TRUE-TRACE

Con-Trol-Path — Con-Trol-Scan

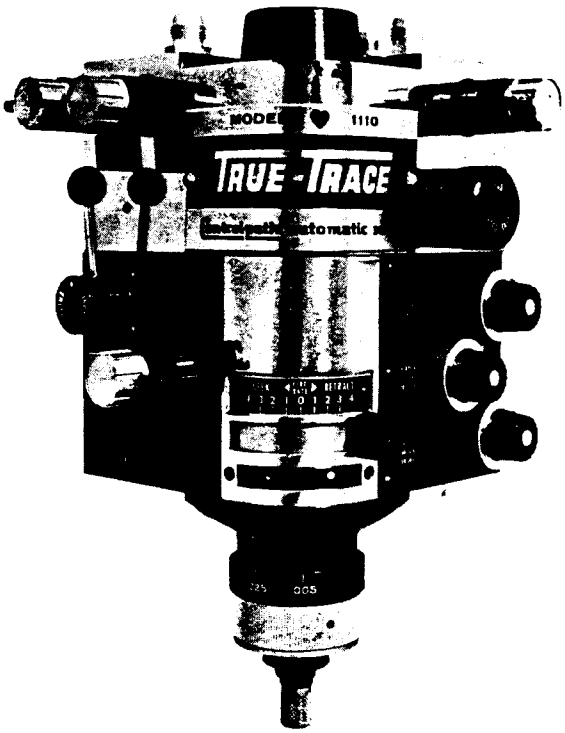
AUTOMATIC TRACER CONTROL SYSTEM

Technical Bulletin

D-501C

FUNCTIONAL DESCRIPTION

The Con-Trol-Path is usually installed on vertical milling machines for contour milling of a workpiece as a one-to-one duplication of the pattern. It may be controlled either as a pencil-type tracer with the operator guiding the stylus by hand to do two or three dimensional work, or as an automatic tracer for two dimensional (360) tracing in a horizontal plane.



GENERAL

The purpose of this Bulletin is to give technical information on the product group that is more comprehensive in nature than that included in the sales literature. The theory of operation of the Controlpath Tracer Valve Series is covered in this bulletin. Summarized specifications of the various model valves in this group are given on the Model Sheets. Separate dimensional data information is available by drawing number.

This bulletin will touch on applications and construction in a general nature only. Detailed functional theory will be given on:

Servo Valve Operations.

Operation of the Tracer Valve Spindle.

Stylus to Tool Relationship.

Feed Rate Control.

Description of Action When Tracing a Contour Manually.

Description of Action When Tracing a Contour Automatically.

A basic schematic is also shown of a typical Controlpath control system in the back of this bulletin.

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Adjustments

CONTENTS

This section is perhaps most important to the serviceman and the repairman for making adjustments in the Tracer Valve. It has detailed information on 90% of the adjustments that are made on these Tracer Valves by our field service engineers.

It is an important part of the manual in that by following these simple instructions, your Tracer Valve may be kept in peak operating condition. This will enable you to have a trouble-free running machine. This section covers the following adjustments:

REPLACING THE DRIVE BELT

To replace the drive belt (140), the access cover (68) together with the escutcheon plate (67) has to first be removed. To do that, proceed as follows:

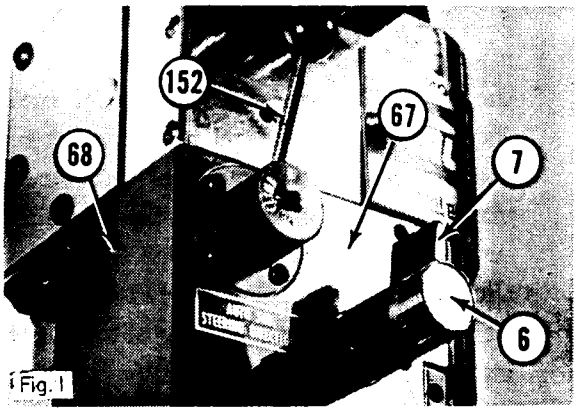

Fig. 1

1. Unscrew the lever (152) out of the Servovalve Assembly. Then remove the lever nut (6) and shutoff valve lever (7). Figs. 1 and 3.

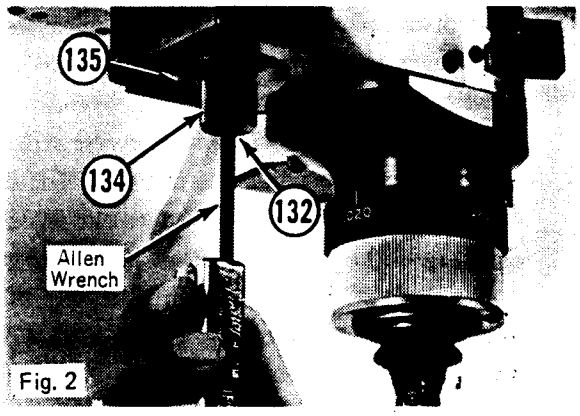

Fig. 2

2. Next, using an Allen wrench, remove the Allen nut (132) from inside the bias knob (134) as shown in Fig. 2. This will release the bias knob together with the lockwasher (133) and will allow you to remove the cover plate (135) from underneath the Servovalve Assembly.

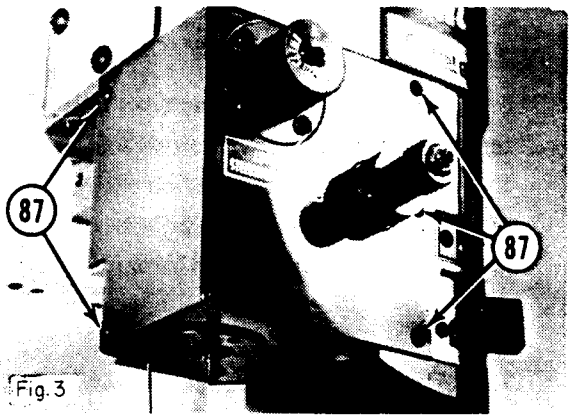

Fig. 3

3. Now remove the five button-head screws (87) and the escutcheon cover. Fig. 4 shows the escutcheon cover removed exposing the Feed Direction Servovalve Assembly (141) together with the drive belt (140) and pulley (137).

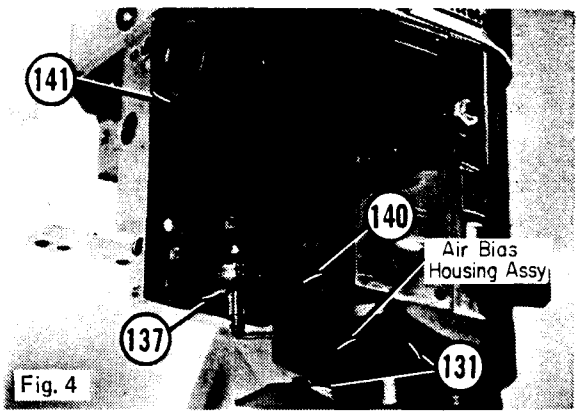

Fig. 4

4. To get to the drive belt (140), you now have to remove the Air Bias Housing Assembly (129), which is held by three 8-32 socket head screws (131). When removing the housing assembly, care should be taken not to drop the two steel balls (155). This may be done by placing your small finger into the opening of the housing assembly as shown in Fig. 5. This action will prevent the steel balls from falling out while you are removing the housing assembly from the Tracer Valve.

NOTE: Later models have two roll pins for locating bias housing to nose assembly for close register.

Replacing the drive belt (cont)

5. Before replacing the new drive belt (140), it is advisable to remove the steel balls (155) from the Air Bias Housing Assembly and to inspect them for dirt or any foreign matter that might be stuck to them. The removal of these steel balls may be done by looking into the opening and turning the housing assembly in such a way as to allow the balls to fall out, one at a time. After cleaning the balls and blowing out inside the housing assembly, replace the balls by rolling them back into the opening with the ball location rotated to the bottom part of the housing assembly as you are placing them into the hole. After the new drive belt is on and in position, proceed to reassemble the Tracer Valve in a reverse sequence as shown in the preceding illustrations. The drive belt may be placed in position on the motor pulley (137) by sliding the bias knob (134) onto the spline shaft of the motor. With the help of the thumb of one hand, push the drive belt and twist the bias knob at the same time, as shown in Fig. 7. This action will assist in getting the belt into position.

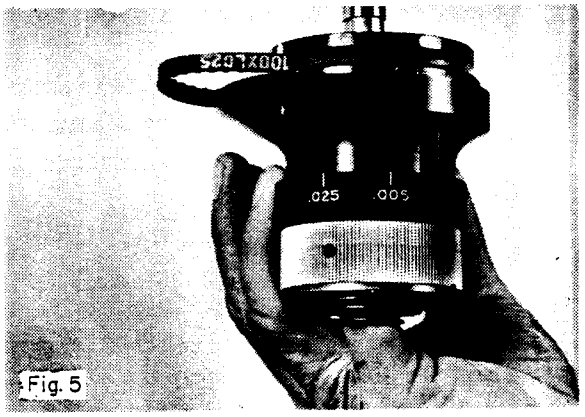

Fig. 5

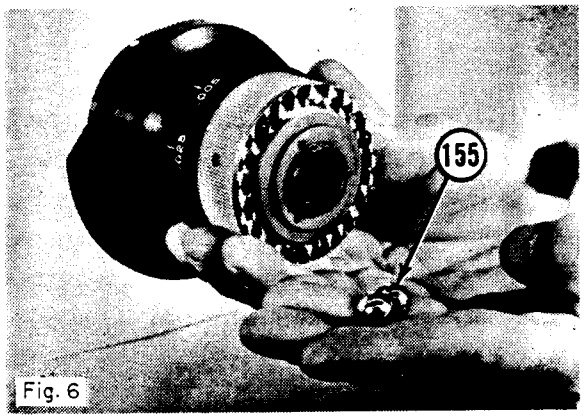

Fig. 6

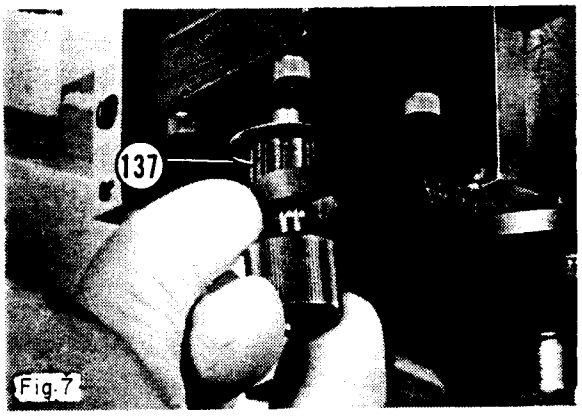

Fig. 7

6. Before the access cover (68) is replaced, the tension of the new drive belt should be checked. It is possible that the drive belt may be too tight or too loose and may need adjustment. For adjusting the drive belt, see information in this section.

7. After the drive belt (140) is on the pulley, the bias knob (134) may be removed and the escutcheon cover replaced. Here again the reassembly of the escutcheon cover is done in reverse sequence of the disassembly as shown in the previous illustrations. For correct sequence of the assembly of parts, see exploded view in Parts Identification List section of this manual and Bulletin D-665.

Replacing the drive belt (cont)

ADJUSTING THE DRIVE BELT FOR PROPER TENSION

The Feed Direction Servovalve Assembly is held in position by two 6-32 socket head screws (69) as shown in Fig. 8. These screws have to first be loosened before any belt adjustment is attempted. Loosening of these screws should be limited to moving of the assembly only. After the two holding socket head screws are loose, the whole assembly may be adjusted by inserting an Allen wrench as shown in Fig. 9 into the openings provided for this purpose. There are two 10-32 setscrews (82) for this adjustment.

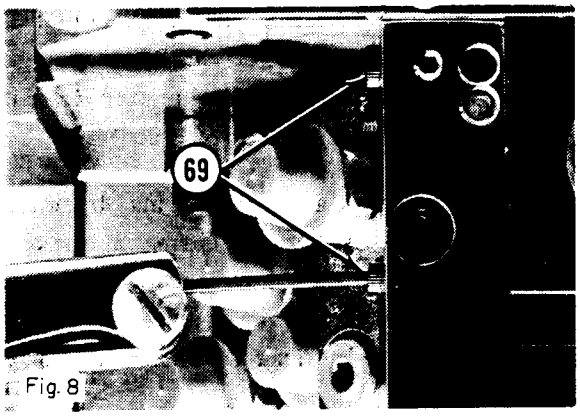

Fig. 8

A good guide to follow in adjusting the belt is the slot between the Feed Direction Servovalve Assembly and the body proper of the Tracer Valve itself. Again in Fig. 9, this slot is shown as not being parallel. To correct this condition, the setscrews (82) have to be repositioned rotationally.

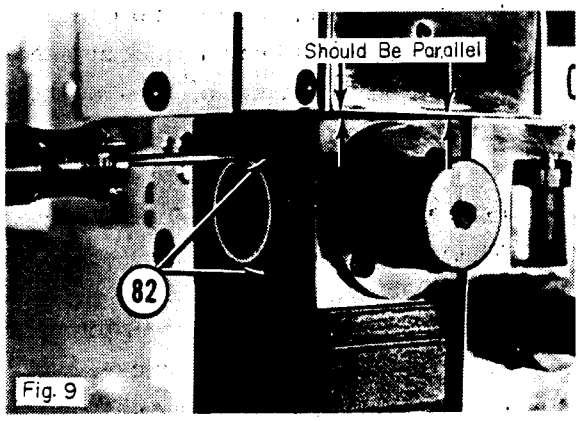

Fig. 9

In Fig. 9, the left side of the slot is wider than the right side. Consequently, the upper setscrew would have to be backed out and the lower setscrew would have to be advanced, in order to correct this condition.

The adjustment of the drive belt (140) has to be kept in mind at the same time. When the belt is in correct adjustment, there should be 1/8-inch play between the time that you touch the belt with the scale and when you depress it. The tension should be 1 to 7/8 of an inch, leaving a play of 1/8 inch as shown in Figs. 10 and 11.

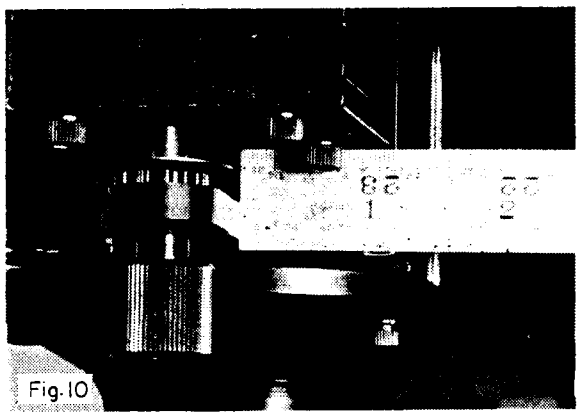
Fig. 10

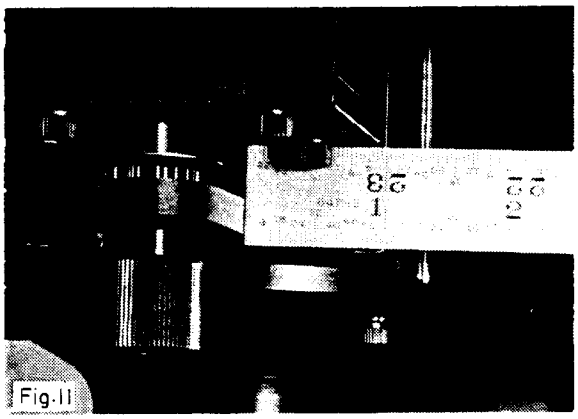
Fig. 11

REPLACING THE SEAL IN ONE OF THE THREE REGULATORS (i.e., Stylus Pressure Regulator, 360 Auto, Vertical Stylus Pressure Regulator, or Steering Air Regulator 360 Auto)

In the event of an air leak, it may be necessary to replace one of the seals (O-ring) in one of the regulators (106). To remove one of the regulators, it is necessary to first remove the cover (98) which is held down by five 6-32 button-head screws (87).

1. Before attempting to remove the cover (99), the three knurled aluminum lock nuts shown in Fig. 12 have to be taken off to allow the escutcheon plate to come off.

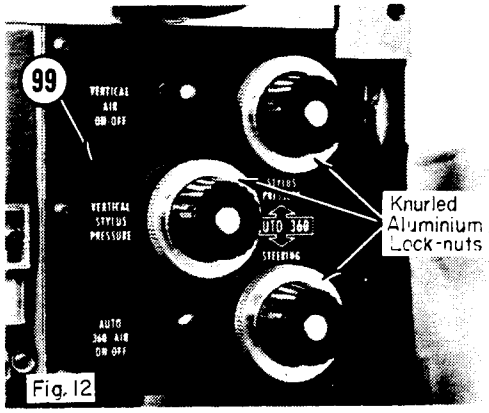

Fig. 12

Fig. 13 shows the knurled aluminum lock nuts removed.

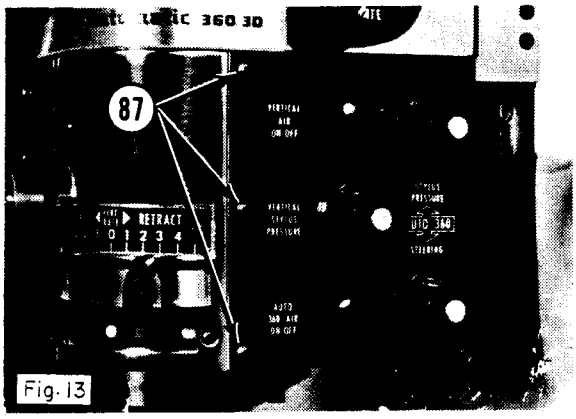

Fig. 13

2. To remove one of the regulator assemblies (106), simply unscrew the three 6-32 socket head screws (107) holding each one of them. This will expose the two O-rings (101 and 103) as shown in Fig. 15.

To replace the regulator assembly (106), simply reverse the procedure in steps 1 and 2. In this case, as in all cases, when reassembling parts, make certain that there is no dirt or lint evident before "buttoning-up" that area. Also make certain that all bolts and screws are secure.

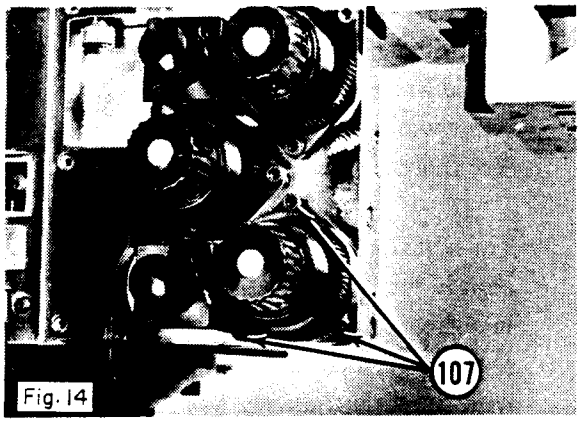

Fig. 14

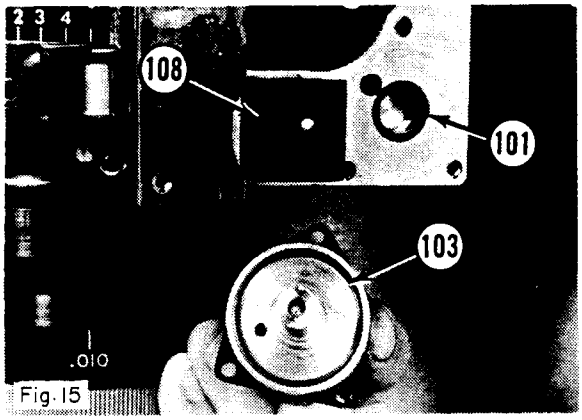

Fig. 15

REPLACING THE VALVE CORE IN THE VERTICAL AIR ON-OFF VALVE OR THE AUTO 360 AIR ON-OFF VALVE

When replacing the valve core (83), remove the air shutoff valve housing (108) by unscrewing the two 6-32 socket head screws (109). Fig. 16 shows the housing removed and the valve core exposed in the center opening.

