June 11, 1957 E. Y. SEBORG 2,795,089

HONING MACHINE

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Fig. 1

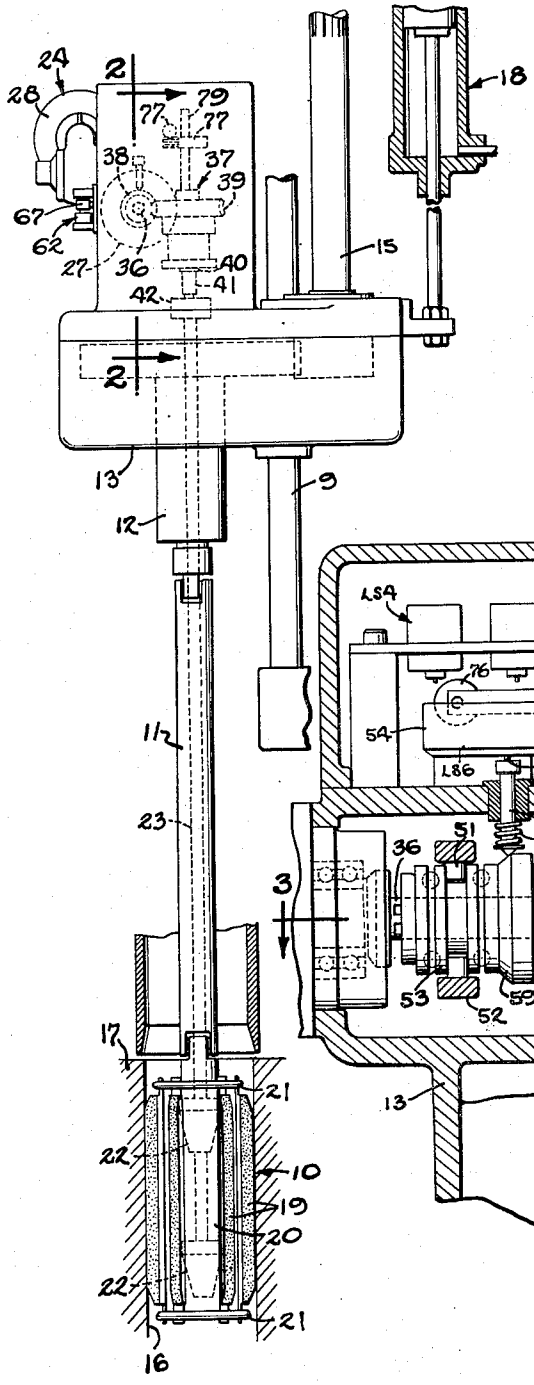
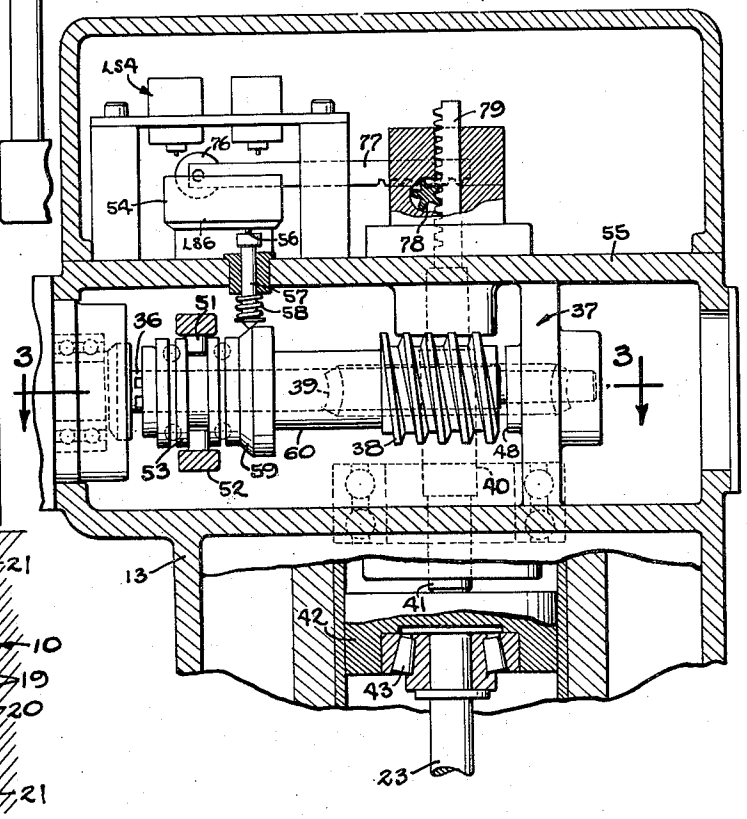


