **98.** This operation of the motor **98** moves the probe member **74** from the inactive condition of FIG. **7** toward the active condition of FIG. **9.** Of course, when the left reference surface **70** is moved to a predetermined position in the work area **30,** the actuator arm **82** actuates the detector switch **64** in the manner previously explained in association with FIG. **8.**

If the next succeeding workpiece **28** has a right reference surface **52,** the selector valve **138** is operated to the condition shown in FIG. **10** to reverse the fluid connections between the main control valve **126** and motor **98.** Thus, the selector valve connects the conduit **128***a* with the conduit **130***b* and the conduit **130***a* with the conduit **128***b*. Actuation of the main control valve **126** from the initial position of FIG. **5** to the activated position of FIG. **10** effects operation of the motor **98.** This operation of the motor **98** moves the probe member **74** from an inactive condition to the active condition of FIG. **10.** As the right reference surface **52** is moved to the desired position relative to the work area **30** under the influence of the head and tailstocks **24** and **26,** actuator arm **82** compresses the spring **112** and activates the detector switch **64** in a manner similar to that previously explained in association with FIG. **6.**

A hydraulic control circuit **150** for coordinating operation of the probe assembly **60** with operation of the head and tailstocks **24** and **26** is illustrated in FIG. **11** in association with the workpiece **28** having a left reference surface **70.** During operation of the grinding machine **22,** various valves shown in association with the hydraulic circuitry of FIG. **11** are activated by the electrical circuitry **154** of FIG. **12.**

When the grinding machine **22** is to be utilized to shape a workpiece **22** having a left reference surface

70, an operator positions the workpiece between the head and tail stock spindles 40 and 46. A start switch 160 (line 1 of the control circuit 154) is then closed to energize a 3CR relay 162 having contacts 164 (line 2) which are closed to effect energization of a 4CR relay 166. Energization of the 4CR relay 166 closes its contacts 168 (line 4) to complete a circuit for energizing the 5CR relay 170. The 5CR relay 170 then closes contacts 174 and 175 (line 13) to complete a circuit to energize a 3A solenoid 176.

Energization of the 3A solenoid 176 actuates a headstock control valve 180 toward the left (as viewed in FIG. 11) to port fluid under pressure to the rod end of a cylinder 182 and connects the head end of the cylinder with drain. The cylinder 182 is located in the headstock spindle drive assembly 56 (see FIG. 1). Porting fluid under pressure into the rod end of the cylinder 182 moves a piston 184 from the position shown in FIG. 11 to the position shown in FIG. 1. During this movement of the piston 184, a rack gear 186 rotates a pinion 188 (FIG. 1) which is connected to a screw 190. Rotation of the pinion 188 and screw 190 moves the headstock spindle quickly toward the right (as viewed in FIG. 1).

Upon completion of the stroke of the piston 184, a 2LS switch 190 (FIG. 11 and line 12 of FIG. 12) is opened to effect deenergization of a 9CR relay 192. It should be noted that the 9CR relay was previously held energized over its own normally open contacts 194 (line 12). The 9CR relay 192 was initially energized in a circuit including closed contacts 198 (line 11) of the 4CR relay 166.

Deenergization of the 9CR relay 192 effects actuation of a valve 202 (FIG. 11) to clamp the tailstock 26. Thus, energization of the 9CR relay opens contacts 206 and 208 (line 16 of FIG. 12) to effect energization of solenoid 209 and activation of the valve 202. This results in movement of a piston 212 in the headstock 26 under the influence of the spring 48 to press the headstock spindle 46 firmly against the workpiece 28. As the piston 212 moves toward the left (as viewed in FIG. 11) the 1LS switch 214 is actuated. Actuating the 1LS switch 214 completes a circuit to energize a 6CR relay 218 (FIG. 12, line 5) by a circuit which includes the now closed contacts 168 of the 4CR relay 166.

Energization of the 6CR relay 218 effects operation of the probe assembly 60 from the inactive condition of FIG. 7 to the active condition of FIG. 9. Thus upon energization of the 6CR relay, contacts 222 and 224 (line 14 of FIG. 11) are closed to energize the solenoid 134 (see FIG. 11 and line 14 of FIG. 12). As was previously explained, energization of the solenoid 134 operates the main control valve 126 to port fluid under pressure to the selector valve 138 through the conduit 130a. The selector valve 138 was previously actuated manually to the left reference surface sensing condition of FIG. 9. Therefore, energization of the solenoid 134 and operation of the main control valve 126 effects movement of the probe member 74 in a counter clockwise direction (as viewed in FIG. 9) to the active condition in which the locating surface 78 is disposed in abutting engagement with the reference surface 70 on the workpiece 28.