To remove the valve core (83), a regular automobile tire valve core tool may be used as shown in Fig. 16. Simply back out the valve core and remove it with a pair of tweezers or similar tool as shown in Fig. 17. After the valve core is removed, replace with a new valve core and reverse the procedure in replacing the housing (108). Before replacing the cover (98), make certain that all the screws are secure and all housings in proper position and alignment. To replace the cover (98), simply reverse the procedure indicated in the beginning of this section. After the cover is replaced, screw the knurled aluminumlock nuts back on each regulator.

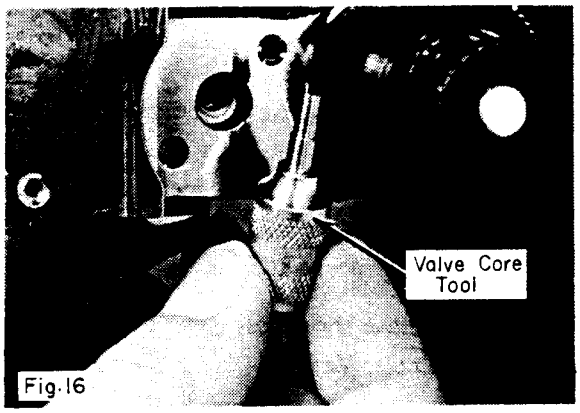

Fig. 16

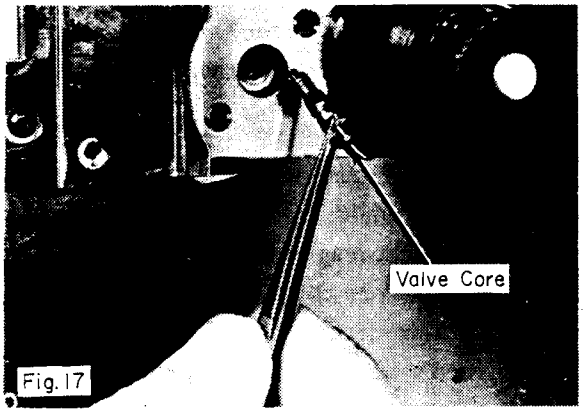

Fig. 17

RATING IN THE SPOOLS

At certain times it may be necessary to adjust and equalize the speed of either the Cross or Longitudinal sector of the machine tool. This is called "rating in the spools." When this adjustment is necessary, proceed as follows:

a. Remove the access cover (21) from the face of the Tracer Valve.

b. Adjust one sector at a time. Start with either the Longitudinal or the Cross sector. When adjusting one sector, turn off the shutoff valve of the opposing section.

c. With a screwdriver, turn adjusting screw (51) clockwise while deflecting spindle back and forth, until a slight drag is felt at the yoke. Then turn adjusting screw counterclockwise slightly until yoke moves freely without mechanical drag. Tighten setscrew (48) snugly.

Mechanical clearance at yoke may be checked with a dial indicator, as shown in Fig. 18. Holding spindle with one hand (in extreme left or right position), move control slide (50) right and left with other hand to determine clearance. Maximum desirable clearance shall be one ten-thousandth of an inch (0.0001).

d. Repeat step c for second axis, being sure to adjust both axes equally.

NOTE: If the yoke is removed from the Tracer Valve for cleaning, be sure threaded half-nuts (49) located under setscrew (48) are installed, so as to prevent cross-threading of adjusting screw (51).

e. Set the 360 Feed Rate Control (H) to maximum open position (Fig. 18). Loosen setscrew (48) about 1/8 of a turn, just enough to break the hold. With a small tool, screwdriver or Allen wrench for leverage, apply a gentle tapping action on the lugged adjusting washer (33) at the front of the spool, thereby rotating the lugged washer a few thousandths of an inch at one time (Fig. 19).

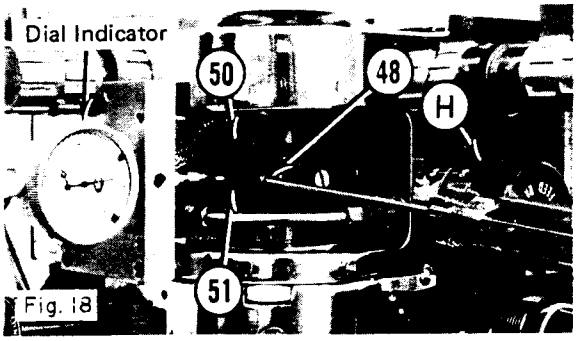

Fig. 18

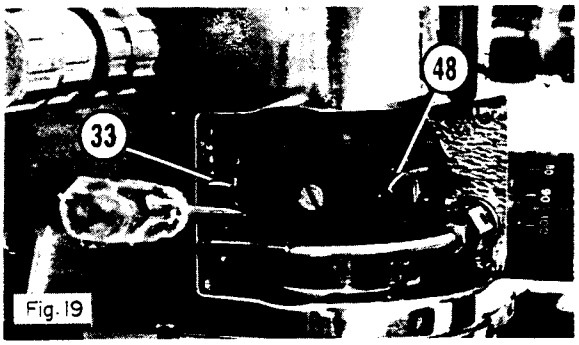

Fig. 19

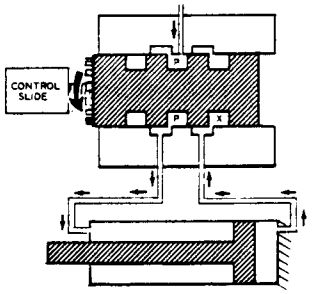

Fig. 20

CYLINDER STATIONARY

Here the Spool is off center toward the Control Slide. If the Machine Tool Slide involved is attached to the Piston Rod (the Cylinder being stationary) the Slide will move slower to the left and faster to the right. This will be more evident in the lower feed rates. To correct this condition, move the Spool away from (out of) the Control Slide as indicated by the arrow, counterclockwise.

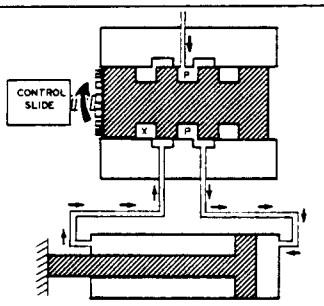

Fig. 21

ROD STATIONARY

Here the Spool is off center away from the Control Slide. If the Machine Tool Slide involved is attached to the Cylinder (the Piston Rod being stationary) the Slide will move slower to the left and faster to the right. This will be more evident in the lower feed rates. To correct this condition, move the Spool toward (into) the Control Slide as indicated by the arrow, clockwise.

Rating in the spools (cont)

This may have to be done in both directions (i.e., clockwise or counterclockwise), depending on the direction in which the Longitudinal or Cross member is moving faster. If after rotating the lugged adjusting washer (33) the Longitudinal or Cross sector becomes more out of adjustment than before, then you will have to turn the lugged washer in the opposite direction. (See illustration, Figs. 20 and 21.)

f. After an even adjustment is obtained of the same speed in both directions, the setscrew (48) should be tightened and slide speed rechecked.

g. A check should be made once more on this sector to be sure that the adjustment is correct.

The opposing sector is done in exactly the same manner. The shutoff valve should be open in the sector that is being worked on, and the shutoff valve of the opposing sector should be closed.

REFERENCE NOTE: A rotation of one degree of the spool moves the linear position of the spool approximately 0.0001 inch. The width of one lug on the adjusting washer is equal to 1/24 of the total circumference, or 15 degrees. Therefore, by rotating the lugged washer the distance of one lug width, the spool movement will be approximately 0.002 inch.

BALANCING THE X AND Y SECTORS

After the spools have been rated in, it will be necessary to balance the X and Y sectors so that they will be moving at the same speed in all four directions clockwise and counterclockwise, i.e., in conventional and in climb; for this purpose, a square template is necessary.

a. Loosen the 360 Feed Rate Control knob (H) by unscrewing setscrew (61) as shown in Fig. 22.

b. Remove both setscrews (46) on the flexible drive shaft (47). These setscrews are removed because they may not be in the same position after adjustment, and may not be accessible when tightening is necessary.

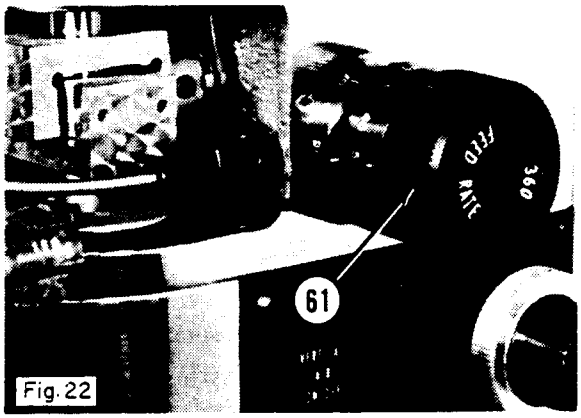

Fig. 22

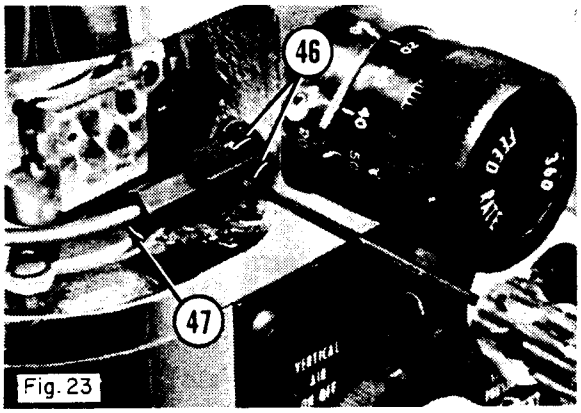

Fig. 23

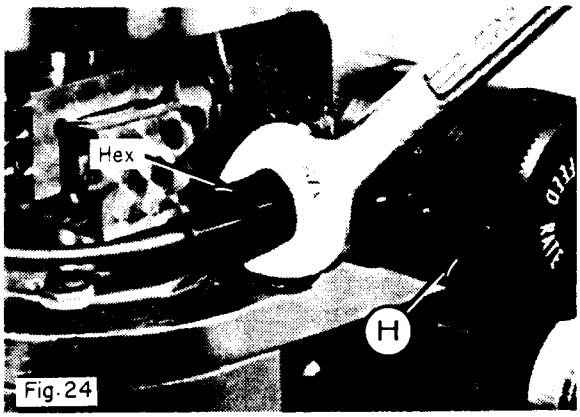

Fig. 24

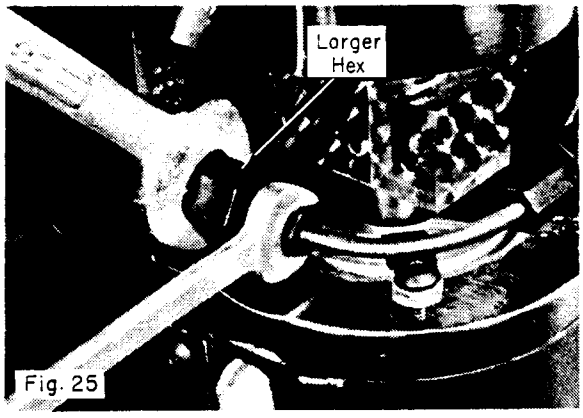

Fig. 25

Balancing the X and Y sectors (cont)

c. Rotate the larger hex of the flexible drive shaft (47, Fig. 24) until you get a minimum feed of approximately 1/4 inch a minute (0.250 inch).

NOTE: A clockwise rotation of the right-hand side hex will decrease the feed rate. Conversely, a counterclockwise rotation will increase the feed rate.

d. After the necessary speed is attained, set the Feed Rate Control knob (H) to zero and lock the setscrew (61).

It will now be necessary to match the opposing sector to the one on the right.

e. Using two wrenches as shown in Fig. 25, rotate the larger hex to match the feed rate to the right-hand side of the sector.

f. After the necessary feed rate is attained, it will be necessary to balance all four directions of the feed rate in the automatic mode. To accomplish this, a square template is needed, approximately 6 by 6 inches. The setup for this adjustment is shown in Fig. 26.

A stopwatch is necessary for this purpose. To make this adjustment, proceed as follows:

a. Start by adjusting one sector at a time. In automatic mode, lead the stylus to the square template. Starting with the right-hand spool, clock the length of time it takes for the Tracer to go along a straight edge of the template from the time it rounds corner number 1 to the time it rounds corner number 2 and again on the opposite side. Note the amount of seconds. As soon as the Tracer rounds corner number 3 of the opposite side of the template, start clocking again and note the time it takes until it rounds corner number 4.

b. Compare the time element against both sides; if one side is slower or faster to a given speed, match it to the side closest to the desired speed by adjusting as described previously in this section. For example, if one side takes 30 seconds and the opposing side takes 20 seconds (Fig. 26), then you

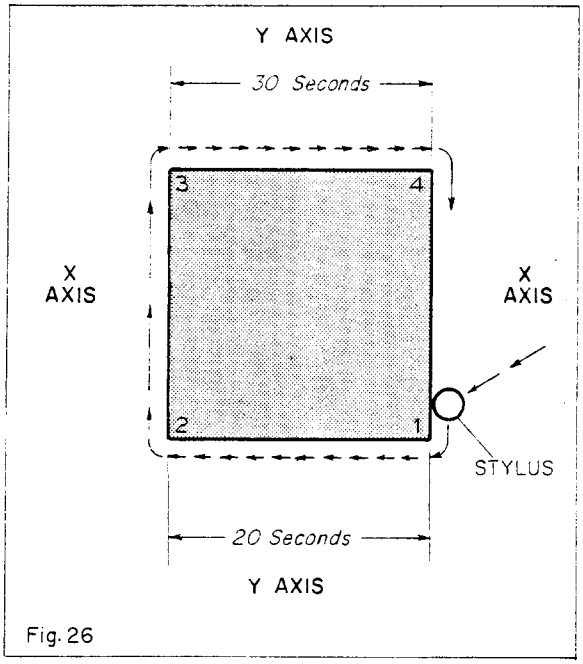

Fig. 26

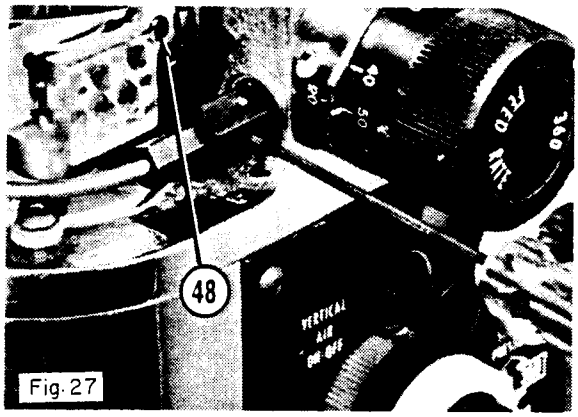

Fig. 27

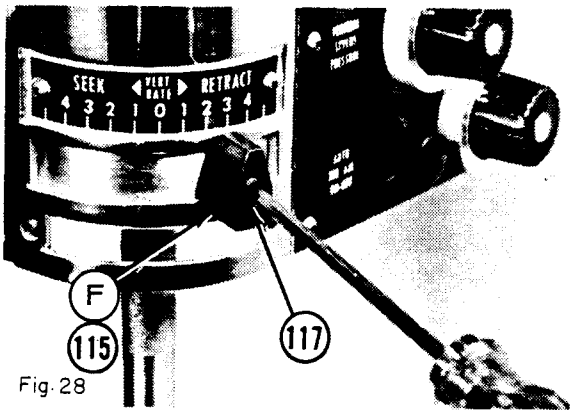

Fig. 28

should try to have both sides adjusted to travel 25 seconds each way.

c. When one sector is balanced out, tighten the setscrews (48) and proceed to adjust the opposing spool in the same manner as stated previously in this section. (Fig. 27)

When matching the sides of the opposing sector, adjust them to within 2 seconds of the same feed rate as you had on the first side. After adjusting the second sector, make the check one more time; the Tracer should go around the template on each side with not more than 2 seconds' variance between them.

REMOVING THE SPINDLE FROM THE TRACER VALVE

The initial steps for removing the spindle from the Tracer Valve are identical to the section on Replacing the Drive Belt.

After the nose assembly is off (Fig. 28), remove the Allen screw (117) that holds the Vertical Rate Control Lever (F). After the lever is off, the ring closure (124) may be shifted in a rotary direction to make access possible to the setscrews (125). These setscrews are approximately at right angles to each other. By moving the ring closure to the right and to the left, these two setscrews may be loosened (Fig. 29). After the setscrews are loose, the spindle assembly, together with the vertical rate control sleeve (126), may be unscrewed counterclockwise and dropped out of the Tracer Valve (Fig. 30).

CAUTION: Observe care in removing spindle assembly to prevent three ball bearings (118) from falling out.

NOTE: There are three sets of holes in the vertical rate control ring (127). Note which set you were using, as on reassembly you will have to replace the control lever (115) in the same location.

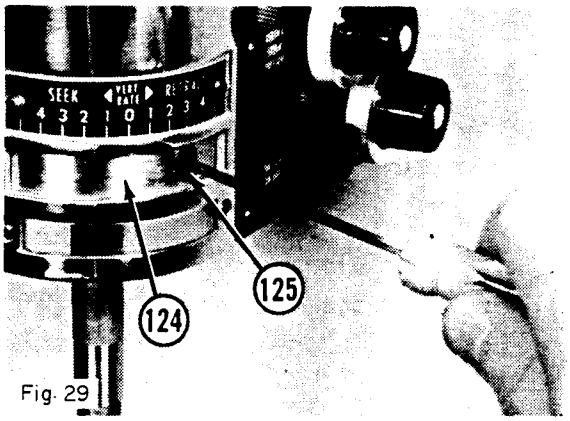

Fig. 29

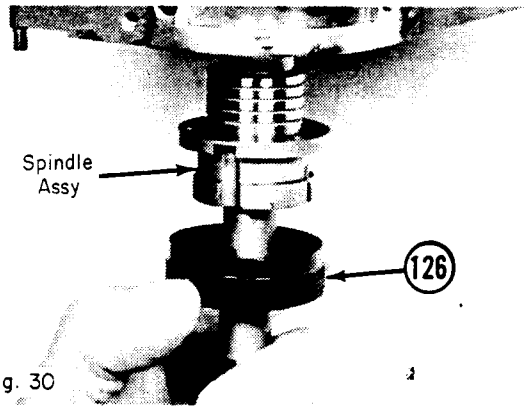

Fig. 30

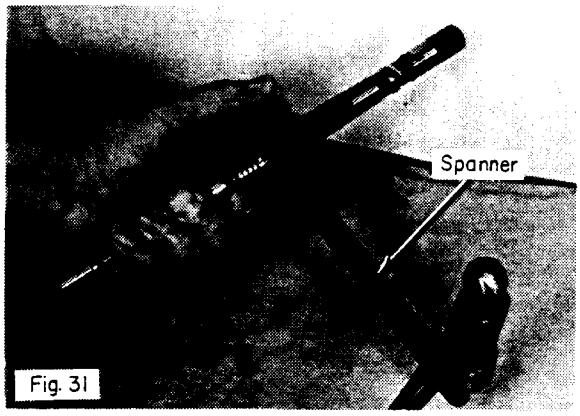

Fig. 31

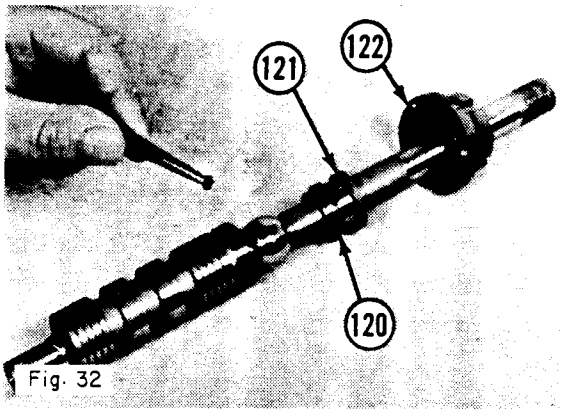

Fig. 32

ADJUSTING THE SPINDLE BALL WITHIN THE SPOOL

After the spindle assembly is out of the Tracer Valve, it may be disassembled in the following manner:

a. Hold the spool and spindle assembly by the spool in one hand and hook a Spanner Wrench on the lock nut (122) as shown in the illustration (Fig. 31).

b. Holding the whole assembly over a workbench, position the Spanner so that the handle of the Spanner is horizontal to the plane of the workbench.