Fig. 2



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Fig. 3

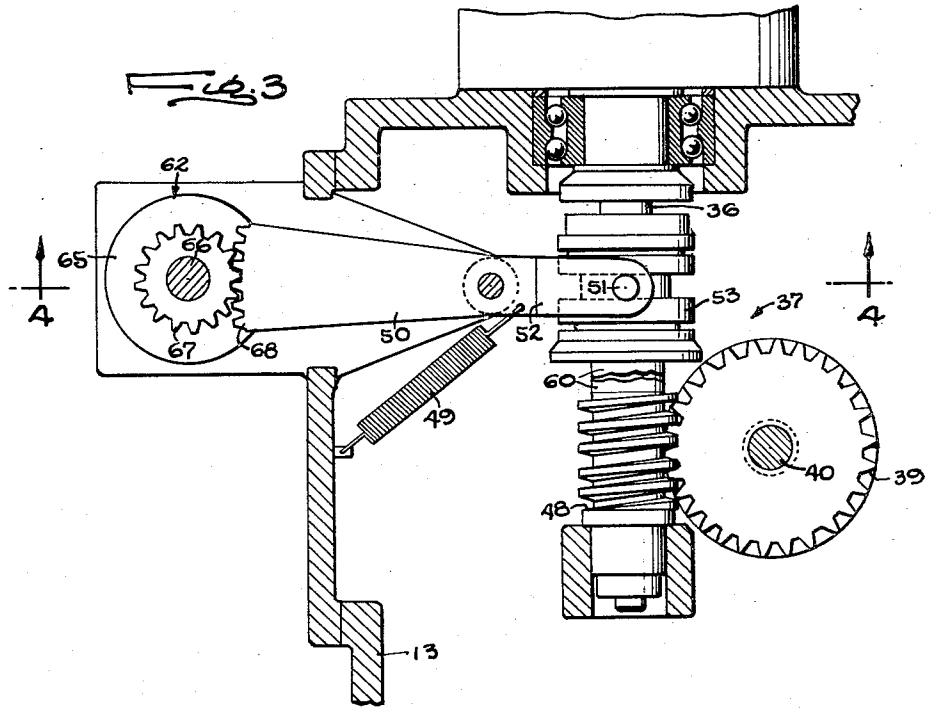
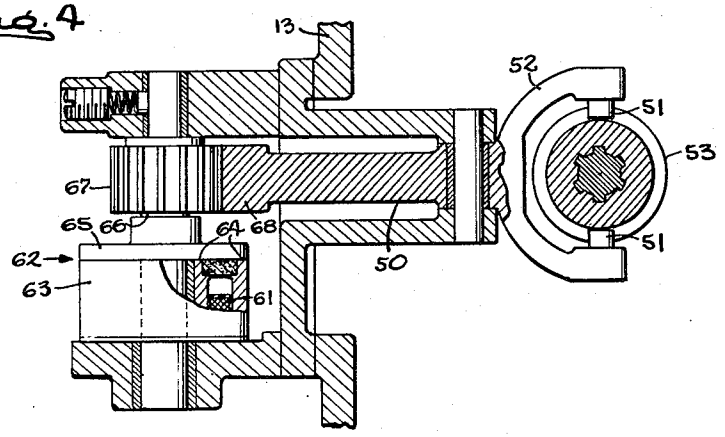