In addition to effecting energization of the 6CR relay 218, closing of the 1LS switch 214 (line 5 of FIG. 12) completes a circuit to effect energization of a 6TR relay 228 (line 6 of FIG. 12) which is of the time delay type. After the probe assembly 60 has been moved to the active condition of FIG. 9, the 6TR relay 228 times out to close its contacts 232 (line 7 of FIG. 12). Closing the contacts 232 completes a circuit to energize a 7CR relay 236 (line 8 of FIG. 12).

Energization of the 7CR relay 236 completes a circuit to energize a solenoid 240 (line 15) which actuates a valve 242 in the hydraulic circuitry 150 (FIG. 11) to effect slow movement of the headstock 24 toward the left (as viewed in FIG. 1). Thus, energization of the 7CR relay 236 closes contacts 244 and 246 (line 15 of FIG. 12) to energize the solenoid 240 and actuate the valve 242. It should be noted that the 5CR relay 170 (line 4 of FIG. 12) was previously energized so that normally closed contacts 248 of a 6CR relay 218 are open. If, for some reason, the normally opened contacts 248 of the 6CR relay should hang up, normally opened contacts 250CR of the relay assure that the 5CR relay 170 is deenergized to effect energization of the 7CR relay 236 and solenoid 176 prior to the energization of the solenoid 240. Therefore, the control valve 180 is in its unactuated position illustrated in FIG. 11. This enables high pressure fluid to flow to the head end of the cylinder 182.

Upon energization of the solenoid 240, the valve 242 (FIG. 11) is actuated to connect the rod end of the cylinder 182 with drain through an orifice 250 so that the piston 184 and the rack gear 186 move slowly upward (as viewed in FIGS. 1 and 11). This results in the pinion 188 and screw 190 (FIG. 1) being rotated to gradually retract the headstock spindle 40 toward the left (as viewed in FIG. 1). The spring 48 holds the tailstock spindle 46 firmly against the workpiece 28 as it is moved toward the left.

When the workpiece 28 has been moved toward the left (as viewed in FIGS. 1 and 9) through a distance sufficient to move the reference surface 70 into a predetermined position relative to grinding wheel 34, the detector switch 64 is closed by the actuator arm 82 in the manner previously explained. Actuation of the detector switch 64 (line 7 of FIG. 12) effects deenergization of the 7CR relay 236 (line 8 of FIG. 12) to deenergize the solenoid 240 (line 15 of FIG. 12). The deenergization of solenoid 240 results in the spring biased control valve 242 (FIG. 11) being actuated back to its normal position in which the piston 184 is locked in position to hold the workpiece in the predetermined location. In addition, actuation of the detector switch 64 completes the circuit to energize a 7TR relay 251 (line 9, FIG. 12) which, after a time delay, effects operation of control circuitry (not shown) to move the grinding wheel 34 into engagement with the workpiece 28. The general mode of operation of the grinding machine is similar to that described in U.S. Pat. No. 3,171,234 and will not be further described herein.

When operations on the workpiece have been completed, stop switch 262 is actuated (line 2 of FIG. 12) to deenergize the 4CR relay 166. Deenergization of the 4CR relay 166 results in closing of its contacts 198 (line 11 of FIG. 12) to energize the 9CR relay 192 (line 12 of FIG. 12). Energization of the 9CR relay 192 energizes the solenoid 209 (line 16 of FIG. 12) to actuate the valve 202 (FIG. 11) and release the footstock 26. In addition, deenergization of the 4CR relay 166 results in opening of its contacts 168 (line 4 of FIG. 12) to deenergize the 6CR relay 218 so that the solenoid 134 (line 14 of FIG. 12) is also deenergized. The deenergiz-

ation of the solenoid **134** results in operation of the spring biased main control valve **126** to effect movement of the probe assembly **60** from the active condition to the inactive condition.

In view of the fore going description is is apparent that the workpiece locator assembly **20** can be utilized to detect when a right reference surface **52** or a left reference surface **70** is in a predetermined position in a work area. To facilitate sequential operation on workpieces **28** having different shapes, the locator assembly **20** can be utilized to locate a right reference surface **52** on one workpiece relative to the work are **30** and to subsequently locate a left reference surface **70** without disassembling the locator assembly.

The probe member **74** is connected with a double acting motor **98** by a yieldable connection **106** which enables the probe member to move relative to the motor. The yieldable connection **106** includes a pair of springs **110** and **112** of the same free lengths.