In that position, give a light blow with a hammer to the end of the Spanner Wrench, forcing a counterclockwise action. This may have to be done several times in order to break the hold between the lock nut and the spool assembly.

After the lock nut (122) is removed, this will expose the lower pivot bearing (121) and the spacer (120) (Fig. 32). Examine the bearing surface of these parts; make certain that there are no burrs or nicks either on the lower pivot bearing, on the spacer, or the lock nut where they mate. Before you assemble, make certain that all parts are clean and free from lint. To tighten the lock nut back on the spool, reverse the action as shown in the illustration.

After the assembly of the spindle and spool, grasp the spindle and spool as shown in Fig. 33 and check for any looseness. The spindle should be free within the spool body, but at the same time there should be no endplay, either sideways or up and down. The spindle action within the spool has to be free-moving but firm. (Best check is made on a surface plate with a V-block and a dial indicator.) Total tolerable play must not exceed one ten-thousandth of an inch (0.0001).

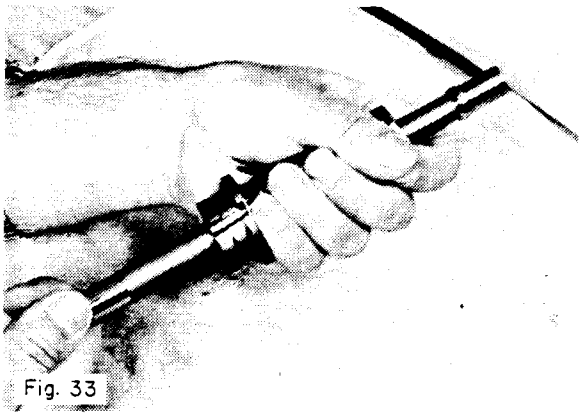

Fig. 33

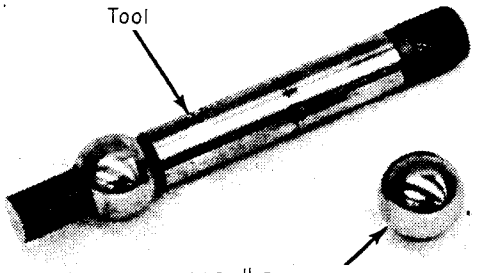

Fig. 34 .8750" Ball Bearing may be used as a substitute for the tool.

If after assembly and snugging of the lock nut (122) you find that the spindle ball is loose and has endplay, you will have to disassemble the parts, remove the spacer (120), and lap it on a surface plate which, in turn, will tighten the spindle ball.

If, however, you find that after cleaning and reassembly the spindle ball is too tight and cannot be rotated freely within the spool body, you will have to again disassemble the parts and lap the ball seat of the lower pivot bearing (121) (Fig. 34). To do this, you have to have a tool which for all practical purposes is an identical size ball as the spindle ball (Fig. 34).

1. To tighten the ball, lap the spacer.
2. To loosen the ball, lap the lower pivot bearing.

Thoroughly wash all parts before reassembling the

Adjusting the spindle ball within the spool (cont)

spool and spindle ball back into the body of the Tracer.

After the desirable adjustment of the spindle ball is attained, you are now ready to reassemble the spool back into the sleeve of the Tracer Valve. Before attempting to slide the spool assembly back into the sleeve, make certain that the anti-rotation pin (119), shown in Fig. 35, is back in its proper place. There is a slot in the spindle ball, and this pin must fit into that slot before the spool is put back into the sleeve of the Tracer Valve.

a. Make certain all parts are clean. Do so before reassembly. Flood the spool with oil, the same kind of oil that is used in the power unit. Hold the spool perpendicular and in line with the sleeve of the nose, then slide it up gently as shown in Fig. 36. If the spool refuses to fall in place, back off; do not force the spool into the sleeve. These parts are very closely fitted and will have to be in perfect alignment before they will assemble together. Make sure that the three ball bearings (118) which register in the indentations of the spool lock nut (122) are either in the holes of the nose assembly or on the lock nut. When replacing the spool back into the sleeve, hold the spool and not the spindle of the assembly; this will give you a better feel and make it a little easier to line up the two parts.

b. After the spool is in position, hold the spindle up with one hand and with the other hand slip the vertical rate control sleeve (126) over the spindle. As shown in Fig. 37, there is a notch in the lock nut (122) and a rise to fit that notch in the vertical rate control sleeve. Line these two up as you are sliding the spool into the sleeve of the nose (Fig. 37). When the spool bottoms out and is all the way up, start turning the spindle by the knurled end and at the same time hold the vertical rate control sleeve against the vertical rate control ring (127) as shown in Fig. 38. After the threads catch, you may screw the lock nut all the way until it bottoms out and then back it off one-half turn. You may now replace the nose and drive belt assembly back onto the Tracer. To do this, refer to front of this section.

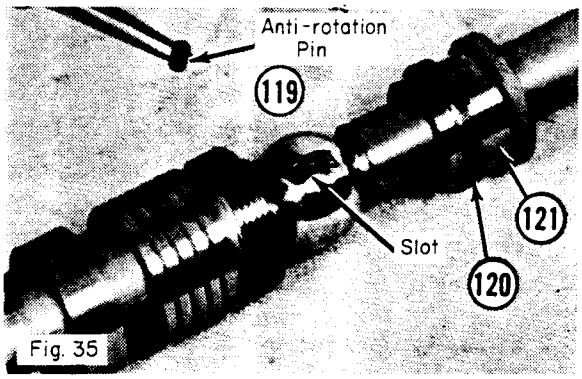

Fig. 35

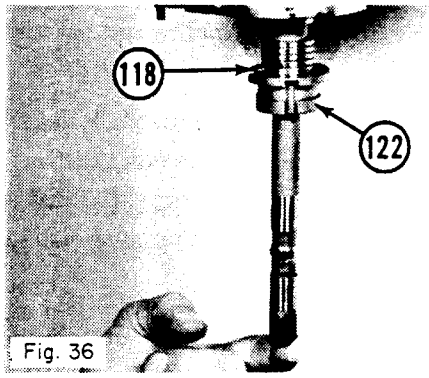

Fig. 36

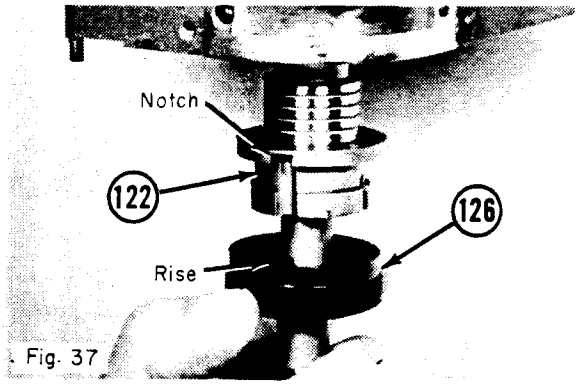

Fig. 37

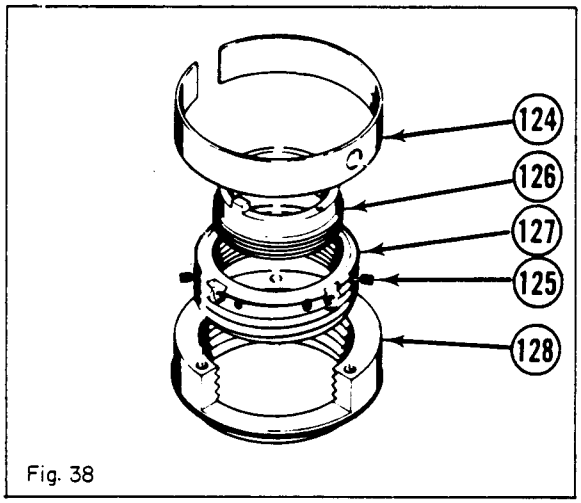

Fig. 38

F5377

READJUSTING THE VERTICAL RATE CONTROL TO NULL

After the Tracer is reassembled and all bolts and screws are secure, the Vertical Rate Control (F) may be adjusted so that the zero mark on the vertical rate control dial will keep the Tracer from drifting up or down.

To do this, proceed as follows:

a. Before starting this adjustment, drop the knee all the way down by bottoming out the vertical cylinder.

b. Turn off the Pressure Shutoff Valve (A). This will keep the X and Y sectors from drifting in any direction while you are making the adjustment. With the aid of a dial indicator, as shown in Fig. 41, proceed as follows:

The two setscrews (125) must be loose at this time, and the Vertical Sector Shutoff Valve (D) should be open when making this adjustment.

c. Holding the Vertical Rate Control (F) with one hand, rotate the spindle (123) counterclockwise until the knee starts to rise. You can get immediate evidence of this by watching the face of the dial indicator.

d. As soon as the knee starts to rise, start rotating the spindle in the opposite direction or counterclockwise until no movement is evident. You can check this with the help of the dial indicator.

e. After movement stops and you are satisfied that the vertical sector is not moving, you can remove the control level (115) and rotate the ring closure (124) first to the right and tighten the setscrew (125), and then rotate the ring closure to the left until you locate the other setscrew (125) and lock it also. After the setscrews are secure, replace the control lever and tighten the 8-32 socket head screw (117).

f. Again with the help of the dial indicator, position the Vertical Rate Control lever (F) to the zero mark and check if there is any vertical movement by watching the face of the dial indicator.

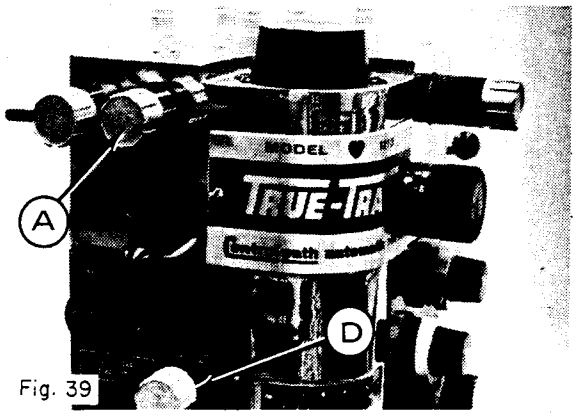

Fig. 39

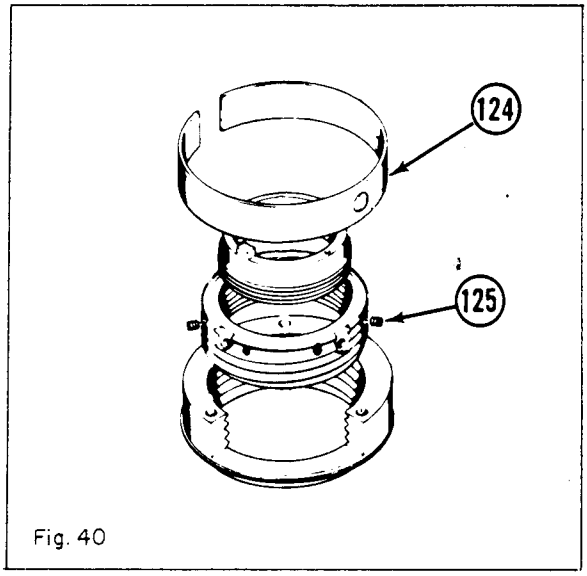

Fig. 40

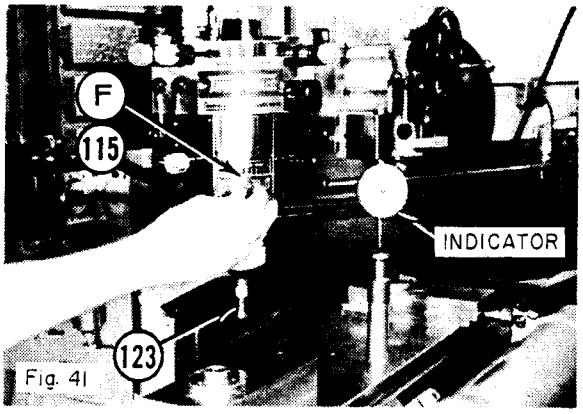

Fig. 41

Readjusting the vertical rate control to null (cont)

If the Vertical Rate Control lever (F115) has to be positioned at other than the zero mark, then you will have to loosen the setscrews (125) and repeat steps d, e, and f.

Before attempting to use the Tracer in a standard production run, make certain that all bolts and screws are secure and that all controls are working properly.

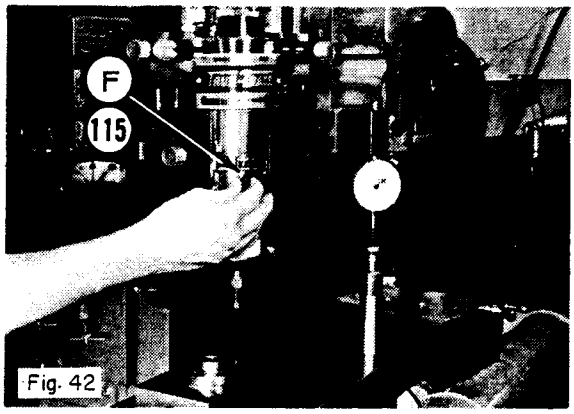

Fig. 42

REMOVING THE CONTROL SLIDE ASSEMBLIES AND SPOOLS

In the event that it may be necessary to remove either of the control slides (50) from the Tracer, the nose assembly will have to be removed in order to disengage the spindle from the interior of the control slides. To remove the control slides, proceed as follows:

a. Remove the button-head screw (87) holding leaf spring (86) in position under adjusting leaf spring screw (88) as shown in Fig. 43. Now remove the three screws (139) that secure the nose assembly to the bottom of the Tracer and drop nose assembly out of Tracer.

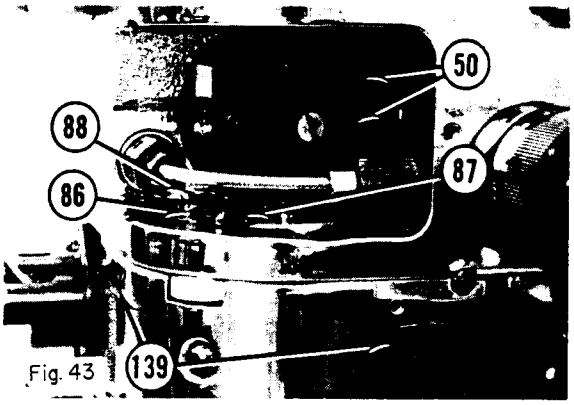

Fig. 43

b. Remove the four ¼-20 button-head screws (2) from the back of the Tracer as shown in Fig. 44. This will release the spool cover (1). After that cover is off, you may remove the rate control pinion cover (3) by first removing the four 8-32 button-head screws (4). (Fig. 44)

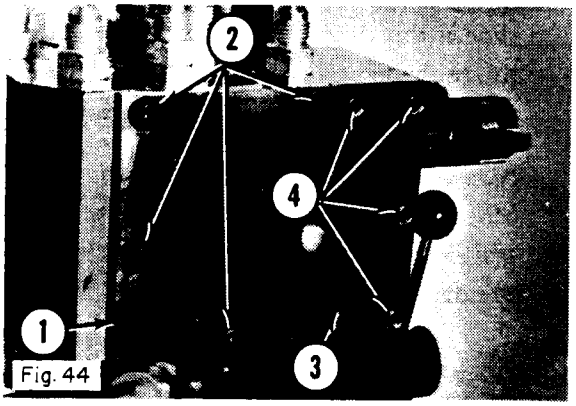

Fig. 44

c. The removal of the two covers will expose two gears, the spool gear (37) and the spur gear (41). Before proceeding any further with the disassembly of the valve, mark the two gears with a scribe, as shown in Fig. 45. This will assure your matching the gears to the same location on reassembly.

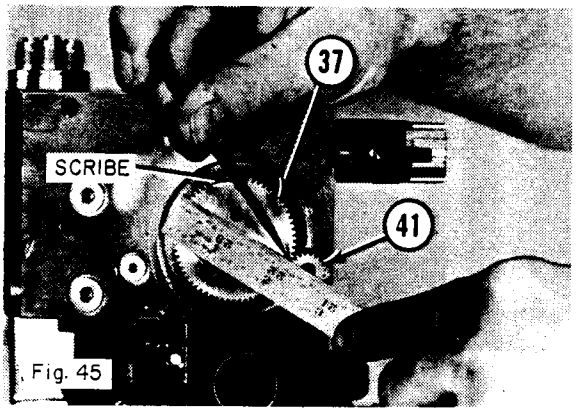

Fig. 45

F5378

Removing the control slide assemblies and spools (cont)

Also, it would help to mark the lugged washer (33) with some nail polish or some other permanent paint opposite the setscrew (48). With this precaution, you should be well assured to match the spool to the matching control slide in the same location when reassembling the Tracer.

d. To remove the control slide assembly, the slides (50) must first be separated from the spools. Loosen the setscrew (48) with an Allen wrench and rotate the lug washer (33) clockwise. This may be done with the same Allen wrench or a screwdriver as shown in Fig. 46. When doing this, the setscrews (46) on the feed rate shaft must be loose. Continue to rotate the lug washer until the bottom slide of the slide assembly is separated from the spool shaft (34).

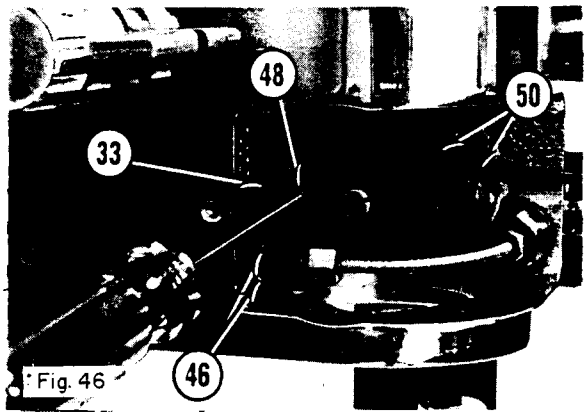

Fig. 46

e. When the spool shaft is unscrewed all the way out of the slide, the spool may then be pulled out as shown in Fig. 47.

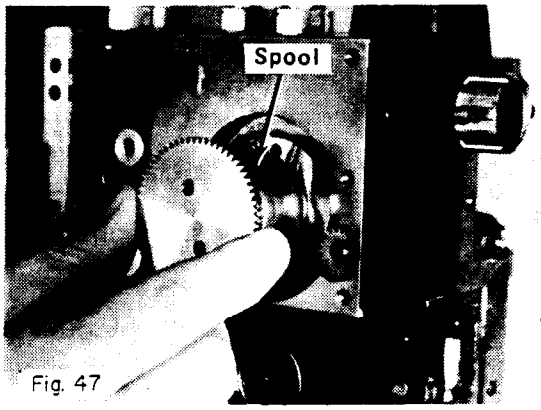

Fig. 47

Next, the bottom part of the slide assembly may be slipped out as shown in Fig. 48.

f. If it is necessary to remove the other control slide at this time, loosen the setscrew (48) and rotate the lugged washer (33) clockwise with an Allen wrench or screwdriver as shown in Fig. 49.