Fig. 4



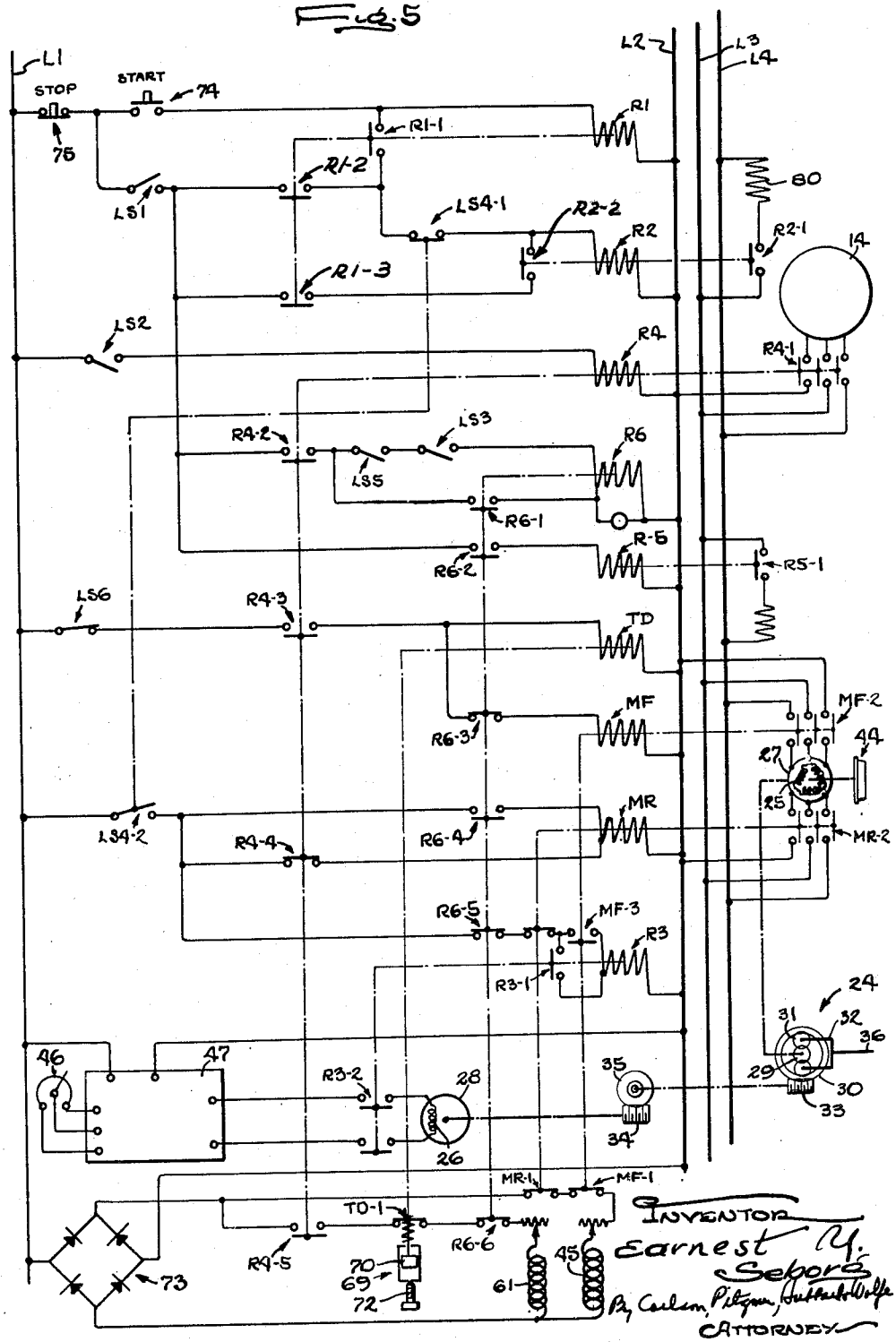
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HONING MACHINE

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Fig. 5



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HONING MACHINE

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6 Claims. (Cl. 51—184.3)

This invention relates generally to honing machines in which the hone, after its entry into a work bore, is expanded first rapidly into engagement with the bore wall and then at a controlled slow rate during enlargement of the bore. More particularly, the invention relates to hone expanding mechanism of the type in which pressure for expanding the hone is transmitted from a two speed power operated drive mechanism to the hone expander through a connection having parts movable relative to each other in response to engagement of the hone with the bore wall whereby to limit the pressure transmitting capacity of the connection.

One object of the invention is to provide novel hone expanding mechanism of the above character in which the full pressure transmitting capacity of the connection is established in response to contact of the hone with the bore wall and in timed relation to termination of the high speed expansion so as to reduce the time required for the transition from high to low speed expansion while avoiding damage to the hone.

Another object is to establish the full pressure transmitting capacity of the connection by clamping the relatively movable parts of the latter together as an incident to contact of the hone and the work.

A more detailed object is to utilize the relative movement of the pressure limiting parts themselves to produce a signal for changing from rapid to slow expansion and for timing of the clamping of the parts against further relative movement.

Other objects and advantages of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings, in which

Figure 1 is a fragmentary elevational view of the head and tool of a honing machine embodying the novel features of the present invention.

Figure 2 is a fragmentary sectional view taken along the line 2—2 of Fig. 1.

Fig. 3 is a fragmentary sectional view taken along the line 3—3 of Fig. 2.

Fig. 4 is a fragmentary sectional view taken along the line 4—4 of Fig. 3.

Fig. 5 is a schematic view of the hone expander drive mechanism and an electric circuit diagram.

