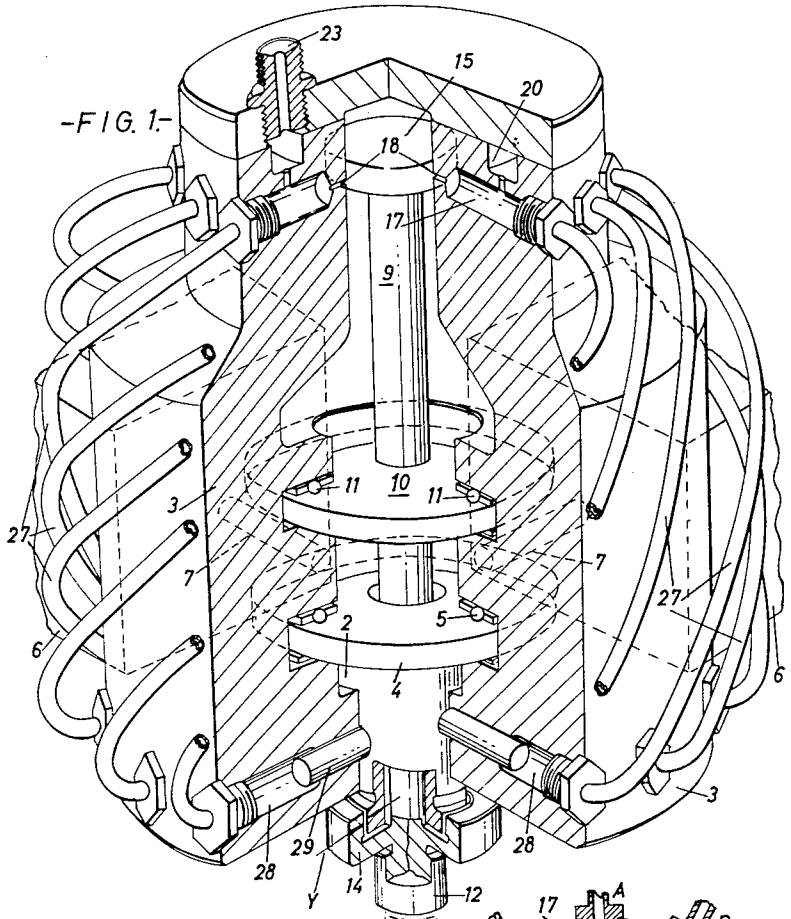
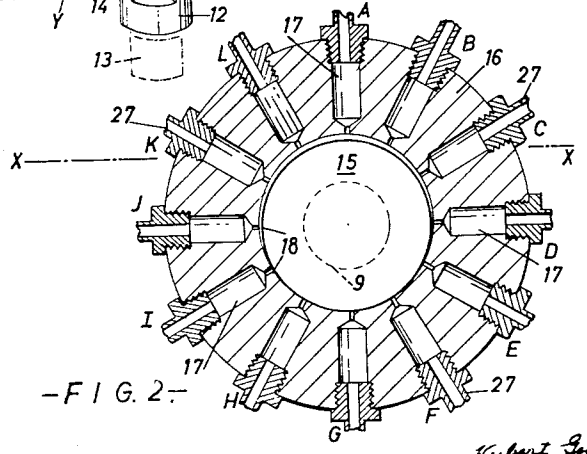
March 6, 1962 H. G. HAYES ETAL 3,023,778

HYDRAULIC TRACER VALVE UNITS

Filed Oct. 10, 1960 3 Sheets-Sheet 1

-FIG. 1-





-FIG. 2-

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HYDRAULIC TRACER VALVE UNITS