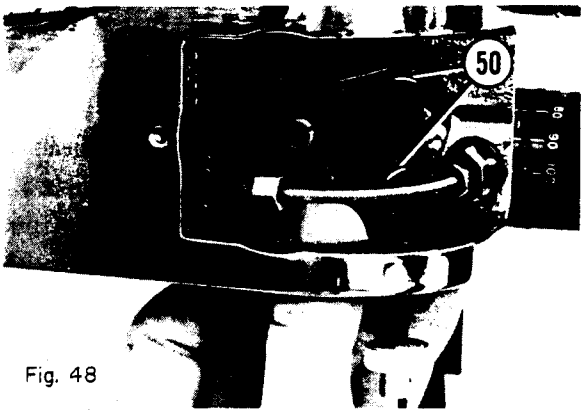

Fig. 48

NOTE: It may not be necessary to remove the other control slide unless a completely new control slide assembly is going to be fitted to a new spindle (123).

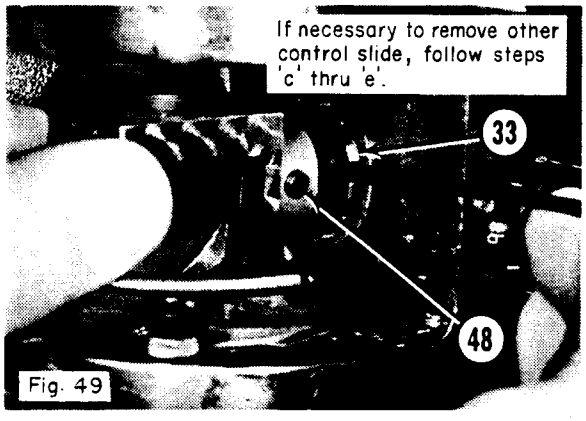

Fig. 49

F5379

REMOVING THE FLEXIBLE SHAFT ASSEMBLY

It is possible to remove the flexible shaft assembly (47) out of the Tracer Valve without removing the spool on the left-hand side of the tracer body. However, putting one back in without removing the spool may turn out to be quite difficult. Also, there is a possibility of damage to the cable because of the severe bend that has to be applied to the cable when reinserting one side of it back into the feed rate shaft (45). Consequently, it is recommended that the feed rate shaft, together with the bearing tube spacer (42) and spur gear(41), be removed or at least backed out enough to facilitate access to the flexible shaft assembly (47).

As stated before, to remove the flexible shaft assembly (47), the left-hand side spool must first be backed out as shown in Fig. 47.

a. The setscrews (46) have to be removed before attempting to pull the flexible shaft assembly (47) from the feed rate shaft (45) as shown in Fig. 51.

b. Loosen the setscrew (24) using an Allen wrench, as shown in Fig. 50.

c. Then, holding the flexible shaft assembly (47) with one hand, apply pressure on it so as to relieve the spring tension bearing on the feed rate shaft (45) as shown in Fig. 52.

d. With the other hand, pull on the spur gear (41) which is attached to the feed rate shaft (45) together with the bearing tube spacer (42). Pull it out far enough to remove one end of the flexible shaft assembly.

To remove the flexible shaft assembly (47) from the other side of the feed rate shaft, simply remove setscrews (46) and pull the flexible shaft assembly out, as shown in Fig. 53. To replace the flexible shaft assembly, reverse the procedure and reinstall all setscrews.

Before resuming normal operation of the Tracer Valve, make certain all parts are secured and all setscrews and bolts are tight.

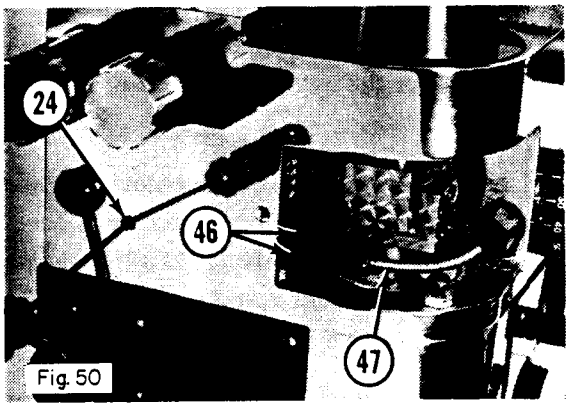

Fig. 50

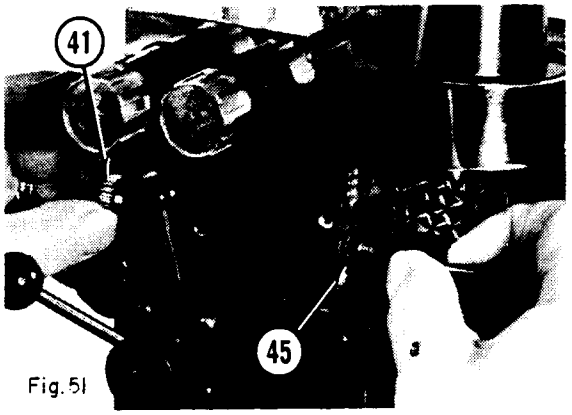

Fig. 51

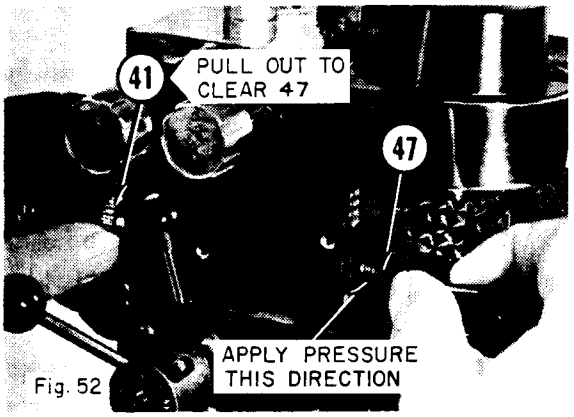

Fig. 52

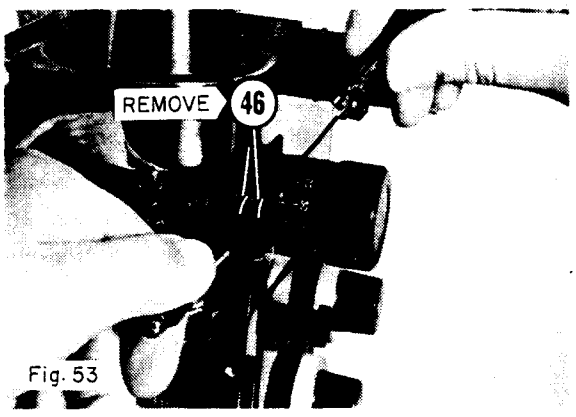

Fig. 53

F4683A

DISASSEMBLY OF THE SHUTOFF VALVE

It may sometimes be necessary to replace the O-rings or the nylon seat in one of the Shutoff Valves.

In order to remove the valve stem (14) and valve cage assembly (23), it is necessary to have to special tools. Tool number 17278 (Fig. 54) is a special Spanner wrench, and tool number 17277 (Fig. 55) is an ejector for the valve cage.

All four Shutoff Valves are identical in parts and assembly except for the Pressure Shutoff Valve (A). The only difference is the spacer (17) which makes up for the longer stem (19). With those two exceptions, the remainder of the assembly and disassembly of parts of all the Shutoff Valves is identical.

To disassemble a Shutoff Valve:

a. Remove the lever nut (6), as shown in Fig. 56, by applying a counterclockwise pressure. This will usually come off finger tight. If, however, the lever nut does not come off by hand, put a cloth around the nut and, using channel locks, break the hold.

After the lever nut (6) is unscrewed, the valve lever (7) slips right off the valve lever hub (9) to expose the lock nut (8), as shown in Fig. 57.

b. To get to the valve stem (14), the valve lever hub (9) has to be removed first, which is directly in front of the cage retainer (11). In order to unscrew the lock nut (8), the valve stem has to be held from rotation by inserting a small tool like an Allen wrench into the valve stem (Fig. 57). This is done through the opening in the valve lever hub. Using a box wrench or a similar tool, rotate the valve stem until the two holes line up as shown in the illustration. Insert the Allen wrench into the opening of the valve lever hub and on down to the valve stem hole provided for this purpose.

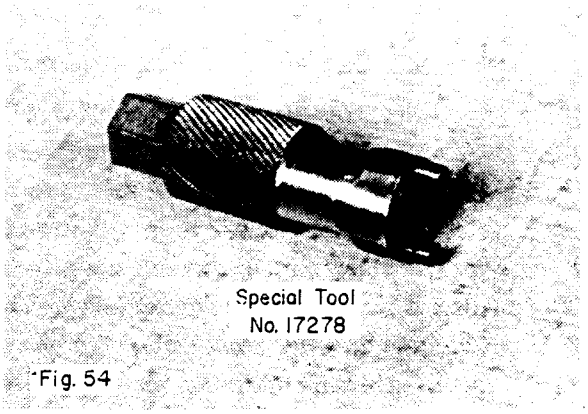

Fig. 54

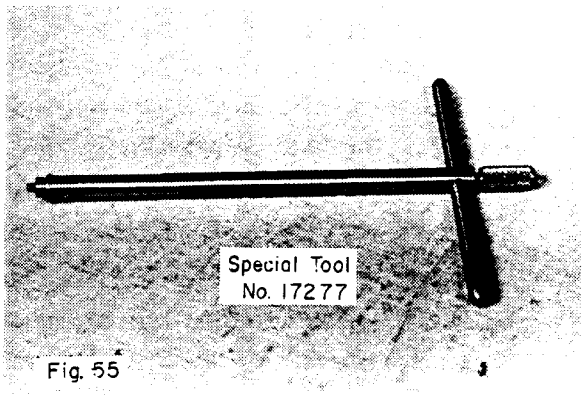

Fig. 55

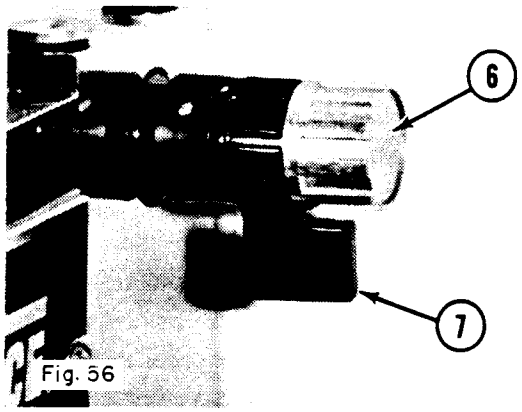

Fig. 56

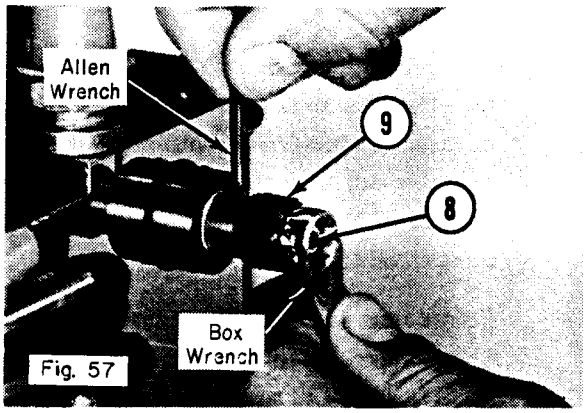

Fig. 57

F4684A

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Disassembly of the shutoff valve (cont)

c. After having inserted the Allen wrench into the valve stem hole, the lock nut (8) may now be removed. This will allow you to slip off the valve lever hub (9),which should pull right out. (Fig. 58)

d. The next piece to be moved is the cage retainer (11). This requires a special tool, number 17278, which is a small Spanner wrench. (Fig. 59)

Insert tool 17278 into the opening and line up the two pins to fit into the two holes in the cage retainer (11). By using a box wrench or a crescent wrench, apply a counterclockwise pressure on the tool to break the hold of the cage retainer.

e. With the cage retainer (11) out, grasp the valve stem (14) by the threaded end and pull out. (Fig. 60) If the valve stem refuses to come out, apply a slight rocking circular motion; this should break the hold. No pliers or tools should be used here, because the only thing that is holding the valve stem is the contact of the O-ring seals.

f. With the valve stem (14) removed, it is now necessary to use the other special tool, number 17277, to remove the valve cage (23) together with the valve seat (26). With the expander knob pushed all the way against the tool handle, insert the tool into the opening and on down through the valve cage until the tool bottoms out.

At this point, the end of the tool with the prongs closed should be through the valve seat (26), bottomed against the body of the Tracer.

g. The tool is now ready to have its prongs catch around the inside periphery of the nylon valve seat (26). Pull back and lift up on the tool so that you can feel the prongs catch on the inside of the valve seat. (Fig. 61)

After you feel the tool catch, pull on the expander knob (about ¼ inch) to make sure that you have a good hold on the valve seat (26). (Fig. 61)

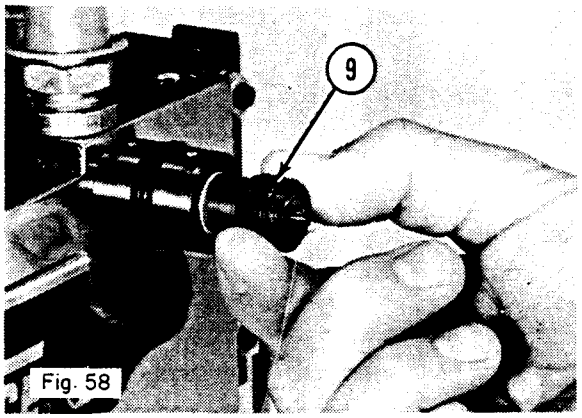

Fig. 58

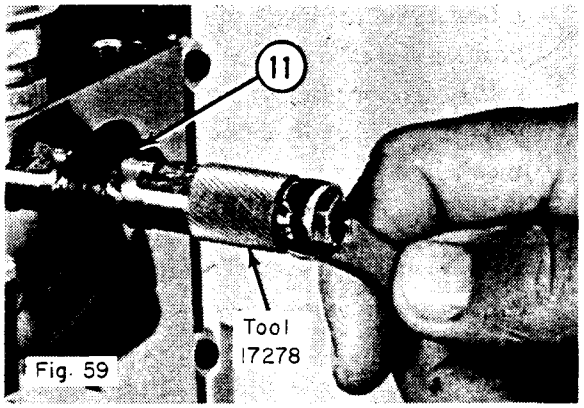

Fig. 59

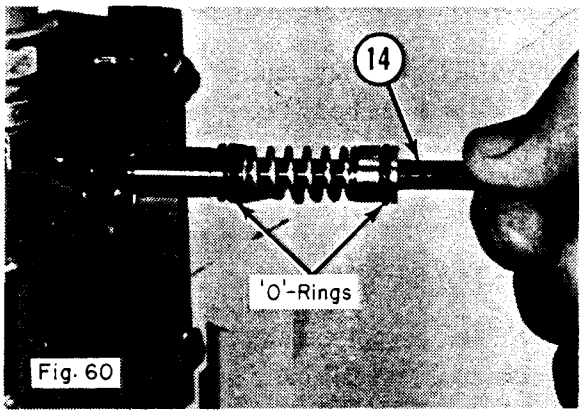

Fig. 60

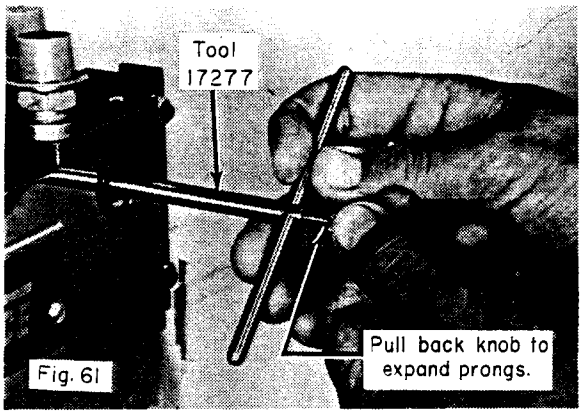

Fig. 61

F4685A

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Disassembly of the shutoff valve (cont)

At this point, you can start pulling on the tool handle and the valve cage (23) should come, with a steady tug. (Fig. 62)

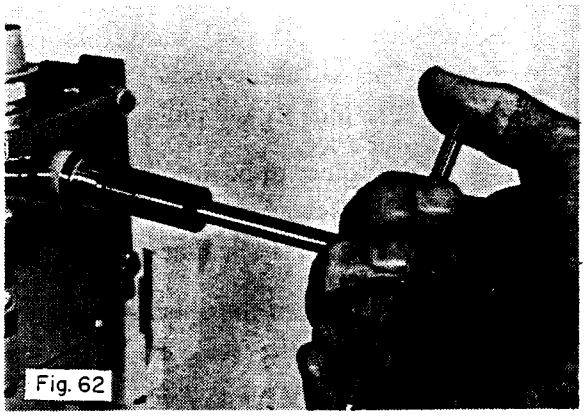
Fig. 62

h. After the valve cage (23) is out, remove the tool by pushing the expander knob in. This will collapse the prongs on the tool and allow you to remove it from inside the valve cage.

j. To separate the valve seat (26) from the valve cage (23), insert the valve stem (14) back into the valve cage so that the large end of the valve stem is bearing on the inside of the nylon seat (Fig. 63). Position the valve stem with its threaded end on a soft surface or place a cloth under it. Grasp the valve cage and apply a downward pressure on it, thereby pushing the valve seat out enough to break the hold. (Fig. 64) You may now remove the valve seat with your fingers.

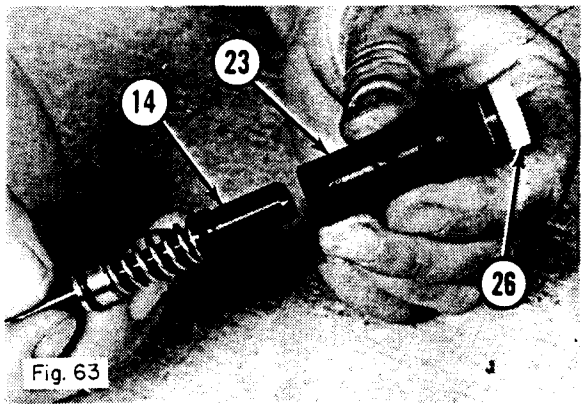

Fig. 63

Inspect the valve seat (26), especially the mating area where the seat meets the valve stem (14). Look for nicks or imbedded dirt or chips. Replace the seat if necessary, and reassemble all parts.

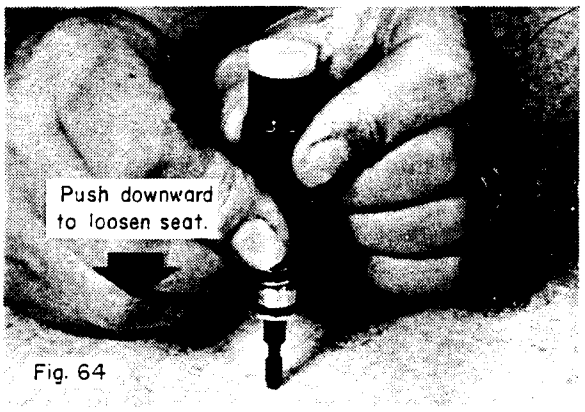

Fig. 64

CAUTION: When replacing the valve cage (23) back into the body (using tool 17278, Fig. 59), care should be used not to overtighten. A torque of approximately 75 inch-pounds should be used. More torque than this will distort the valve cage and cause leakage.

NOTE: A tool kit, Model 3059-03 with the special tools, is available if desired. The kit consists of the following:

1. Seat Extracting Tool, Part Number 17277
2. Spanner Wrench, Part Number 17278

REASSEMBLING THE SERVOVALVE SPOOL IN THE FEED DIRECTION SERVOVALVE ASSEMBLY

If it should become necessary to replace some of the seals or O-rings in the feed direction servovalve assembly, proceed as follows: The first three steps are identical to those shown in this section, page 1, steps 1 through 3. (replacing the drive belt).

1. After the access cover and escutcheon plate have been removed, the servovalve spring adjustment housing (190) is now exposed. This housing is held in place by a retaining ring (189). To get at the spool, it is necessary to first remove the retaining ring (189). This may be done by inserting a screwdriver or a similar tool, as shown in Fig. 65, and springing it toward the center. One end of the retaining ring has a small "notch" in it which is there for the purpose of being able to catch the ring in that area and removing it from its locking position.