While the invention is applicable to all types of honing machines, it is especially adapted for high production machines and is shown for purposes of illustration incorporated in a so-called vertical machine in which the honing tool 10 is carried by the lower end of a jointed hollow shank 11 coupled to a spindle 12. The latter is journaled in a hollow head 13 reciprocable vertically on stationary guides 9 on the machine frame (not shown) and is rotated by an electric motor 14 mounted on the frame and driving a splined shaft 15 geared to the spindle. To raise and lower the head 13 for entry and removal of the collapsed hone into and out of the bore 16 of a workpiece 17 and for reciprocation of the expanded hone within the bore, a hydraulic actuator 18 mounted on the frame is connected to the head and is supplied with pressure fluid in a manner well known in the art.

The honing tool 10 is of the type comprising a series of stones 19 spaced angularly around and shiftable radially relative to the body 20 and normally held in inner collapsed positions by garter springs 21. Outward expansion of the stones is effected in this instance by downward axial shifting of a rod 23 which extends upwardly through the hollow tool shank 11 and spindle 12 and, at its lower end, carries conical cams 22 acting on the inner sides of the stones, the latter shifting inwardly under the action of the garter springs during upward shifting of the rod and the cams.

Motion for shifting the expander rod 23 to expand the hone 10 is derived from power operated mechanism 24 (Figs. 1 and 4) which produces motion at high and low speeds respectively in response to the energization of two electromagnetic windings 25 and 26. In the present instance, the windings are parts of two electric motors 27 and 28 mounted on the head 13 and coupled to the terminal members 29 and 30 of a planetary type differential gearing (Fig. 5). The shaft of one motor 27 carries the sun gear 29 of the differential, this gear meshing with angularly spaced planet gears 31 whose shafts are journaled on the spider or intermediate member 32 of the differential. The ring gear 30 meshes with the planet gears 31 and, on its outer periphery, is toothed to constitute a worm wheel meshing with a worm 33 which is connected to the shaft of the other motor 28 through another worm 34 and worm wheel 35. A shaft 36 journaled in the head 13 (Fig. 2) and secured at one end to the spider 32 constitutes the output member of the drive mechanism 24.

The motion of the output shaft 36 of the expander drive mechanism 24 is converted to reciprocatory motion and is transmitted to the expander rod 23 by a connection 37. Herein, the latter comprises a worm 38 rotatable with the output shaft 36 and meshing with a worm wheel 39 journaled on the head for rotation about a vertical axis. The wheel is threaded internally to form a nut for a screw 40 on a vertical shaft 41 slidable endwise along the axis of the expander rod but held against turning relative to the head. At its lower end, the screw shaft bears against a slidable plug 42 supporting the upper end of the expander rod 23 in a thrust bearing 43 (Fig. 2).

It will be apparent that the rotary motions of the motors 27 and 28 are combined by the differential to produce rotary motion of the output shaft 36, and, after further speed reduction by the worm gearing 38, 39 and the nut and screw 39, 40, are converted to axial shifting motion of the expander rod 23. The gear ratios of the parts of the drive mechanism 24 and the connection 37 are such that, when the windings 25 and 26 of both motors are energized for operation of the latter in a direction to move the rod downwardly, the hone 10 expands at a comparatively rapid rate such as .047 of an inch per second. On the other hand, when only the winding 26 is energized for operation of the motor 28 alone and the sun gear 29 is held against rotation, the rate of expansion is much slower, for example, .00019 of an inch per second, this rate corresponding approximately to the rate of wearing off of one type of honing stone and work material. The sun gear 29 preferably is held against rotation each time the motor 27 is deenergized by a suitable brake 44 which may be of the electromagnetic friction type having a winding 45 (Fig. 5) and operable, when the winding is energized to apply a retarding torque to the motor shaft, the winding being energized and deenergized respectively when the motor is deenergized and energized. Variation of the rate of slow expansion may be obtained by manually adjusting a potentiometer 46 forming a part of a speed regulator 47 (Fig. 5) which controls energization of the slow motor 28.

To enable the rapid expansion parts to come to a stop

without applying further pressure to the stones **19** after the latter contact the bore wall **16**, the connection **37** includes a device having parts normally held against relative movement but shiftable relative to each other in response to the build-up of pressure in the connection following engagement of the stones with the bore wall, the device thus limiting the torque transmitting capacity of the connection. In the present instance, the torque limiting device comprises the output shaft **36** of the drive mechanism **24** and the worm **38** which is splined on this shaft. During rapid expansion of the stones, the worm is urged axially of the output shaft and against a stop **48** as shown in Fig. 3 on the head **13** by a spring **49** acting between the head and a lever **50** fulcrumed intermediate its ends on the head. The lever is connected to the worm **38** by trunnions **51** formed on a yoke **52** at one end of the lever and projecting into a peripheral groove of a collar **53** journaled on but fixed against movement axially of the worm. The spring **49** yields for shifting of the worm away from the stop when the pressure builds up in the connection **37** but before such pressure becomes sufficient to crush the stones.