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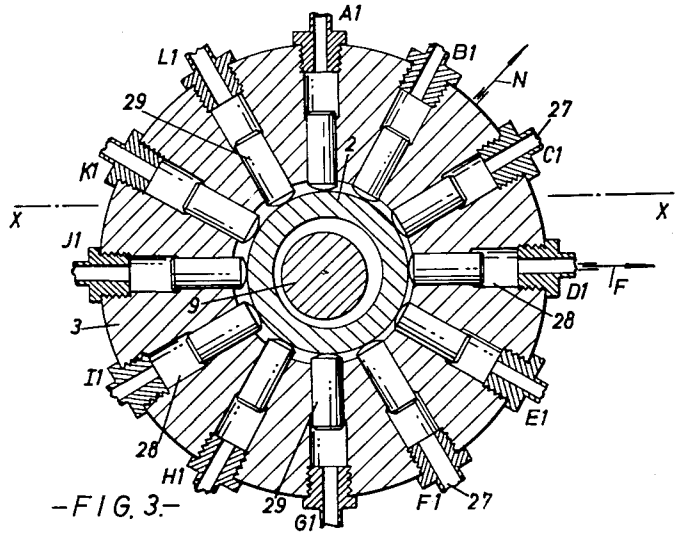
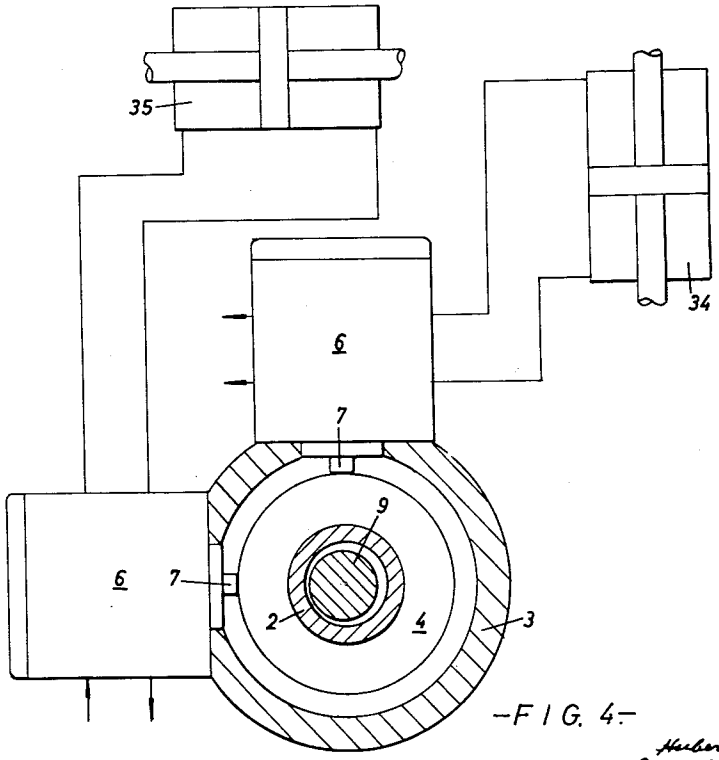


-FIG. 3.-



-FIG. 4.-

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HYDRAULIC TRACER VALVE UNITS

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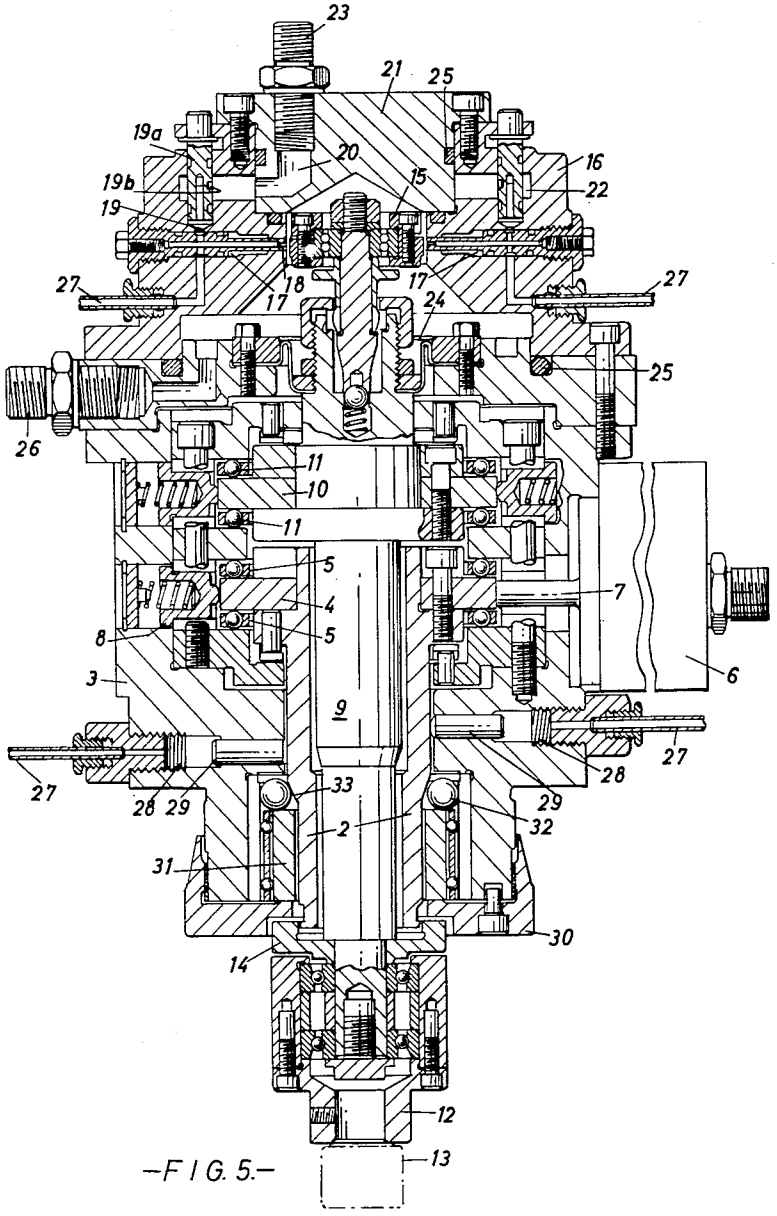