To enable the locator assembly **20** to be utilized to sequentially locate a right reference surface **52** on a first workpiece **28** relative to a work area **30** and to thereafter locate a left reference surface **70** on another workpiece relative to the work area, a selector valve **138** is associated with the motor **98.** Actuation of the selector valve **138** to a first position enables the motor **98** to pivot the probe **74** in a first direction from an inactive condition to an active condition when the probe member is to be utilized to locate a right reference surface **52.** Similarly, actuation of the selector valve **138** to a second position enables the motor **98** to pivot the probe member **74** in a second direction from an inactive condition to an active condition when the probe member is to be utilized to locate a left reference surface **70.**

Having described one specific preferred embodiment of the invention, the following is claimed:

1. An apparatus for sequentially operating on a plurality of workpieces each of which has a reference surface facing toward either one of two opposite end portions of the workpiece, said apparatus comprising support means for moving the workpiece axially in a work area, said support means including means for supporting a first workpiece with a reference surface facing toward a first end portion of the work area and for subsequently supporting a second workpiece with a reference surface facing toward a second end portion of the work area which is opposite from said first end portion of the work area, means for moving a cutting tool into engagement with a workpiece held by said support means, control means for effecting operation of said support means to move a workpiece axially in a first direction to position the workpiece relative to the work area, sensor means for detecting when the reference surface on said first workpiece has been moved in said first direction to a predetermined position in the work area and for subsequently detecting when the reference surface on said second workpiece has been moved in said first direction to a predetermined position in the work area, said sensor means including a probe member having first surface means disposed on one side of said probe member for engaging the reference surface on said first workpiece as said first workpiece is moved axially in the first direction by said support means and second surface means disposed on another side of said probe member opposite from said one side for subsequently engaging the reference surface on said second workpiece as said second workpiece is moved axially in the first direction by said support means, said second surface means being spaced apart from said first workpiece during engagement of the reference surface on said first workpiece by said first surface means, said first surface means being spaced apart from said second workpiece during engagement of the reference surface on said second workpiece by said second surface means, and detector means for detecting when a reference surface engaged by either one of said surface means on said probe member is in a predetermined position in the work area and for effecting operation of said control means to interrupt axial movement of the workpiece by said support means in response to detection that a reference surface engaged by either one of said surface means on said probe member is in a predetermined position.

2. An apparatus set forth in claim **1** wherein said sensor means includes means for supporting said probe member for movement in opposite directions relative to the work area and means for effecting movement of said probe member in one direction relative to the work area to move said first surface means into engagement with a reference surface on said first workpiece and for effecting movement relative to the work area of said probe member in another direction opposite from said one direction to move said second surface means into engagement with a reference surface on said second workpiece.

3. An apparatus as set forth in claim **2** wherein said sensor means further includes means for effecting movement of said probe member in said other direction relative to the work area to move said first surface means away from the reference surface on said first workpiece and for effecting movement of said probe member in said one direction relative to the work area to move said second surface means away from the reference surface on said second workpiece.

4. An apparatus as set forth in claim **1** and wherein said sensor means further includes motor means operable between first and second conditions to move said probe member relative to the work area, said motor means being operable from said first condition to said second condition to move said first surface means into engagement with the reference surface on said first workpiece during operation of said apparatus on said first workpiece, said motor means being operable from said second condition to said first condition to move said second surface means into engagement with the reference surface on said second workpiece during operation of said apparatus on said second workpiece.

5. An apparatus as set forth in claim **4** wherein said motor means includes piston and cylinder having an operating stroke extending parallel to the axis of a workpiece supported by said support means.

6. An apparatus as set forth in claim **1** wherein said sensor means includes motor means for moving said probe member relative to said work area and spring means for yieldably connecting said probe member with said motor means.

7. An apparatus for operating on a workpiece having a reference surface, said apparatus comprising support means for moving a workpiece in a work area, means for moving a cutting tool into engagement with a workpiece held by said support means, means for effecting operation of said support means to move the workpiece in the work area to position the workpiece relative to

the cutting tool, and sensor means for detecting when the reference surface on the workpiece is in a predetermined position in the work area, said sensor means including a probe member having a surface means for engaging the reference surface, said probe member being movable between an inactive condition in which said sensor means is ineffective to detect when a reference surface is in the predetermined position in the work area and an active condition in which said sensor means is effective to detect when a reference surface is in the predetermined position in the work area, motor means for moving said probe member between the inactive and active conditions, said motor means having an operating condition in which said motor means is effective to move said probe member and a nonoperating condition in which said motor means is ineffective to move said probe member, and connection means for yieldably interconnecting said probe member and said motor means for enabling said probe member to move relative to said motor means when said probe member is in the active condition and said motor means is in the non-operating condition.