Means is provided to sense initial contact of the stones **19** with the bore wall **16** during rapid expansion of the stones. In the present instance, such contact is detected as a build-up of torque in the connection **37** between the drive mechanism **24** and the hone expander **23**. To simplify the construction, the initial relative shifting of the parts of the torque limiting device **36**, **38** in response to the pressure build-up after contact of the stones and the bore wall preferably is utiilzed to actuate a switch LS**6** (Figs. 2 and 5) which thus provides a signal of such contact. In this instance, the switch is housed within a casing **54** mounted on a partition **55** in the head **13** for movement of the switch actuator **56** by a plunger **57** slidably mounted on the partition and yieldably urged by a spring **58** away from the actuator and against a cam surface **59** on a sleeve **60** rigid with the worm **38**. The switch LS**6** is located in circuits which control energization of the rapid expansion motor **27** and operate, when the switch is actuated upon contact of the stones with the bore wall **16**, to deenergize the motor and energize the brake winding **45** in a manner to be described later to bring the rapid expansion parts to a quick stop.

Due to their inertia, the rapid expansion parts require a finite time interval to come to a stop, the worm **38** continuing to shift along the output shaft **36** against the action of the spring **49** to limit the torque transmitting capacity of the connection **37** during such stopping. To allow time for the stopping while avoiding any loss of time for the transition from rapid expansion of the stones to slow expansion for feeding of the same into the work **16**, the present invention contemplates establishment of the full pressure transmitting capacity of the connection **37** in timed relation to contact of the stones with the bore wall and as soon as possible after the rapid expansion parts have come to a stop. This is accomplished by the locking or clamping of parts **36** and **38** of the pressure limiting device rigidly together in response to contact of the stones and the work and at the end of a predetermined time interval which expires long enough after such contact to insure that the rapid expansion parts have stopped.

Clamping of the worm **38** against further axial shifting along the output shaft **36** and away from the stop **48** after the rapid expansion parts have come to a stop is effected by energization of an electromagnetic winding **61**. The latter, in this instance, is part of an electromagnetic friction brake **62** (Fig. 4) having a magnet with an annular core **63** of magnetic material of U-shaped cross section enclosing the winding and stationarily mounted on the head **13**. Annular axially facing pole faces **64** on the core are spanned by and adapted for axial gripping engagement with a flat magnetic armature disk **65** which is fast on a shaft **66** journaled in the head for rotation about the axis of the core. The retarding torque of the brake produced by energization of the winding is transmitted to the worm **38** by a gear **67** fast on the brake shaft **66** and a gear segment **68** meshing with the gear and formed on the end of the lever **50** remote from the yoke **52** which is connected to the worm to shift axially therewith as described above.

The time interval for stopping of the rapid expansion parts and for energization of the worm brake **62** is determined by a timer TD (Fig. 5) whose operation is started in response to actuation of the contact sensing switch LS**6** upon initial shifting of the worm **38** away from its stop **48**. Herein, where the contact sensing switch is normally closed and is opened upon contact of the stones **19** and the work **16**, the timer TD may comprise a relay which is connected in series with the sensing switch across supply lines L**1**, L**2** (Fig. 5) and is of the type having a delayed drop out. Such delay may be effected, for example, by a dash pot **69** of which the piston **70** is connected to the movable one of the contact elements TD–**1** of the relay TD with the rate of movement of the piston varied by adjustment of a valve **72**. To apply the worm brake **62** at the end of the interval determined by the timer relay TD, an energizing circuit for the brake includes normally closed contacts TD–**1** of the relay connected in series with the brake winding **61** across the output terminals of a rectifier **73** whose input terminals are connected to the supply lines L**1** and L**2**.

Operation

Energization and deenergization of the windings **25** and **26** of the motors **27** and **28** for expanding and contracting the hone **10** occur at proper times in an automatic cycle of the honing machine governed by mechanism well known in the art and including certain of the control circuits of Fig. 5. Assuming that a cycle has been completed, the circuits are conditioned as shown in Fig. 5 with the spindle drive motor **14**, the hone expansion motors **27** and **28**, and the worm brake winding **61** deenergized and with the rapid expansion brake winding **45** energized through a circuit extending between the output terminals of the rectifier **73** and through normally closed contacts MF–**1** and MR–**1** of two relays MF and MR controlling energization of the rapid expansion motor **27** for rotation in opposite directions.