2. After the servovalve spring adjustment housing is removed, remove the spring (192) and O-ring (193) which seat inside the opening of the servovalve spool. With the aid of a small screwdriver, you may be able to pull the spool out of the servovalve body (194) if necessary. (Fig. 66) On replacing the spool back into the servovalve body, you will note that one end of the spool has a threaded hole, as shown in Fig. 67. This threaded hole goes opposite the spring end. (Except for the spring, the opposite side is identical.)

3. On reassembly, make certain that all parts are clean and free of any foreign matter. Before inserting the servovalve spool back into the servovalve body (194), flood the spool with oil, the same oil that is being used in the power unit.

NOTE: It is important that the spool go back into the servovalve body in the same position that it came out. That is, with the hole in the servovalve pointing away from you on reassembly.

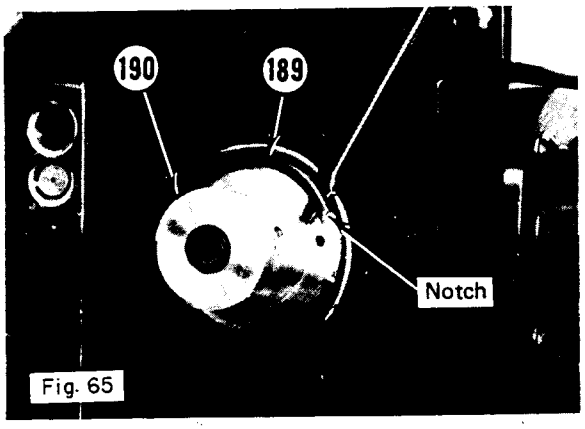

Fig. 65

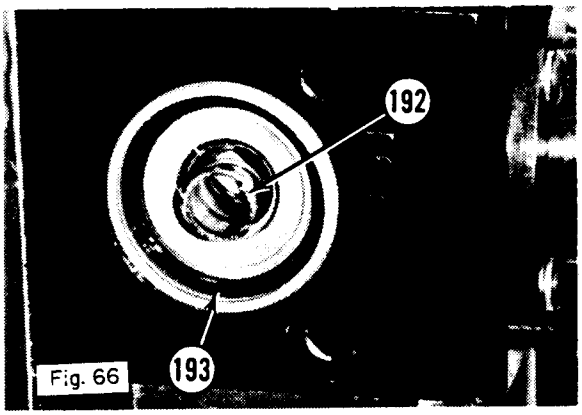

Fig. 66

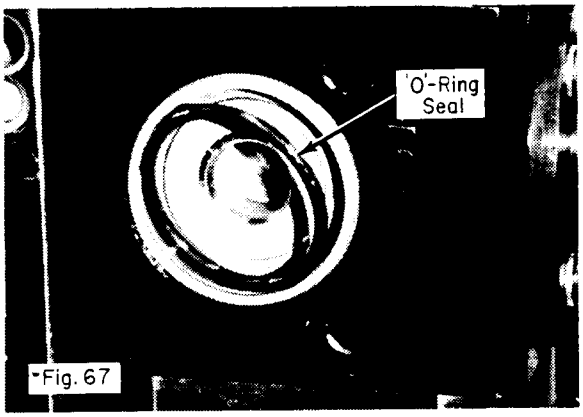

Fig. 67

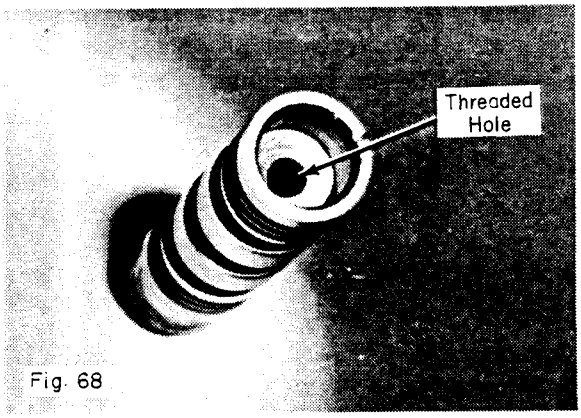

Fig. 68

ADJUSTING THE SERVOVALVE SPRING ADJUSTMENT MECHANISM

If it should become necessary to adjust the servovalve spring adjustment mechanism, proceed as follows:

1. In order to adjust the servovalve, the starting position of the spring adjustment screw (188) should be with the adjustment screw extended approximately 1/8 inch from the outer surface of the servovalve spring adjustment housing (190).

NOTE: Before attempting to turn the adjustment screw (188), make sure that the locking setscrew (60) is backed off. (Fig. 69)

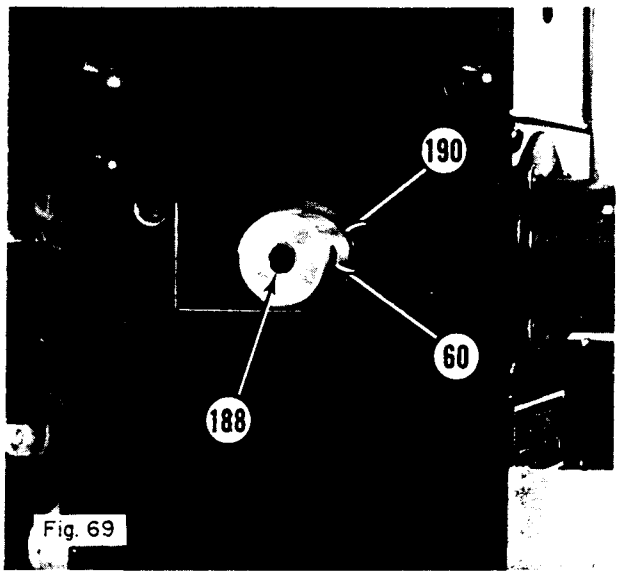

Fig. 69

2. Set the deflection adjustment to 0.005 inch and the Feed Rate Control to approximately 30%. With the stylus tracing a template, turn the adjustment screw (188) in (clockwise) until a strong dither (pulse) is felt at the steering motor drive shaft (lower left side of the Tracer Valve). Move the Feed Rate Control dial through its full range. The dither should not change.

Open the deflection adjustment to 0.015 inch and readjust the steering air regulator to obtain the correct bias position. Repeat the procedure of moving the Feed Rate Control dial through its full range. If the intensity of the dither has changed from the 0.005-inch deflection setting, turn the adjustment screw (188) in (clockwise) until a good dither is obtained.

NOTE: Each time that the adjustment screw (188) is changed, the bias position will need to be readjusted, using the Steering Air Regulator.

3. Open the deflection adjustment to 0.020 inch, and then to maximum position. Repeat the previous procedure at each point until a good dither can be obtained throughout both the deflection and the feed rate ranges.

When the final adjustment has been made, the setscrew (60) and locking plug (169) should be snugged against the adjustment screw (188).

NOTE: Do not overtighten setscrew.

VERTICAL FEED RATE RESTRICTOR

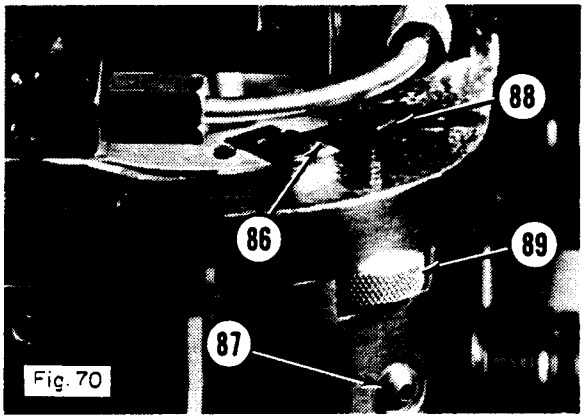

Fig. 70

The Vertical Feed Rate Restrictor (P) controls the vertical feed rate of the machine when an upward pressure is applied to the stylus. This control does not regulate the doward or seeking speed of the vertical member; it controls only the upward speed.

There is a Leaf Spring (86) coupled to the adjusting knob (89). The adjusting leaf spring screw (88) has a flat at the bottom half and a 6-32 screw (87) alongside of it to keep it from rotating when the adjusting leaf spring knob is rotated clockwise or counterclockwise. (Fig. 70)

The adjusting leaf spring screw (88) is a right-hand thread; consequently, when you rotate the adjusting knob (89) counterclockwise, you are bringing the adjusting leaf spring screw, together with the leaf spring, downward, restricting the upward motion of the spool.

This restriction can always be overridden when tracing; simply exert a little more pressure beyond the spring restriction and the vertical member will move as fast as its capacity will permit.

To increase the vertical speed when tracing, simply rotate the adjusting knob (89) clockwise; this will move the adjusting leaf spring screw (88) upward, thereby allowing the screw to move farther out and thereby opening the oil flow to a greater volume.

ADJUSTING THE SAFETY AIR RELEASE ROCKER PLATE

The Safety Air Release works in conjunction with the True-Trace Safety Diversion Valve, 4111-01. For a complete description of the Diversion Valve and all its advantages, ask for Bulletin S-900.

Before attempting to adjust the Safety Air Release, check out the "Null" position of the Vertical Rate Control Lever (F). (Fig. 71) A complete description of this adjustment is given previously in this section.

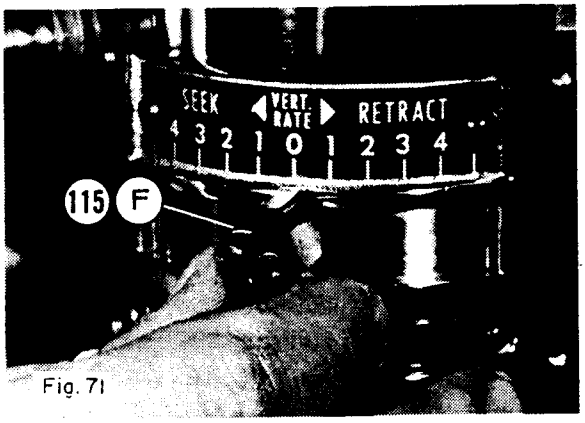

Fig. 71

You should be able to actuate the Safety Air Release with a very slight upward movement of the spindle when the Vertical Rate Control Lever (F115) is at full retract position (all the way to the right). An upward thrust of 0.003 inch to 0.005 inch should actuate the Safety Air Release. If you cannot hear air escaping when you actuate the stylus upward, the Safety is not functioning properly.

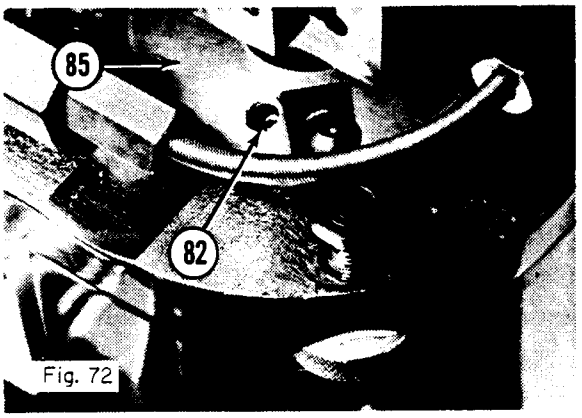

Fig. 72

To adjust the Safety Air Release, proceed as follows:

1. Position the Vertical Rate Control Lever (115) all the way to the right "Retract" (this may be done with hydraulic power off but with air on).

2. With Allen Driver, turn setscrew (82) clockwise until you can hear air escaping.

3. As soon as air starts to escape, back off the setscrew (82) out of the safety air release rocker plate (85) until air stops escaping. (Fig. 72)

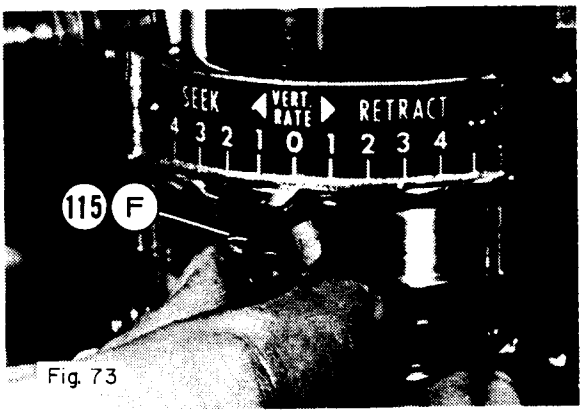

Fig. 73

4. Move the Vertical Rate Control Lever (F115) all the way to the left "Seek" and then back all the way to the right "Retract." (Fig. 73) The Safety Air Release Rocker Plate (85) should get actuated with approximately 0.003 inch to 0.005 inch upward pressure on the stylus or spindle (123). You can check this out with the aid of a dial indicator if necessary.

5. Replace the access plate (21) after making certain that the Safety Air Release is working properly.

Before resuming normal production, make sure that all bolts and lines are secure and Tracer is in operating condition.

F5382

REPLACING THE AIR VALVE CORE IN THE PILOT CHECK VALVE

To replace the valve core (83), you have to first remove the pilot check valve housing (75), together with the pilot check valve cover (72). (Fig. 74) Loosen the two 6-32 cap screws (69). This will expose the opening that houses the air valve core (83). If it is necessary to replace the O-ring in the pilot check piston, then you will have to remove the other 6-32 cap screws (70) to separate the pilot check cover (72) from the pilot check valve housing (75).

For proper sequence of reassembly, see the Parts List.

To remove the valve core, use a regular tire valve core tool for this purpose. After unscrewing the valve core, it may be removed with a pair of tweezers or a pair of long-nosed pliers.

On reassembly, make certain the pilot check valve housing (75) is positioned to line up with the air passage of the Tracer Valve body which is in the lower right-hand corner of the hole pattern of the Tracer.

Before "buttoning-up," make certain that all the O-rings have been replaced and all screws are tight.

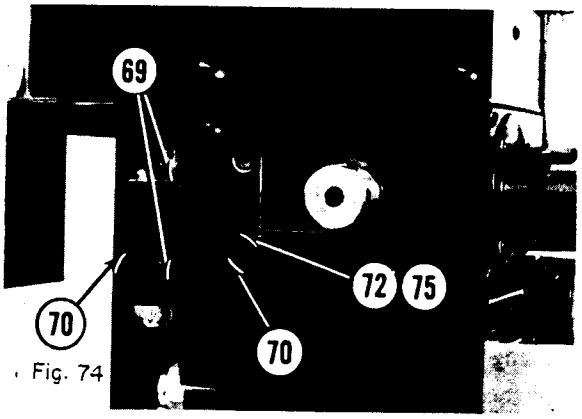

Fig. 74

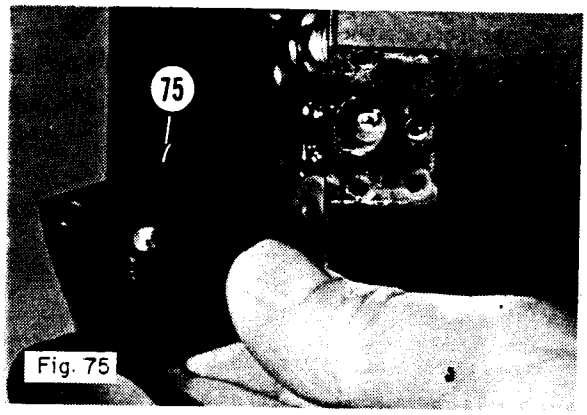

Fig. 75

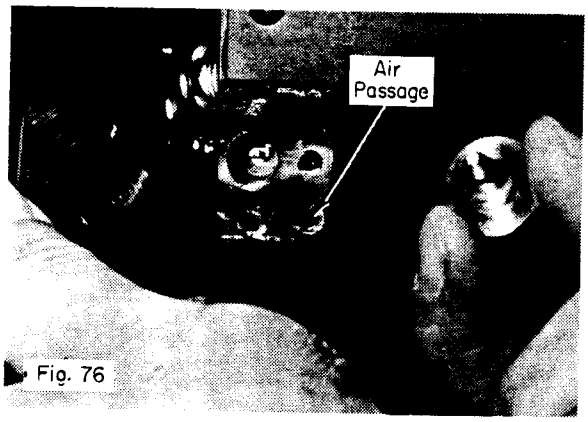

Fig. 76

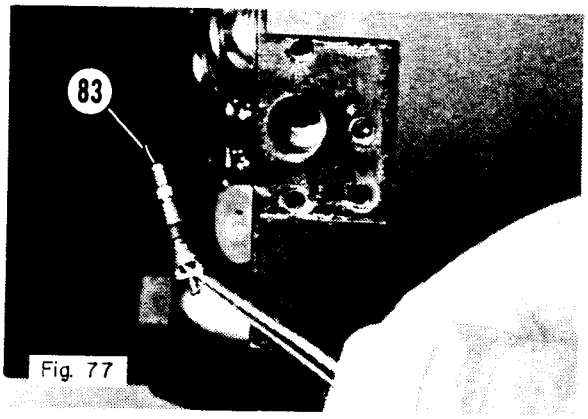

Fig. 77

DISASSEMBLY AND ADJUSTMENT OF CHECK VALVE (in back of Tracer Valve)

To remove the check valve assembly, unscrew the boss hex nut (94) and remove it from the opening as shown in Figs. 78 and 79.

To remove the cartridge-type insert (92), use either a small screwdriver or a pair of tweezers. Using the inside hole of the cartridge, draw it out of the opening by applying a slight side pressure.

When replacing the cartridge-type insert (92), note the direction of the arrow; the arrow must be pointing inside the hole with the beveled edge of the cartridge facing you, as shown in Fig. 80.

On reassembly, make certain that the spacer (93) is not omitted. For the proper sequence of re-assembly, see the Parts List.

If you are replacing parts or O-rings, you must readjust the setscrew (97) and jam nut (96). On reassembly of the setscrew, jam nut, and boss hex plug (94), loosen the jam nut and back the set-screw out of the boss hex plug several turns. After reassembling the spacer (93) and cartridge-type insert (92), replace the hex plug, tighten it, and then turn the setscrew until you feel it bottoming out. Do not apply much pressure after you feel the resistance of the spacer (93). When you have made contact with the spacer, tighten the jam nut. You should now have the check valve assembly in proper adjustment.

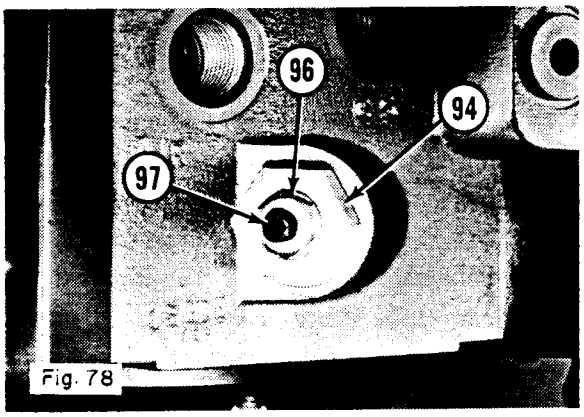

Fig. 78

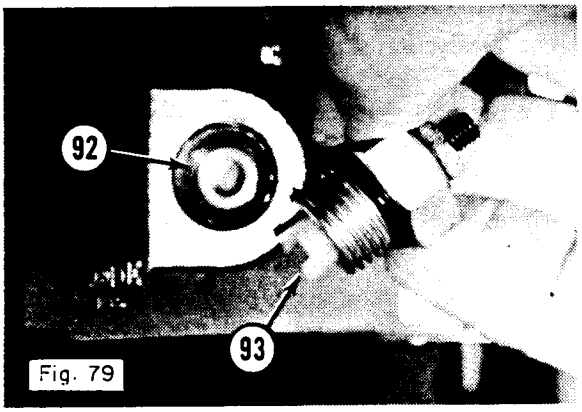

Fig. 79

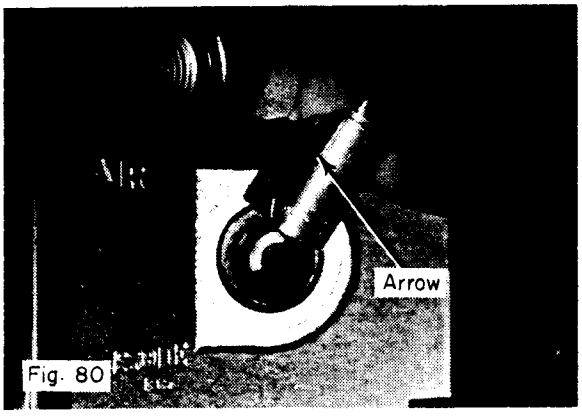

Fig. 80

TRUE-TRACE®

REPLACING THE SELECTOR PISTON IN THE FEED DIRECTION SERVOVALVE ASSEMBLY

In the event it becomes necessary to replace the selector piston (186) or associated O-ring (187), proceed as follows:

1. Remove the lever (182) out of the shear seal housing (183).

2. Remove the four 6-32 button-head screws. This will expose the selector piston (186). (Fig. 82)

To remove the selector piston (186), simply pull it out with your fingers or with the aid of a screw-driver.