8. An apparatus as set forth in claim **7** wherein said motor means is reversible to enable said motor means to move said probe member in opposite directions relative to the work area, said connection means including first and second springs and means for connecting said springs with said motor means to enable said motor means to move said probe member in a first direction from said inactive condition to said active condition upon operation of said motor means in one of said opposite directions and for connecting said springs with said motor means to enable said motor means to move said probe member in a second direction from said inactive condition to said active condition upon operation of said motor in the direction opposite to said one direction, and control means for effecting operation of said motor means in said one direction to move said probe member in said first direction from said inactive condition to said active condition and for effecting operation of said motor means in said direction opposite to said one direction to move said probe member in said second direction from said inactive condition to said active condition.

9. An apparatus as set forth in claim **7** wherein said connection means includes a first spring member disposed on one side of said probe member, and a second spring member disposed on a side of said probe member opposite from said one side and in a coaxial relationship with said first spring member, and means for connecting said spring members with said motor means.

10. An apparatus as set forth in claim **7** wherein said motor means includes a cylinder, a piston disposed within said cylinder, and a piston rod connected with said piston and extending outwardly from said cyliner, said connection means including first spring element disposed adjacent to one side of said probe member in a coaxial relationship with said piston rod, a second spring element disposed adjacent to another side of said probe member in a coaxial relationship with said piston rod and said first spring element, and means for connecting said first and second spring elements with said piston rod.

11. An apparatus for sequentially operating on a plurality of workpieces each of which has a reference surface facing toward either one of two opposite end portions of the workpiece, said apparatus comprising support means for moving the workpiece axially in a work area, said support means including means for supporting a first workpiece with a reference surface facing toward a first end portion of the work area and for subsequently supporting a second workpiece with a second reference surface facing toward a second end portion of the work area which is opposite from the first end portion of the work area, means for moving a cutting tool into engagement with a workpiece held by said support means, control means for effecting operation of said support means to move a workpiece axially in a first direction to position the workpiece relative to the work area, sensor means for detecting when the reference surface on said first workpiece has been moved in said first direction to a predetermined position in the work area and for subsequently detecting when the reference surface on said second workpiece has been moved in said first direction to a predetermined position in the work area, said sensor means including a single probe member having first surface means disposed on one side of said probe member for engaging the reference surface on said first workpiece as the first workpiece is moved axially in the first direction by said support means and second surface means disposed on another side of said probe member opposite from said one side for subsequently engaging the reference surface on said second workpiece as said second workpiece is moved axially in the first direction by said support means, detector means for detecting when the reference surface engaged by either one of said surface means on said probe member is in a predetermined position in the work area and for effecting operation of said control means to interrupt axial movement of the workpiece by said support means in response to detection that the reference surface engaged by either one of said surface means on said probe member is in a predetermined position, motor means for moving said probe member in a first direction from an inactive condition to an active condition in which the reference surface on said workpiece is engageable with said first surface means and for moving said probe member in a second direction from an inactive condition in which said second surface means on said probe member is engageable with the reference on said second workpiece, and connection means for yieldably interconnecting said probe member and said motor means for enabling said probe member to move relative to said motor means when said probe member is in the active condition.

12. An apparatus for sequentially operating on a plurality of workpieces each of which has a reference surface facing toward either one of two opposite end portions of the workpiece, said apparatus comprising support means for moving the workpiece axially in a work area, said support means including means for supporting a first workpiece with a reference surface facing toward a first end portion of the work area and for subsequently supporting a second workpiece with a second reference surface facing toward a second end portion of the work area which is opposite from the first end portion of the work area, means for moving a cutting tool into engagement with a workpiece held by said support means, control means for effecting operation of said support means to move a workpiece axially in a first direction to position the workpiece relative to the work area, sensor means for detecting when the reference surface on said first workpiece has been moved