After a new workpiece has been clamped in a suitable fixture (not shown) on the machine, a start switch **74** is closed manually to complete a circuit across the A. C. power lines L**1** and L**2** for energizing a relay R**1** through a normally closed stop switch **75**. The resulting closure of contacts R**1**—**1** completes a circuit for energizing the relay R**2** through contacts LS**4**—**1** of a switch LS**4** (Figs. 2 and 5) positioned on the head for actuation by a roller **76** carried by a rack bar **77** meshing with a pinion **78**. The latter meshes with rack teeth **79** formed on an extension of the screw shaft **41**, endwise motion of the expander rod **23** to its upper limit position thus being utilized to close contacts LS**4**—**1** when the hone is fully collapsed and to open the contacts when the rod starts its downward movement to expand the hone.

Energization of the relay R**2** closes its contacts R**2**—**1** thereby completing a circuit across supply lines L**3** and L**4** for energizing a solenoid **80** to supply pressure fluid to the hydraulic actuator **18** and thereby initiate downward movement of the head **13**. In the first part of this movement, a switch LS**1** is closed to complete a holding circuit for the relay R**1** through contacts R**1**—**2** thereof and the stop switch **75**, and a holding circuit for the relay R**2** through the then closed contacts R**1**—**3** and R**2**—**2**. Operation of the switch LS**1** and of a switch LS**2** referred to below is effected in response to movements of the head **13** in a manner well known in the art.

When, in the continued downward movement of the head **13**, the honing tool **10** reaches the lower end of the work bore **16**, the switch LS**2** is closed, this switch

remaining closed while the tool reciprocates within the bore but opening in response to withdrawal of the tool from the bore. Closure of the switch LS2 completes a circuit through a relay R4 for closure of its contacts R4—1 to energize the spindle motor 14, contacts R4—2 in a sizing circuit, and contacts R4—3 in series with the now closed contact sensing switch LS6 to energize the timing relay TD and the relay MF. Contacts R4—5 in series with the worm brake winding 61 are closed and contacts R4—4 are opened in series with the relay MR controlling rotation of the rapid expansion motor 27 in a direction to withdraw the expander rod 23. The relay MF then opens contacts MF–1 for deenergization of the brake winding 45, closes contacts MF–2 thereof for energization of the rapid expansion motor 27, and closes contacts MF–3 in series with a relay R3 for the slow expansion motor 28.

In the initial part of the ensuing downward shift of the expander rod 23, the contacts LS4—1 of the switch LS4 are opened by withdrawal of the roller 76 as shown in Fig. 2 and companion contacts LS4—2 are closed, the latter completing the circuit through the contacts MF–3 for energization of the relay R3. The latter pulls in to close contacts R3—1 in a holding circuit around the contacts MF–3 and contacts R3—2 for connecting the slow expansion motor 28 to the speed regulator 47 thereby energizing this motor.

With both expansion motors 27 and 28 operating, the output shaft 36 rotates at its fast speed to shift the expander 23 downwardly and expand the honing tool 10 to the full size of the work bore 16 in a small fraction of a second. As soon as the rapidly expanding stones 19 come against the work, the pressure thereon and the torque in the driving connection 37 build up rapidly. When such torque attains a value sufficient to overcome the spring 49, the worm 38 and its sleeve 60 shift axially away from the stop 48 and, in their initial movement, the cam 59 shifts the plunger 58 outwardly to open the switch LS6 and thereby signal contact of the stones with the work. The relay MF thus is deenergized to open the contacts MF–2 in the circuit for the rapid expansion motor 27 and to close the contacts MF–1 for energizing the brake winding 45 thereby bringing the rapid expansion parts to a quick stop. Although the contacts MF–3 are opened at this time, energization of the slow expansion motor 28 continues by virtue of the holding circuit for the relay R3 through the contacts R3—1 and LS4—2.

When the contact sensing switch LS6 opens, the timing relay TD is deenergized to initiate the time interval before the worm brake winding 61 is deenergized. During this interval while the rapid expansion parts are stopping, the worm 38 continues to shift away from the stop 48 and the brake armature 65 is turned relative to the core 63 through the yoke 52, the lever 50, and the gear 67. At the end of the interval which is determined by the setting of the dash pot valve 72 and which is just long enough to insure safely that the rapid expansion parts have stopped, the timing relay contacts TD–1 close to complete the circuit through the worm brake winding 61 thereby energizing the latter to lock the worm against further movement relative to the output shaft 36. The full torque transmitting capacity of the connection 37 thus is established and, the slow expansion motor still being energized, the stones 19 are expanded into the work at their slow feed rate while the hone is reciprocated back and forth through the work bore.