3. When you remove the selector piston (186) and if, after inspection, you find that there is a need to replace it because of nicks or chips in-dented into the teflon portion of the piston, you will have to replace the selector piston. Install the new selector piston in precisely the same position as the one you take out.

4. You may also wish to examine the O-ring. Check if it has any nicks or cuts. If there has been no oil leakage prior to your disassembly of the selector piston, then there should be no need to replace the O-ring. However, if the Tracer Valve has been in hard service for a long time, it would be advisable to replace the O-ring at this time while you have the feed direction servovalve apart.

5. Before reassembly, make certain that there are no chips of any kind in any part of the selector piston. It is advisable to blow off all parts with a strong current of air before reassembly.

On reassembly, reverse the procedure described in steps 1 and 2. Before resuming normal operation, make certain that all bolts and nuts are tight and all lines secure.

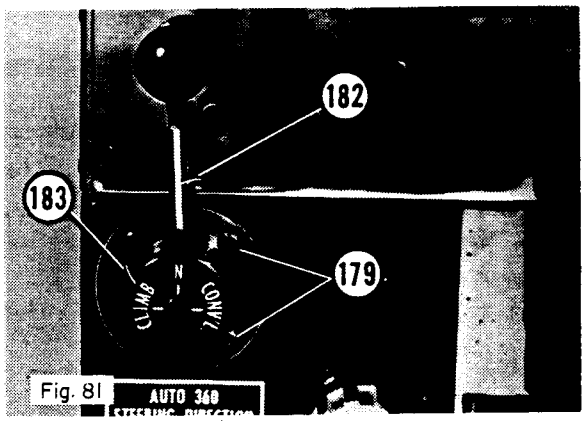

Fig. 81

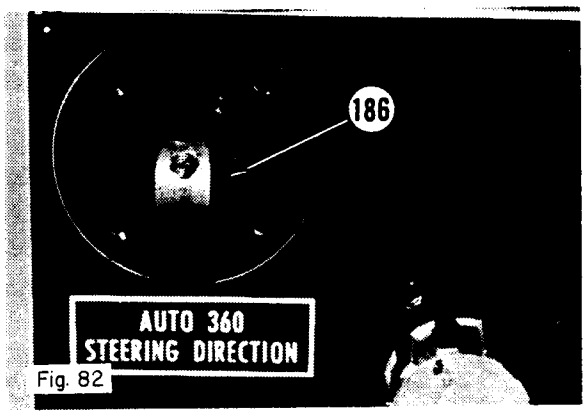

Fig. 82

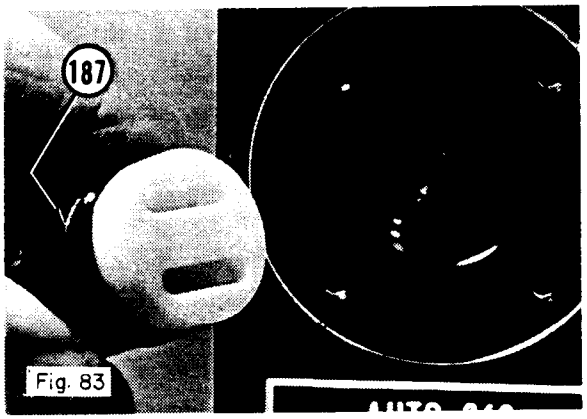

Fig. 83

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DISASSEMBLING THE BIAS HOUSING ASSEMBLY

It may be necessary to replace or check the split ball bearings (152) or to clean the steel ball bearings (155) in the Bias Housing Assembly. To do this, proceed as follows:

1. Remove the two 4-40 cap screws (171) as shown in Fig. 84.

2. With the two cap screws removed, you will be able to lift out the bias index plate (145). Under the bias index plate you will find the housing pulley (146) and the pulley flange (147) as shown in Fig. 85.

3. Next remove the three 4-40 socket head screws (38). After you remove these screws and lift out the bearing retainer (148), you will be able to see the top of the bias spool (154) as shown in Fig. 86.

4. You will note that there are some shim washers (149, 150, and 151) between the top split ball bearing (152) of the bias spool and the bearing retainer (148). These shim washers together form a precise thickness which is necessary for preloading these bearings.

If you are replacing the same bearings onto the bias spool (154) after disassembly, then you can replace the shim washers you just took out which form a 1/1000 preload between the bearings (152) and the bearing retainer (148). However, if you are putting a new set of bearings or bearing into the assembly, then you have to depth mike the distance of the recess in the bearing retainer and the step that is formed between the air bias housing assembly and the outer race of the bearing itself.

The shim washers come in three different thicknesses: 0.001 inch (149), 0.005 inch (150), and 0.010 inch (151). If you do not have the facility in your shop to cut out these shim washers, you

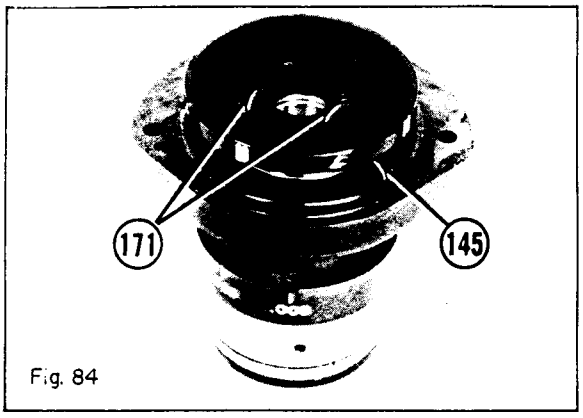


Fig. 84

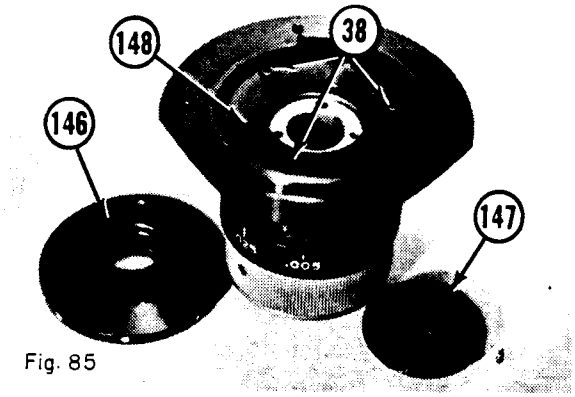


Fig. 85

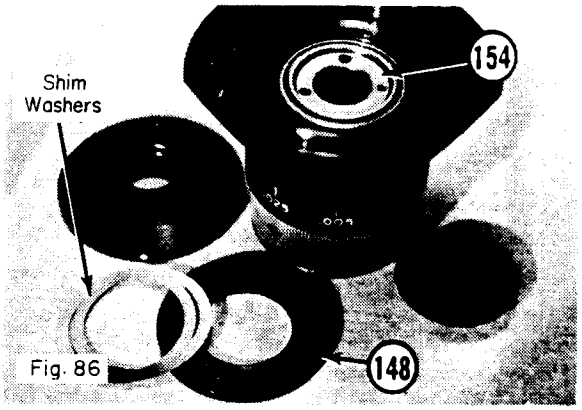
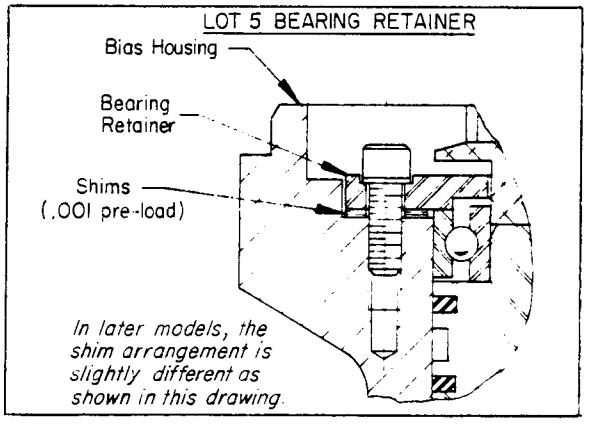


Fig. 86



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Disassembling the bias housing assembly (cont)

may send for the necessary items to True-Trace; with the three different sizes, you can get any combination you may need.

5. Having removed the bearing retainer (148), you may now lift the bias spool (154) out of the air bias housing assembly as shown in Fig. 87.

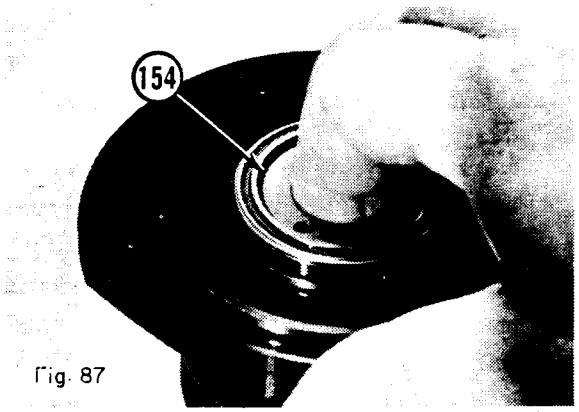


Fig. 87

6. After the bias spool (154) is out, take care not to drop the steel ball bearings (155) out of the spool. You will note that there are two notches in the spool at 180 degrees to each other on either side of the spool where each bearing comes into contact on the flat side of the spool. (Fig. 88)

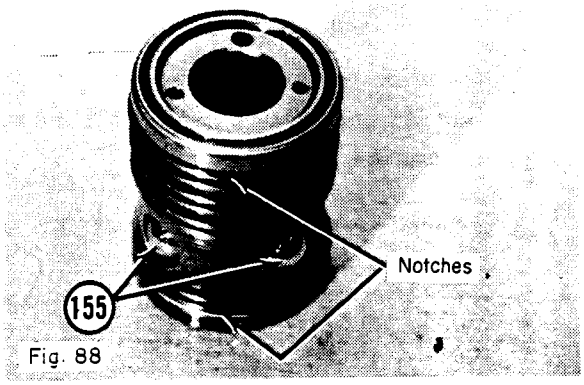


Fig. 88

7. To remove a split ball bearing (152) from either side of the bias spool (154), get two small screwdrivers. Position them in the notches provided, lift up and at the same time push into the notches to lift the bearing off.

CAUTION: *Do not* – repeat, *do not* pry down with your screwdrivers because of the thin wall where the notches are formed. You may break off a piece of the shoulder or land that forms the groove for the nylon backup ring. When removing the bearing, always lift up on the screwdrivers, at least until you have a wide enough opening to bear on the inside of the shoulder.

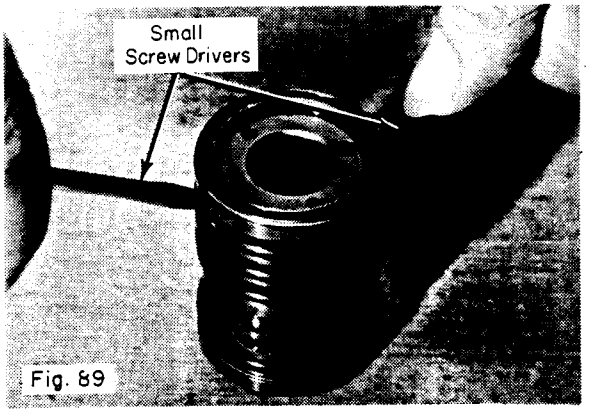


Fig. 89

After you have lifted the bearing off slightly, insert two larger screwdrivers between the bearing and the bias spool. By twisting both screwdrivers at the same time, the bearing should come off.

CAUTION: On reassembly, take care not to force the bearings onto the spool. Make sure bearing is not cocked when attempting to slide it down on the spool.

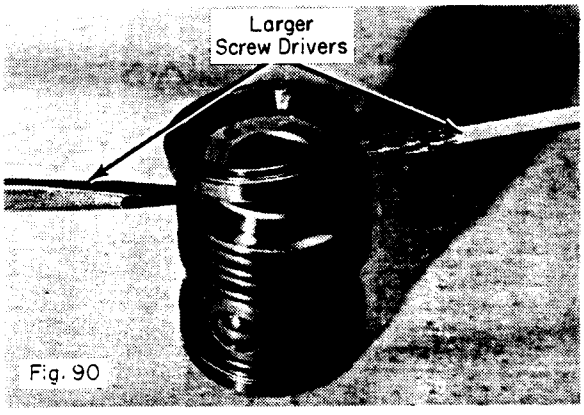


Fig. 90

If it is necessary to remove the bearing on the opposite side of the spool, proceed in the same manner.

Disassembling the bias housing assembly (cont)

To replace the backup rings (153), simply insert a scribe or a small screwdriver in the area where the split ring joins and lift it out as shown in Fig. 91.

On reassembly, make certain that the shim washers (149, 150, and 151) are located properly as shown in Fig. 92. If the washers are not located properly, there will not be the desired preload on the bearings previously mentioned. This will make the air bias housing assembly malfunction.

To reassemble the air bias housing assembly, reverse the procedures shown in steps 1 through 7.

Before starting machine, make certain that all screws are secure and all nuts and bolts are in proper adjustment.

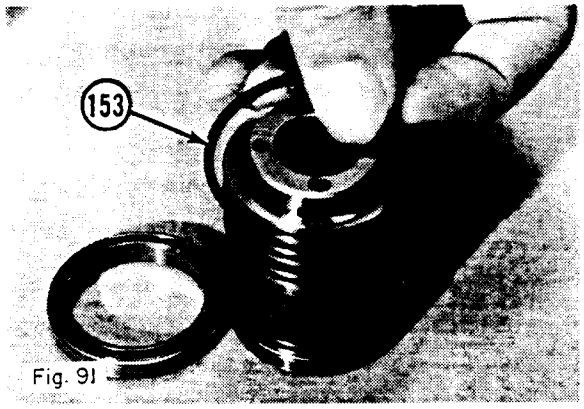


Fig. 91

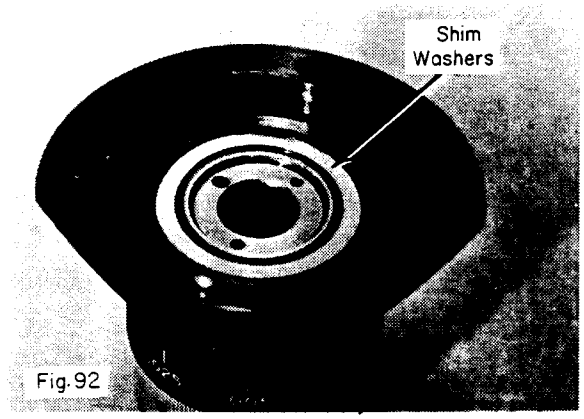


Fig. 92

REMOVING THE AIR SIGNAL RATE CONE ASSEMBLY

In the event that the Rate Ring should get stuck or ceases to be free-moving, it is relatively simple to remove it from the Tracer Valve, for disassembly inspection and cleaning. In order to accomplish this disassembly, IT IS NOT NECESSARY to remove the complete bias housing assembly from the nose of the Tracer Valve. (Fig. 93. shows a complete parts break down of the assy.).

[1] To remove the Rate Cone assembly, it is first necessary to remove the rubber boot (163) and the lower retainer (164) which are attached with three socket head screws (**166**)

[2] The Rate Cone assembly consisting of items (160), (161) and (162), is attached to the lower surface of the deflection control ring (156) by the upper retainer (164) and three socket head screws. Removing the three screws (165), will separate the assembly from the bias housing.

[3] Remove the three screws (38) holding the Rate Cone assembly together. Inspect each piece for any nicks, dirt or lint that may have lodged between bearing plate (161) and the Cone (160) and/or the retainer (162) (Fig. 94) also check for any visible wear marks or high shiny spots which may cause problems.

[4] Clean all parts thoroughly and if necessary, stone each mating surface with a hard Arkansas stone.

[5] On reassembly, make certain that no foreign matter is present on any of the mating pieces.

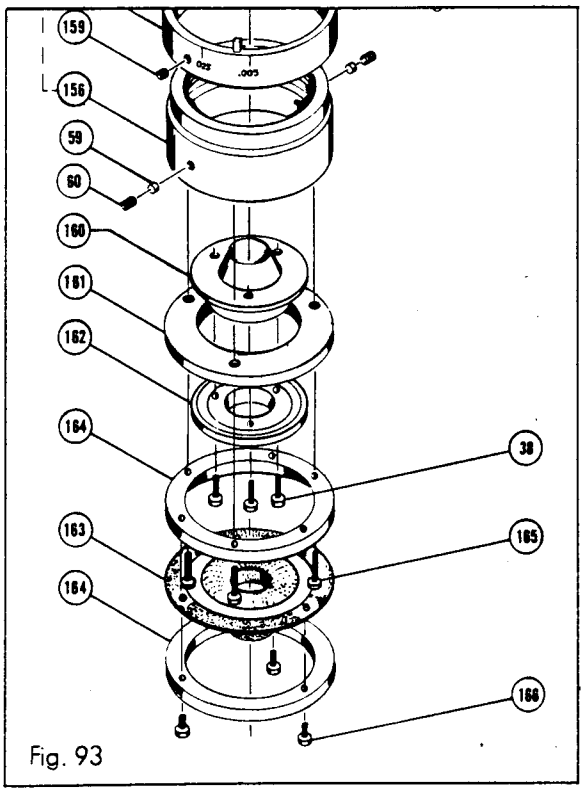


Fig. 93

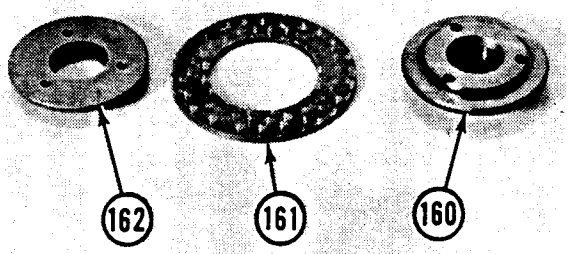


Fig. 94

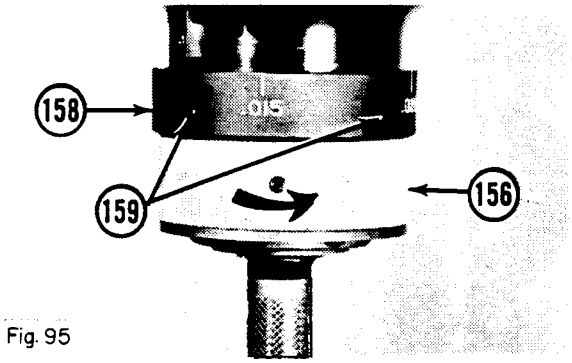


Fig. 95

F4697B

[6] Before the upper retainer (164) is locked down, make sure that the bearing plate (161) is centered on the outside of the deflection control ring (156). The boot and lower retainers may now be reinstalled.