in said first direction to a predetermined position in the work area and for subsequently detecting when the reference surface on said second workpiece has been moved in said first direction to a predetermined position in the work area, said sensor means including a probe member having first surface means disposed on one side of said probe member for engaging the reference surface on said first workpiece as the first workpiece is moved axially in the first direction by said support means and second surface means disposed on another side of said probe member opposite from said one side for subsequently engaging the reference surface on said second workpiece as said second workpiece is moved axially in the first direction by said support means, detector means for detecting when the reference surface engaged by either one of said surface means on said probe member is in a predetermined position in the work area and for effecting operation of said control means to interrupt axial movement of the workpiece by said support means in response to detection that the reference surface engaged by either one of said surface means on said probe member is in a predetermined position, motor means for moving said probe member in a first direction from an inactive condition to an active condition in which the reference surface on said workpiece is engageable with said first surface means and for moving said probe member is a second direction from an inactivecondition in which said second surface means on said probe member is engageable with the reference on said second workpiece, and connection means for yieldably interconnecting said probe member and said motor means for enabling said probe member to move relative to said motor means when said probe member is in the active condition, said connection means includes first and second spring members disposed adjacent to opposite sides of said probe member.

13. An apparatus as set forth in claim **7** wherein said connection means includes spring means for enabling relative movement to occur between said motor means and probe member when said probe member is in the active condition and said motor means is in the nonoperating condition, said spring means being compressible under the influence of forces applied to said probe member by the workpiece when said probe member is in the active condition and the workpiece is being moved by said support means.

14. An apparatus as set forth in claim **7** wherein said connection means includes spring means for moving said probe member relative to said motor means when said probe member is in the active condition and the workpiece is being moved by said support means with said motor means in the nonoperating condition.

15. An apparatus for sequentially operating on a plurality of workpieces each of which has a reference surface facing toward either one of two opposite end portions of the workpiece, said apparatus comprising support means for moving the workpiece axially in a work area, said support means including means for supporting a first workpiece with a reference surface facing toward a first end portion of the work area and for subsequently supporting a second workpiece with a reference surface facing toward a second end portion of the work area which is opposite from said first end portion of the work area, means for moving a cutting tool into engagement with a workpiece held by said support means, control means for effecting operation of said support means to move a workpiece axially in a first direction to position the workpiece relative to the work area, sensor means for detecting when the reference surface on said first workpiece has been moved in said first direction to a predetermined position in the work area and for subsequently detecting when the reference surface on said second workpiece has been moved in said first direction to a predetermined position in the work area, said sensor means including a single probe member having first surface means disposed on one side of said probe member for engaging the reference surface on said first workpiece as said first workpiece is moved axially in the first direction by said support means and second surface means disposed on another side of said probe member opposite from said one side for subsequently engaging the reference surface on said second workpiece as said second workpiece is moved axially in the first direction by said support means, said second surface means being spaced apart from said first workpiece during engagement of the reference surface on said first workpiece by said first surface means, said first surface means being spaced apart from said second workpiece during engagement of the reference surface on said second workpiece by said second surface means, motor means for moving said probe member in one direction to move said first surface means into engagement with the reference surface on the first workpiece and for moving said probe member in another direction opposite from said one direction to move said second surface means into engagement with the reference surface on the second workpiece, connection means for yieldably interconnecting said probe member and said motor means for enabling said probe member to move relative to said motor means when said motor means is in a nonoperating condition and said first surface means is disposed in engagement with the reference surface on the first workpiece and for enabling said probe member to move relative to said motor means when said motor means is in the nonoperating condition and said second surface means is disposed in engagement with the reference surface on the second workpiece, and detector means for detecting when a reference surface engaged by either one of said surface means on said probe member is in a predetermined position in the work area and for effecting operation of said control means to interrupt axial movement of the workpiece by said support means in response to detection that a reference surface engaged by either one of said surface means on said probe member is in a predetermined position.

16. An apparatus as set forth in claim **15** wherein said connection means includes first spring means for enabling said probe member to move in said other direction upon movement of the first workpiece in said first direction when said motor means is in the nonoperating condition and said first surface means is disposed in engagement with the reference surface on the first workpiece, and second spring means for enabling said probe member to move in said other direction upon movement of the second workpiece in said first direction when said motor means is in the nonoperating condition and said second surface means is disposed in engagement with the reference surface on the second workpiece.

17. An apparatus as set forth in claim **16** wherein said first spring means is compressible under the influence of forces applied to said probe member by the first

workpiece during movement of the first workpiece in the first direction when said motor means is in the nonoperating condition and said first surface means is in engagement with the reference surface on the first workpiece.

18. An apparatus as set forth in claim **17** wherein said second spring means is compressible upon operation of said motor means to move said second surface means into engagement with the reference surface on the second workpiece, said second spring means being effective to move said said probe member in said other direction upon movement of the second workpiece in said first direction with said motor means in the nonoperating condition and said second surface means disposed in engagement with the reference surface on the second workpiece.

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