Termination of the honing operation by contraction of the stones 19 and withdrawal of the tool 10 axially from the bore 16 when the latter reaches the desired diameter may be effected in various ways as by a suitable gaging device (not shown) adapted to measure the bore and close a switch LS5 when the bore is of the finished size. Upon closure of the sizing switch LS5 and a switch LS3 which is closed at the end of each downstroke of the head 13, a circuit for energizing a relay R6 is completed through the stop switch 75 and the head actuated switch LS1. The energization of this relay is maintained through sealing contacts R6—1 and results in closure of contacts R6—2 for energizing a withdraw relay R5 to close contacts R5—1 thereof to establish circuits controlling the pressure fluid system and effect withdrawal of the tool 10 from the bore 16. Also, contacts R6—3 and R6—5 are opened in the circuits to the forward motor relay MF and to the slow expansion relay R3 while contacts R6—4 close to energize the relay MR. Contacts MR–1 of the latter then are opened to deenergize the motor brake winding 45 and contacts MR–2 complete circuits to energize the motor 27 rotation in a reverse direction to retract the expander screw 40 thereby permitting the garter springs 21 to contract the stones 19 and retract the expander rod 23. Other contacts R6—6 open in the circuit for the worm brake winding 61 to deenergize the latter. Then, in the initial reverse turning of the worm with the output shaft 36 the spring 49 shifts the sleeve 60 to permit the contact switch LS6 to close after which the worm again abuts its stop 48.

As soon as the expander screw 40 reaches its fully retracted position, the roller 76 actuates the switch LS4 to close the contacts LS4—1 and open contacts LS4—2 thereby interrupting the circuit to the contact relay MR for deenergization of the fast motor 27. Normally, collapse of the hone by the reverse action of the motor 27 is completed substantially instantaneously and before the hone passes out of the bore. When the hone is withdrawn from the latter under the control of the withdraw relay R5, the switch LS2 opens to deenergize the relay R4 resulting in deenergization of the spindle motor and the relay R6. The withdraw relay R5 and the relays R1 and R2 remain energized until the head 13 has been raised to its fully retracted position as indicated by opening of the switch LS1. The head then comes to rest and the circuits are conditioned for the start of the next cycle which may be initiated by again closing the manual switch 74 after a new workpiece has been placed in the machine fixture.

It will be apparent from the foregoing that the provision of a clamp for locking the parts 36 and 38 of the pressure limiting device against relative shifting makes it possible to protect the stones 19 against crushing pressures during high speed expansion with the clamp deenergized, and yet, to attain rapid transition from high to low speed expansion upon energization of the clamp. By utilizing the relative shift of the pressure limiting parts 36 and 38 to indicate contact of the stones with the bore wall, these parts not only protect the stones against crushing pressures but also perform the additional functions of controlling termination of the rapid expansion and starting the timing of the interval before the parts are locked to establish the full torque transmitting capacity of the connection 37, the timer TD providing a simple and reliable means for controlling and effecting the locking quickly after the rapid expansion parts have stopped.

I claim as my invention:

1. In a machine for honing a work bore, the combination of, a hone having an expander, power operated mechanism for producing motion at high and low speeds respectively in response to the energization of two electromagnetic windings, a connection transmitting the high and low speed motions of said mechanism to said expander and including a worm and worm wheel with the worm yieldably urged axially into a limit position but shiftable axially away from the position in response to the engagement of the hone with a work bore during rapid expansion of the hone whereby to limit the torque transmitting capacity of said connection, means for energizing said mechanism to initiate rapid expansion of said

hone, means operable during such expansion to sense axial shifting of said worm and effect deenergization of said high speed winding while maintaining said low speed winding energized, a timer started in operation in response to the initial shifting of said worm away from said position and operable to measure an interval substantially equal to that required for terminating the high speed expansion of said hone, a brake coupled to said worm and operable when activated to block the worm against shifting axially in a direction away from said position, and means controlled by said timer and operable upon the expiration of said interval to activate said brake whereby to establish the full torque transmitting capacity of said connection during the continued low speed expansion of said hone.