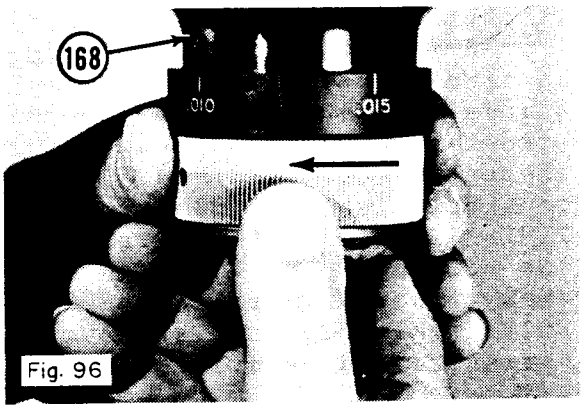


Fig. 96

At this point it is best to reset or check the deflection setting calibration.- The following procedure will accomplish this:

[A] Loosen the two setscrews (159) on dial ring (158). Rotate the deflection control ring (156) in a clockwise direction until no evidence of play is felt in the spindle. (Fig. 95).

[B] Position the dial ring (158) to the .005 deflection position and secure the setscrews (159), (Fig. 97).

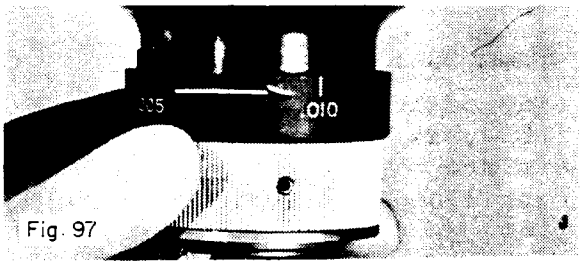


Fig. 97

[C] Rotate the dial (158) together with the deflection ring (156) to the .010 deflection position opposite the stop (168).

[D] Holding the deflection ring (156) stationary, loosen the setscrews (159) and position the dial ring back to the .005 position.- Secure the setscrews. (Fig. 98).

Fig. 98

Before resuming normal operation, make certain that all screws and bolts are secure on the Tracer Valve.

BULLETIN NO. D-682

Feedrate and Accuracy Chart for Con-Trol-Path and Con-Trol-Scan Hydraulic Tracing Systems

This chart shows the feedrate and accuracy which can be expected with the Con-Trol-Path (Model 1110) and the Con-Trol-Scan (Model 1115) tracer valves when used on a small knee type vertical milling machine.

JULY 1982

TRUE-TRACE®
Division of Thiem Industries, Inc.

2520 Pacific Park Drive
Whittier, California 90601
Phone (213) 692-1225

ACCURACY The degree of accuracy which can be obtained from any particular tracer control system is not dependent upon any one system component, but the combination, compatibility, condition and adjustment of both the tracer and the machine tool upon which it is installed. In order to obtain the optimum accuracy from a system, the machine tool and tracer valve must be in their optimum conditions.

Different types of tracers (manual 360/3D, Con-Trol-Path, Con-Trol-Scan, Synchro-Trace, etc.) will each produce separate results. These results may vary from one machine to another, even on machines of the same size, type, style, brand, etc.

In the case of the manually operated valve or manual mode of operation within an automatic valve, a very skilled operator will be able to obtain a higher degree of accuracy than a lesser skilled operator using the same machine. Different degrees of accuracy are also obtained from the automatic modes of operation because of minor adjustment methods or procedures used by various operators which may use the same machine. Accuracy is broken into two separate categories:

(1) PART-TO-TEMPLATE - This is defined as the difference between a dimension of the template and the corresponding dimension of a part cut from the template.

(2) PART-TO-PART - This is defined as the difference between a dimension of one part and the corresponding dimension of another part cut from the same template on the same setup. This is referred to as REPEATABILITY.

In the case of the manual 360/3D, Con-Trol-Path, and Con-Trol-Scan tracer valves, test cuts are made by cutting approximately 4 inch diameter discs. The accuracy of these test cuts are measured against a "PART TO TEMPLATE" accuracy standard as shown on the chart.

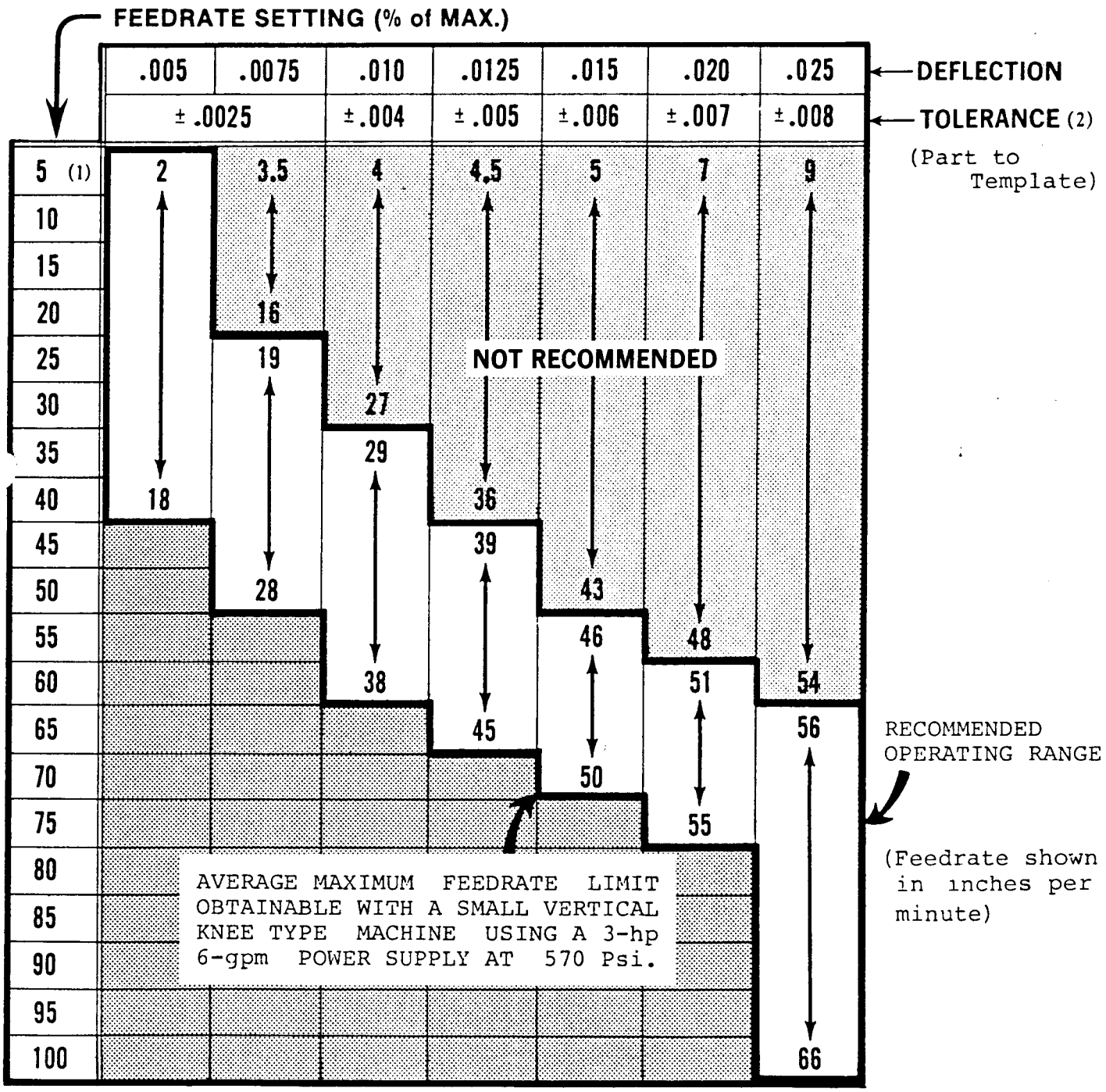
SPECIFICATIONS The surface finish which can be produced by a tracer system is dependent upon the conditions and adjustments of the machine slides, actuators (cylinders or fluid motors), the machine spindle/s, the milling cutter/s, the template, the stylus, the tracer valve, the tooling and the general hydraulic system (including the hydraulic hoses). The average surface finish normally obtained from a small vertical knee type machine in good condition is approximately 50 RMS. As the size of the machine increases, the RMS figure also increases.

The maximum feed rate that can be obtained from a particular tracing system is dependent upon the displacement of the pump and the horsepower of the drive motor used on the hydraulic power unit. Another factor that must be taken into consideration is the pressure drops within the system. At each point that a pressure drop occurs, a loss of flow also occurs. The size of the hydraulic lines (hoses or tubes), the size, type and quantity of fittings and the frictional load on the actuators (cylinder or fluid motor) all contribute to the total pressure drop within the system. The reduction of these pressure drops and frictions will increase the efficiency of the overall system and at the same time provide a greater maximum feed rate.

FEEDRATE ACCURACY Chart Each increase in the deflection setting will produce a higher feed rate but as the deflection increases, the obtainable tolerance also increases. As shown by the chart, the highest degree of accuracy is obtained in the lower DEFLECTION range. In order to obtain the best accuracy for a particular feed rate, always use the minimum DEFLECTION setting that can produce the desired feed rate.

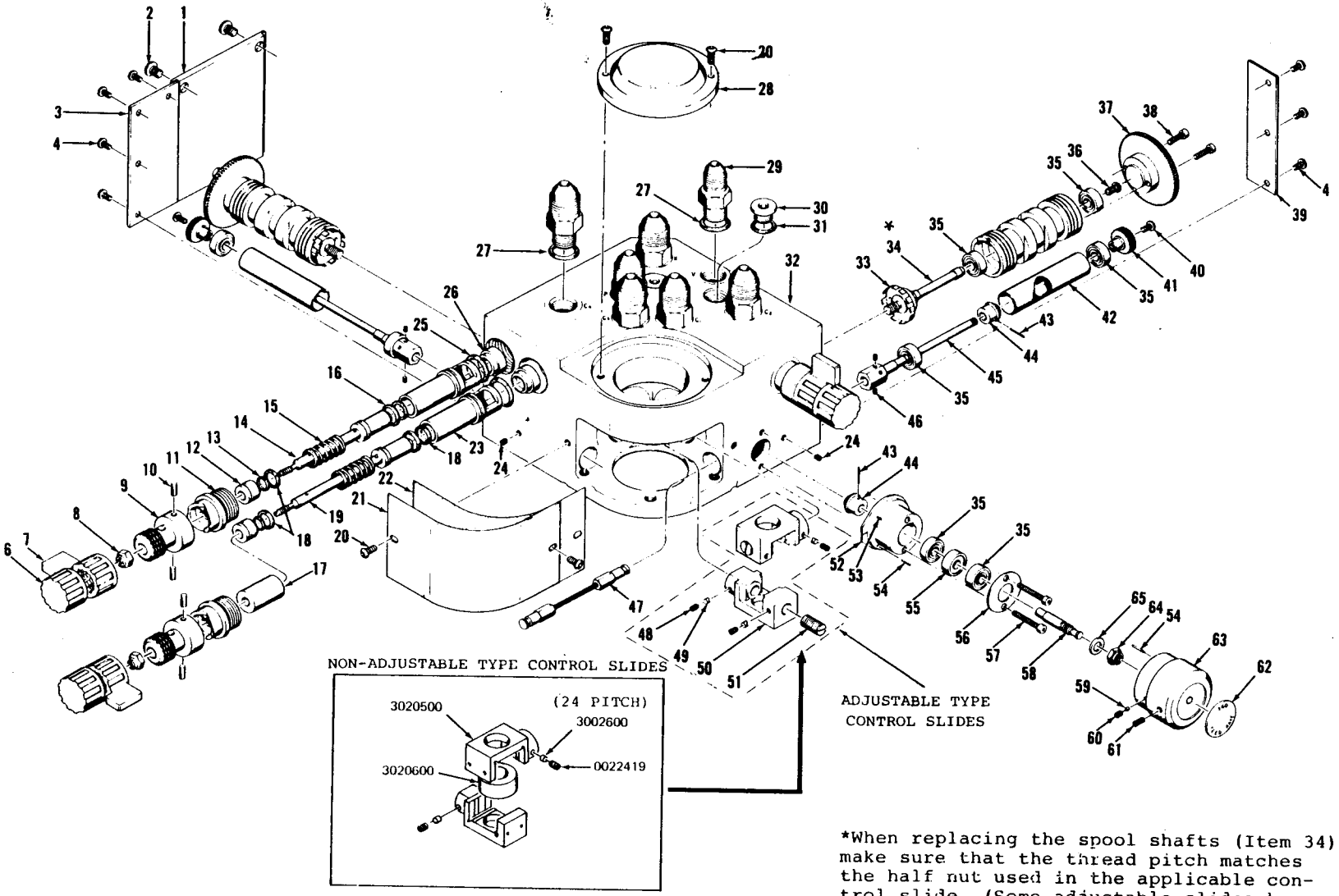
Example A 25 IPM feed rate is required for a particular job. From the chart it is determined that this feed rate can be obtained at all deflection settings of .0075 or greater. By choosing the .0075 deflection setting and increasing the feed rate setting, an accuracy of ± .0025 can be expected but if a deflection setting of say .015 were chosen and the feed rate setting decreased, the best accuracy that can expected is approximately ± .005.

FEEDRATE/ACCURACY CHART



NOTES (1) When using a feed rate setting of less than 5%, a sacrifice in accuracy may occur.

(2) A higher degree of accuracy can be obtained within a particular DEFLECTION range as the FEED RATE setting is increased towards its maximum recommended limit.

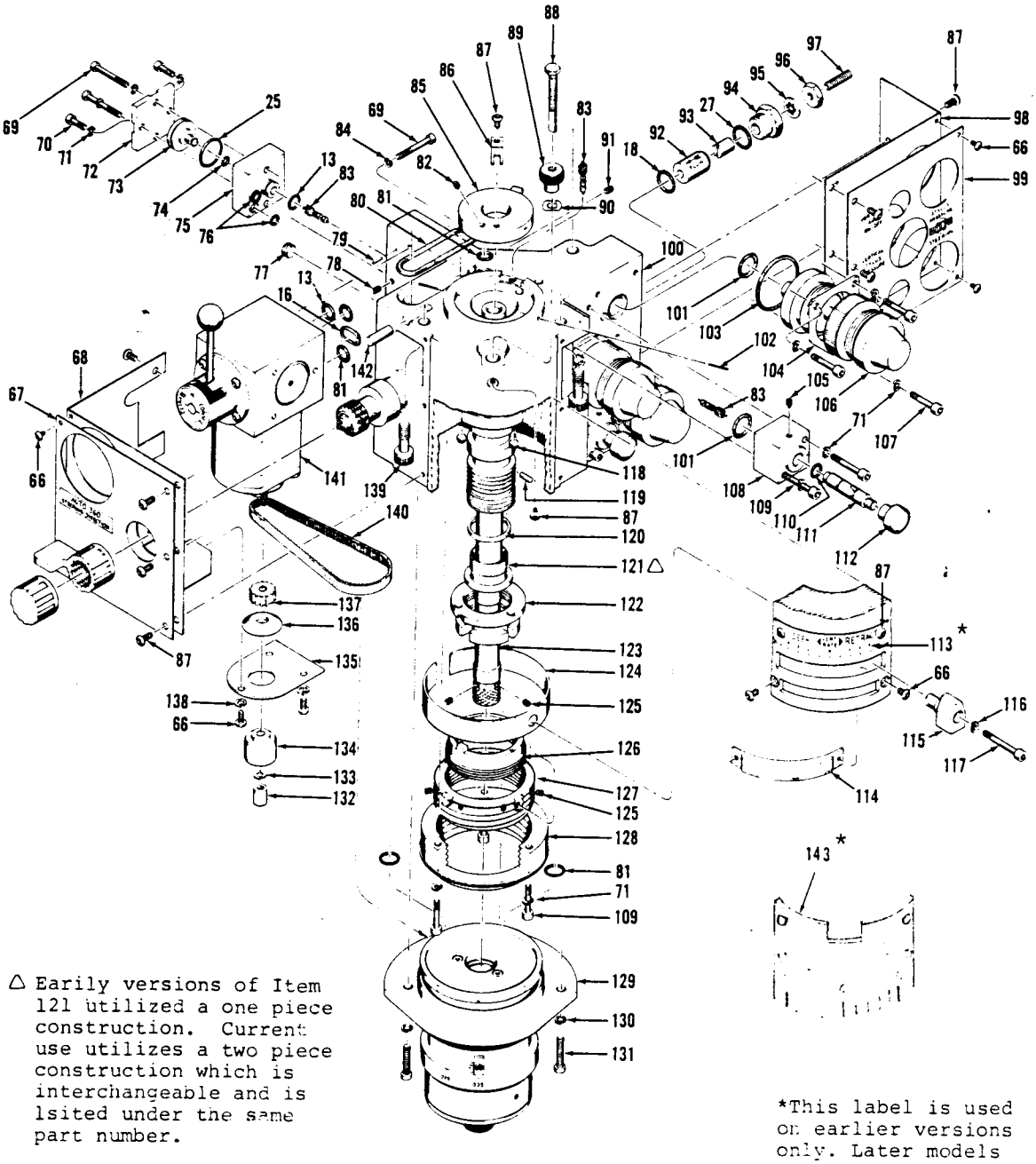


*When replacing the spool shafts (Item 34) make sure that the thread pitch matches the half nut used in the applicable control slide. (Some adjustable slides have 40 pitch threads, the non-adjustable have 24 pitch threads.)

Tracer Valve Body Assembly, 360 Sector

ITEM	P/N	QTY	NAME DESCRIPTION/MFG'R NO.
1	16077	1	COVER
2	0016828	3	SCREW, Button hd, ¼-20 x 3/8 lg
3	16076	1	COVER, LH
4	0016816	7	SCREW, Button hd, 8-32 x ¼ lg
6	32879	4	NUT
7	32472	4	LEVER
8	0014203	4	LOCK NUT, 10-32 Flexloc
9	32471	4	HUB
10	0019315	8	DOWEL PIN, Std, 1/8 dia x 3/8 lg
11	32466	4	CAGE RETAINER
12	32469	4	BUSHING
13	0017310	6	O-RING, Parker No. 2-010-N219-70
14	32467	3	STEM
15	56082	4	SPRING
16	0017313	5	O-RING, Parker No. 2-013-N219-70
17	32470	1	SPACER
18	0017312	9	O-RING, Parker No. 2-012-N219-70
19	32468	1	STEM, Long
20	0016817	4	SCREW, Button head, 8-32 x 3/8 lg
21	16094	1	ACCESS PLATE
22	16726	1	GASKET
23	32465	4	VALVE CAGE
24	0015340	2	SETSCREW, Cup pt, 8-32 x 1/8 lg
25	0017316	5	O-RING, Parker No. 2-016-N219-70
26	32464	4	VALVE SEAT
27	0025705	AR	O-RING, Parker No. 3-906-N507-90
28	17065	1	DOME
29	1626802	1	ADAPTER, Ball check
30	0027703	8	PLUG, 7/16-20
31	0025703	AR	O-RING, Parker No. 3-904-N507-90
32	80065	1	BODY ASSY
33	30023	2	LUGGED WASHER
34	17129	2	SPOOL SHAFT
35	55038	10	BALL BEARING, Fafnir S1K7

ITEM	P/N	QTY	NAME DESCRIPTION/MFG'R NO.
36	0039616	2	SCREW, Button hd, 8-32 x ¼ lg NYLOK
37	16078	2	SPOOL GEAR
38	0014910	10	SCREW, Soc hd, 4-40 x 3/8 lg
39	16087	1	COVER, RH
40	0039612	2	SCREW, Button hd, 6-32 x ¼ lg NYLOK
41	16080	2	SPUR GEAR
42	16092	2	SPACER
43	0018504	2	SPRING PIN, 1/16 dia x 3/8 lg
44	16090	2	MITER GEAR
45	16086	2	SHAFT
46	0015330	4	SETSCREW, Cup pt, 6-32 x 3/16 lg
47	17152	1	FLEXIBLE SHAFT
48	0022419	4	SETSCREW, Flat pt, 10-32 x 3/16 lg
49	16149	4	HALF NUT (40 PITCH)
50	22338	2	CONTROL SLIDE
51	22337	2	SCREW
52	16084	1	HOUSING
53	0018502	1	SPRING PIN, 1/16 dia x ¼ lg
54	0018503	2	SPRING PIN, 1/16 dia x 5/16 lg
55	16085	1	SPACER
56	17127	1	RETAINER
57	0014924	2	SCREW, Soc hd, 6-32 x 7/8 lg
58	16083	1	SHAFT
59	20028	4	NYLON PLUG
60	0022529	5	SETSCREW, Flat pt, 8-32 x 1/8 lg
61	0015335	1	SETSCREW, Cup pt, 6-32 x ½ lg
62	17111	1	LABEL
63	16075	1	KNOB
64	0042402	1	LOCK NUT, ¼-28 ESLOK
65	0017024	1	WASHER, Thrust, ¼ ID x ½ OD x 1/16 thk



△ Earily versions of Item 121 utilized a one piece construction. Current use utilizes a two piece construction which is interchangeable and is lsited under the same part number.

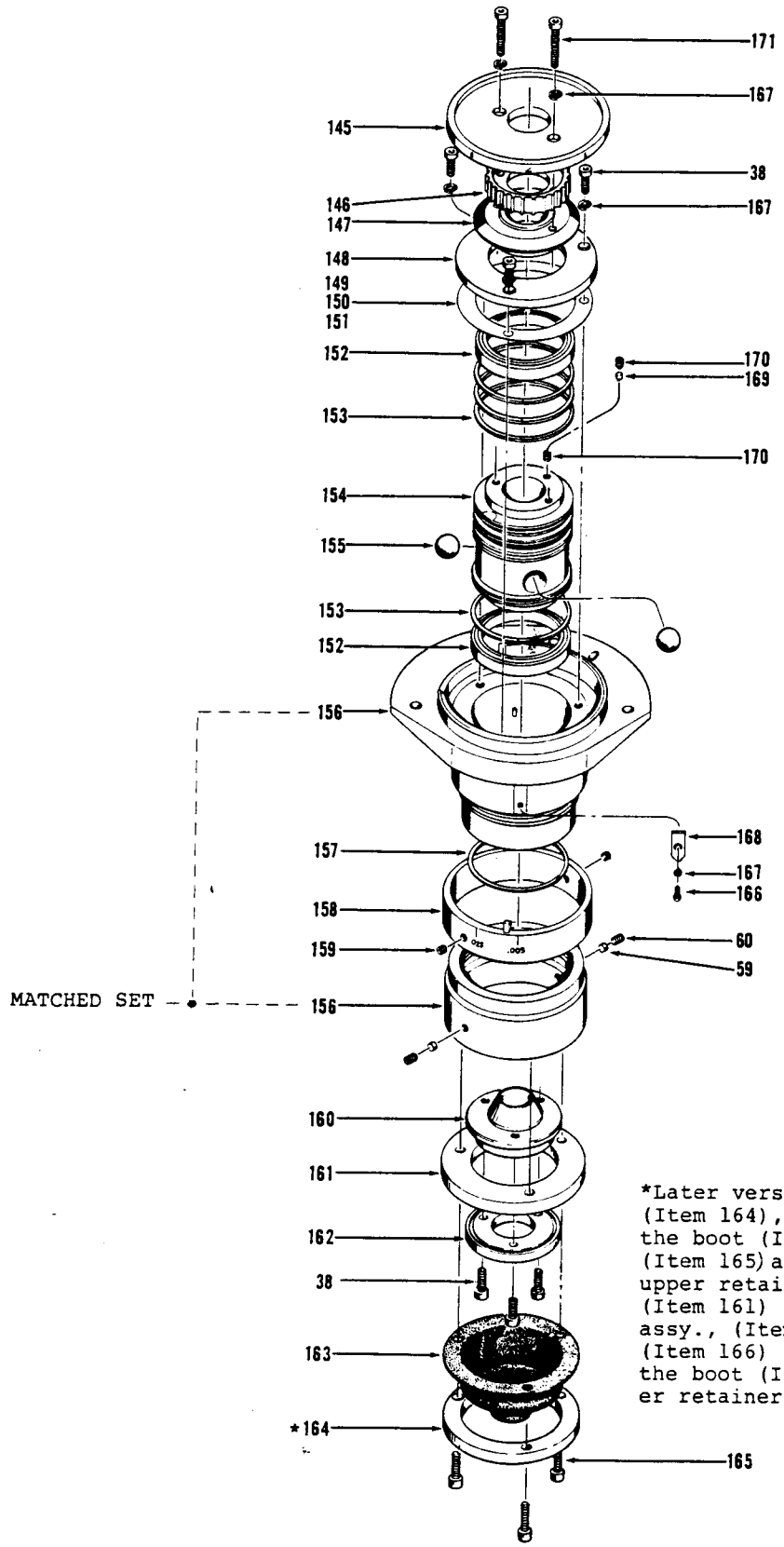
*This label is used on earlier versions only. Later models use No. 22615 (Item 143) which may be used as a replacement on the earlier versions.

3D Nose Assembly Vertical Section

F5387A

ITEM	P/N	QTY	NAME DESCRIPTION/MFG'R NO.
66	0016809	9	SCREW, Button hd, 4-40 x ¼ lg
67	17145	1	ESCUTCHEON PLATE
68	17693	1	COVER
69	0014925	4	SCREW, Soc hd, 6-32 x 1" lg
70	0014919	2	SCREW, Soc hd, 6-32 x ¼ lg
71	0026805	20	LOCK WASHER, No. 6
72	17666	1	COVER
73	17665	1	PISTON
74	0017304	1	O-RING, Parker No. 2-004-N219-70
75	17664	1	HOUSING
76	0017306	2	O-RING, Parker No. 2-006-N219-70
77	0019102	2	PIPE PLUG, 1/8-27
78	0022518	4	SETSCREW, Flat pt, 6-32 x 1/8 lg
79	0018544	2	SPRING PIN, 1/8 dia x 3/8 lg
80	0017410	1	O-RING, Parker No. 2-129-N219-70
81	0017311	6	O-RING, Parker No. 2-011-N219-70
82	0024019	3	SETSCREW, Cup pt, 10-32 x 3/8 NYLOK
83	16101	4	VALVE CORE, Schrader valve No. 9914A
84	0023405	2	LOCK WASHER, No. 6 internal tooth
85	17332	1	ROCKER PLATE
86	17333	1	LEAF SPRING
87	0016812	14	SCREW, Button hd, 6-32 x ¼ lg
88	17723	1	SCREW
89	17719	1	KNOB
90	1603805	1	SPRING WASHER, Shakeproof 3515-18-14
91	0022520	1	SETSCREW, Flat pt, 6-32 x ¼ lg
92	16037	1	CHECK VALVE, Kepner Products 22033-1
93	17796	1	SPACER
94	17797	1	PLUG
95	0011603	1	SEAL, Parker Seal No. 600-001-10
96	0020305	1	JAM NUT, 10-32
97	0022426	1	SETSCREW, Flat pt, 10-32 x ¾ lg
98	16072	1	COVER
99	17146	1	ESCUTCHEON PLATE
100	80123	1	NOSE ASSY
101	0017314	5	O-RING, Parker No. 2-014-N219-70
102	0019312	2	DOWEL PIN, Std, 1/16 dia x ½ lg
103	0017326	3	O-RING, Parker No. 2-026-N219-70
104	16070	3	PLATE

ITEM	P/N	QTY	NAME DESCRIPTION/MFG'R NO.
105	0025514	2	SETSCREW, Half dog, 8-32 x 3/8 lg
106	17514	3	REGULATOR
107	0014922	9	SCREW, Soc hd, 6-32 x 5/8 lg
108	16098	2	HOUSING
109	0014923	7	SCREW, Soc hd, 6-32 x ¾ lg
110	0017308	2	O-RING, Parker No. 2-008-N219-70
111	16099	2	STEM
112	16050	2	KNOB
113	16069	1	LABEL
114	16040	1	WINDOW
115	16068	1	LEVER
116	0026806	1	LOCK WASHER, No. 8
117	0014933	1	SCREW, Soc hd, 8-32 x 1/8 lg
118	0042049	3	BALL, 0.2500 dia
119	15207	1	PIN
120	31798	1	SPACER
121	31797	1	BEARING
122	16067	1	NUT
123	17938	1	SPINDLE
124	17153	1	RING
125	0015341	4	SETSCREW, Cup pt, 8-32 x 3/16 lg
126	17699	1	SLEEVE
127	17698	1	RING
128	17697	1	RING
129	16597	1	BIAS HOUSING ASSY
130	0023406	3	LOCK WASHER, No. 8 internal tooth
131	0014930	3	SCREW, Soc hd, 8-32 x ¾ lg
132	0028215	1	NUT, Internal hex, 10-32
133	0026807	1	LOCK WASHER, No. 10
134	17185	1	KNOB
135	17202	1	COVER PLATE
136	17191	1	FLANGE
137	16022	1	PULLEY
138	0023453	3	LOCK WASHER, No. 4 internal tooth
139	31141	3	SCREW
140	17709	1	BELT, Uniroyal No. 100XL037
141	17887	1	SERVOVALVE ASSY
142	0019334	2	DOWEL PIN, Std, ¼ dia x ½ lg
143	22615	1	ESCUTCHEON PLATE



*Later versions use 2 retainers (Item 164), one on each side of the boot (Item 163). The screws (Item 165) are used to attach the upper retainer and bearing plate (Item 161) to the housing/sleeve assy., (Item 156). 3 screws (Item 166) are used to attach the boot (Item 163) and the lower retainer.

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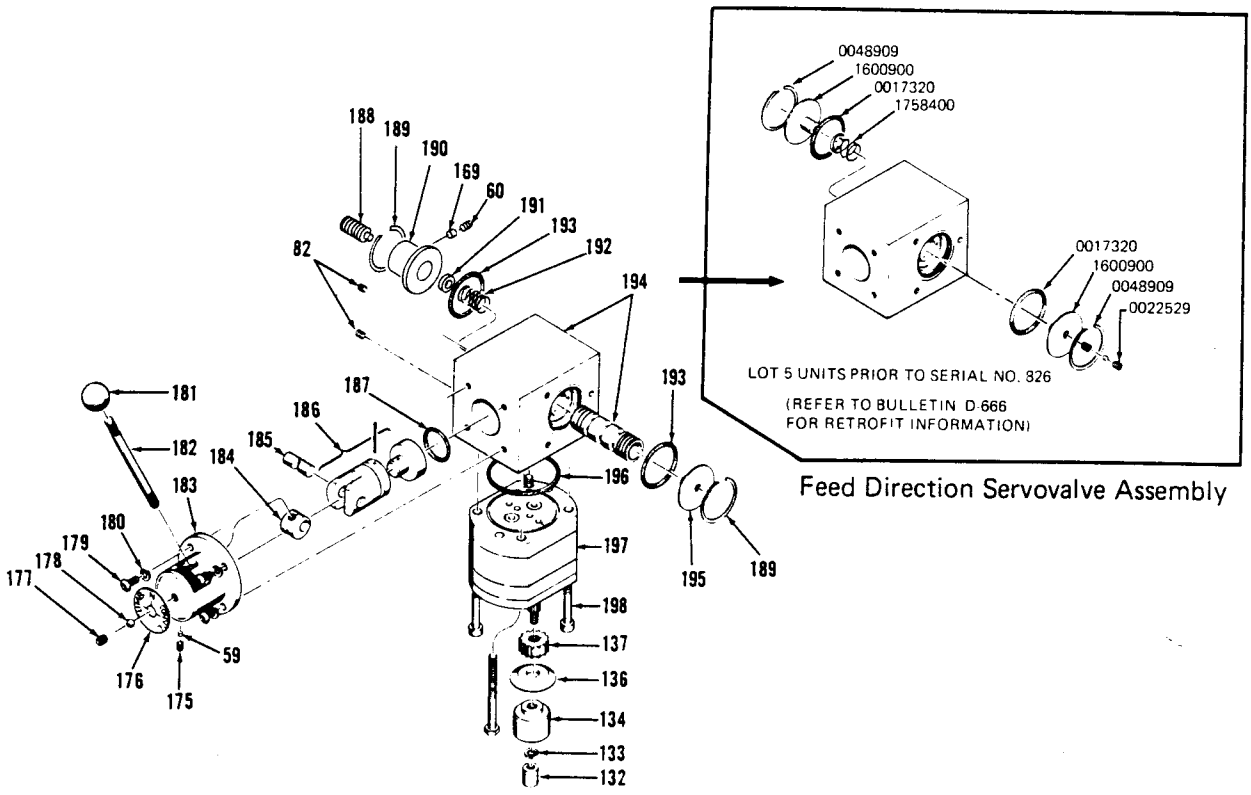
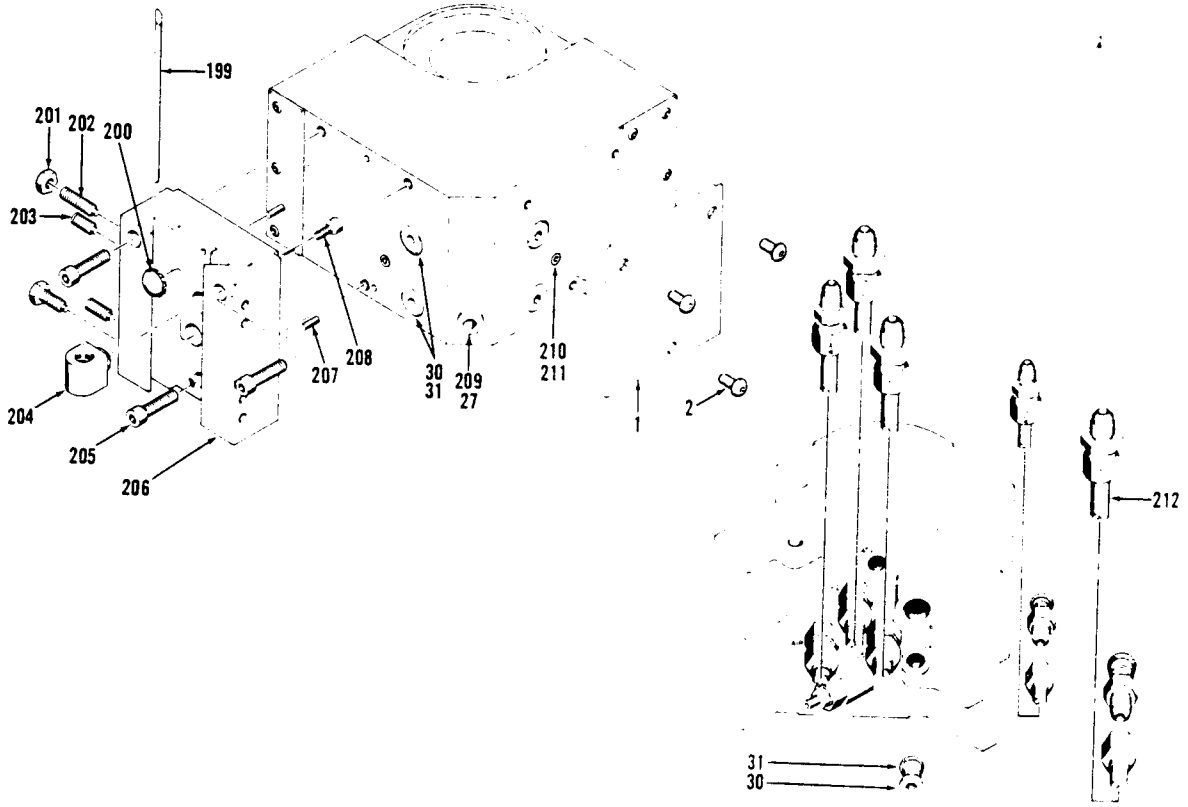
Air Bias Housing Assembly, Automatic Steering Section

ITEM	P/N	QTY	NAME DESCRIPTION/MFG'R NO.
145	17695	1	BIAS INDEX PLATE
146	17694	1	PULLEY
147	17685	1	FLANGE
148	17803	1	RETAINER
149	1780401	AR	SHIM, 0.001 thk
150	1780402	AR	SHIM, 0.005 thk
151	1780403	AR	SHIM, 0.010 thk
152	16042	2	BEARING, Split Ballbearing Co. No. TCR 21-28-U-(2) B542
153	16041	4	BACKUP RING .020 GAP CLEARANCE
154	17682	1	SPOOL
155	0042057	2	BALL, 0.5000 dia
156	16593	1	HOUSING W/SLEEVE
157	0048645	1	RETAINING RING, Spirolox RR-175
158	16049	1	DIAL
159	0015329	2	SETSCREW, Cup pt, 6-32 x 1/8 lg
160	16590	1	RATE CONE
161	16591	1	BEARING PLATE
162	16592	1	RETAINER
163	16594	1	BOOT
164	16595	2	RETAINER
165	0014911	3	SCREW, Soc hd, 4-40 x ½ lg
166	0014909	4	SCREW, Soc hd, 4-40 x ¼ lg
167	0026803	6	LOCK WASHER, No. 4
168	16051	1	STOP
169	1689804	AR	TEFLON ROD, 1/8 dia x 1/16
170	0015351	2	SETSCREW, Cup pt, 10-24 x 3/16
171	0014948	2	SCREW, Soc hd, 4-40 x 7/8 lg



Feed Direction Servovalve Assembly



RH Mounting Shown

F5391

ITEM	P/N	QTY	NAME DESCRIPTION/MFG'R NO.
175	0022531	1	SETSCREW, Flat pt, 8-32 x ¼ lg
176	17064	1	LABEL
177	16023	1	SCREW
178	0042047	1	BALL, 0.187 dia
179	0016813	4	SCREW, Button hd, 6-32 x 3/8 lg
180	0032105	4	LOCK WASHER, No. 6
181	55834	1	KNOB
182	16012	1	LEVER
183	16010	1	HOUSING
184	17164	1	CAM
185	17165	1	PIN
186	17886	1	PISTON
187	0017355	1	O-RING, Parker No. 2-114-N219-70
188	0015716	1	SETSCREW, Half dog pt, ¼-20 x ¾ lg
189	0048909	2	RETAINING RING, Spirolox UR-100
190	22571	1	HOUSING
191	0016506	1	WASHER, No. 8
192	55412	1	SPRING
193	0017320	2	O-RING, Parker No. 2-020-N219-70
194	8008601	1	SERVOVALVE BODY
195	22572	1	COVER
196	0017328	1	O-RING, Parker No. 2-028-N219-70
197	17550	1	HYD MOTOR
198	0014826	4	SCREW, Soc hd, 10-32 x 2 lg
199	30024	1	GIB
200	0038818	1	BUTTON PLUG, ½
201	0019722	2	JAM NUT, ¼-20
202	0015717	2	SETSCREW, Half dog pt, ¼-20 x 1 lg
203	0015716	2	SETSCREW, Half dog pt, ¼-20 x ¾ lg
204	30028	1	RIDING NUT
205	0015005	3	SCREW, Soc hd, ½-20 x 7/8 lg
206	17049	1	MOUNTING PLATE
207	0019325	2	DOWEL PIN, Std, 3/16 dia x ½ lg
208	0014818	1	SCREW, Soc hd, 10-32 x ½ lg
209	0027705	1	PLUG, 9/16-18
210	0027701	2	PLUG, 5/16-24
211	0025701	AR	O-RING, Parker No. 3-902-N507-90
212	80125	1	TUBE KIT
213	17237	1	FILTER-REGULATOR, Norgren No. B02-221-AIM-AU } not shown
*214	--	1	MOUNTING KIT, Norgren No. 18-001-052 } not shown
215	--	1	FILTER KIT, 5 micron, Norgren No. 2992-04 } not shown

F5392A

*Information shown represents that covering earlier versions. Current versions are shown below.

Mfg.	Filter/Regulator	Mtg.Brkt.	5-Micron Element	Air Gauge
Norgren	B12-221-A1LA	5514-06	2992-09	18-013-209
Parker-Hannifin	07E15B18BB	PS-209	PS-203	P-781642