2. In a machine for honing a work bore, the combination of, a hone having an expander, power operated mechanism for producing motion at high and low speeds respectively in response to the energization of two electromagnetic windings, a connection transmitting the high and low speed motions of said mechanism to said expander including a device having two parts normally held against relative movement but movable relative to each other in response to the engagement of the hone with a work bore during rapid expansion of the hone whereby to limit the hone expanding pressure transmitting capacity of said connection, means for energizing said mechanism to initiate rapid expansion of said hone, means operable during such expansion to sense relative movement between said parts and effect deenergization of said high speed winding while maintaining said low speed winding energized, a timer started in operation in response to the initial relative movement between said parts and operable to measure an interval substantially equal to that required for terminating the high speed expansion of said hone, and means controlled by said timer and operable upon the expiration of said interval to clamp said parts together against further relative movement whereby to establish the full pressure transmitting capacity of said connection during the continued low speed expansion of said hone.

3. In a machine for honing a work bore, the combination of, a hone having an expander, power operated mechanism for producing motion at high and low speeds respectively in response to the energization of two electromagnetic windings, a connection transmitting the high and low speed motions of said mechanism to said expander including a device having two parts normally held against relative movement but movable relative to each other in response to the build up of pressure following engagement of the hone with a work bore during rapid expansion of the hone whereby to limit the hone expanding pressure transmitting capacity of said connection, means for energizing said mechanism to initiate rapid expansion of said hone, a sensing device operable during such expansion to detect said engagement of said hone and bore wall, means operable in response to said sensing device to effect deenergization of said high speed winding while maintaining said low speed winding energized, a timer started in operation in response to detection of said engagement by said sensing device and operable to measure an interval substantially equal to that required for terminating the high speed expansion of said hone, means including an electromagnet and operable when activated to clamp said parts together against further relative movement, and means controlled by said timer and operable to activate said clamping means at the expiration of said interval whereby to establish the full torque transmitting capacity of said connection during the continued low speed expansion of said hone.

4. In a machine for honing a work bore, the combination of, a hone having an expander, power operated mechanism for producing motion at high and low speeds respectively in response to the energization of two electromagnetic windings, a connection transmitting the high and low speed motions of said mechanism to said expander including a device having two parts normally held against relative movement but movable relative to each other in response to the build up of pressure following engagement of the hone with a work bore during rapid expansion of the hone whereby to limit the expanding pressure transmitting capacity of said connection, means for energizing said mechanism to initiate rapid expansion of said hone, a sensing device operable during such expansion to detect said engagement of the hone and the work bore, means operable in response to said sensing device to effect deenergization of said high speed winding while maintaining said low speed winding energized, a timer started in operation in response to detection of said engagement by said sensing device and operable to measure an interval substantially equal to that required for terminating the high speed expansion of said hone, and means controlled by said timer and operable upon the expiration of said interval to clamp said parts together against further relative movement whereby to establish the full pressure transmitting capacity of said connection during the continued low speed expansion of said hone.

5. In a honing machine, the combination of, an expansible and collapsible hone having stones and an expander, a power actuatable mechanism for producing motion at high and low speeds respectively, a connection transmitting the high and low speed motions of said mechanism to said expander including a device having parts normally held against relative movement but shiftable relative to each other under the resistance offered by the wall of a work bore when the wall is engaged by said stones, means operable when activated to lock said parts of said device together to transmit sufficient pressure to said stones to feed the same into said bore wall, means for controlling said mechanism to initiate expansion of said hone at said high speed, means for sensing contact of said stones with the wall of a work bore when said hone is expanding at said high speed, a timer responsive to said sensing means and started as an incident to contact of said stones with a bore wall, means controlled by said sensing means and operable to change said mechanism from said high speed to said low speed operation, and means controlled by said timer and operable to activate said locking means after said change from high speed to low speed operation.

6. In a honing machine, the combination of, an expansible and collapsible hone having stones and an expander, a power actuatable mechanism for producing motion at high and low speeds respectively, a connection transmitting the high and low speed motions of said mechanism to said expander including a device having parts normally held against relative movement but shiftable relative to each other under the resistance offered by the wall of a work bore when the wall is engaged by said stones, means operable when activated to lock said parts of said device together to transmit sufficient pressure to said stones to feed the same into said bore wall, means for controlling said mechanism to initiate expansion of said hone at said high speed, means for sensing contact of said stones with the wall of a work bore when said hone is expanding at said high speed, means controlled by said sensing means and operable to change said mechanism from said high speed to said low speed operation in response to contact of said stones with said wall, and mechanism controlling said locking means in response to said sensing means and operable to activate the locking means in timed relation to and after said change from high speed to low speed operation.

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