—FIG. 5.—

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HYDRAULIC TRACER VALVE UNITS

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8 Claims. (Cl. 137—622)

This invention relates to hydraulic tracer valve units having a stylus or equivalent means to follow a master pattern.

It is known to provide tracer valve units for controlling the hydraulic system or systems of machine tools to give the necessary operation to some movable part or parts, such as a tool, workpiece, table, slide or the like according to deflections of the stylus following a template or pattern. It is also known to provide a control unit of this type which is capable of providing control through 360 degrees about the axis to the tracer stylus. Some such units require manual deflection and retention against the profile of the template or pattern but it is known for such units to be automatically operated.

The main object of this invention is to provide an improved form of automatic hydraulic tracer valve unit capable of control through 360 degrees about the axis of the tracer stylus.

Accordingly there is provided a hydraulic tracer valve unit, including a hollow valve operating element mounted in a housing to have bodily lateral movements in any direction in one plane to operate control valve units, a stylus carrier located in said element and mounted also to have similar bodily lateral movements, a stylus forming part of or attached to said carrier at its bottom end, a series of fluid pressure chambers in annular arrangement about a fluid control part of the stylus carrier, small outlet ports from and inlet ports to said chambers, a pressure feed source to said inlets, and fluid supply connections from the chambers to plunger means adapted to operate the said hollow operating element the arrangement being such that engagement of the stylus with the master pattern and consequent lateral deflection of the stylus carrier causes fluid pressure to be directed from a chamber or chambers to a predetermined plunger or plungers to operate the said element for automatically maintaining contact with the pattern for valve operating purposes with the element and stylus carrier moving in unison.

The improved tracer valve unit may have a circular disc-like part at the head of the stylus carrier for controlling the fluid in said pressure chambers according to deflections of the stylus. The stylus may have, or be associated with, a part adapted to engage the valve operating element for the latter to move in unison with the stylus carrier.

Moreover, the inlet ports of the fluid pressure chambers may have a smaller porting area than the outlet ports to prevent operating pressure for the plungers being built up until any outlet port is restricted or closed by movement of the stylus carrier.

The invention will now be more particularly described with reference to the accompanying drawings, in which:

FIG. 1 is a sectional pictorial view showing the basic principles of the invention;

FIG. 2 is a sectional plan view through the upper fluid pressure chambers;

FIG. 3 is a sectional plan view through the lower plunger-cylinders;

FIG. 4 is a substantially diagrammatic plan view through the centre region of FIG. 1 showing the control valve system; and

FIG. 5 is a sectional elevation of a complete tracer valve unit according to the invention.

In the illustrated embodiment of this invention the tracer valve unit includes a hollow valve operating element **2** mounted in a housing **3** so as to be capable of movement in all directions in a horizontal plane, say by providing the element with a peripheral flange **4** interposed between two ball races **5**. Thus the element will be allowed free and precise bodily deflections in any direction in a horizontal plane but be restrained against axial movement. The said hollow operating element **2** has two or more radially disposed valve units **6** associated therewith, each controlling a hydraulic system for a hydraulic motor, so that bodily deflection of the element in a given direction will operate the required valve unit. As shown, the stem **7** of the piston of each unit bears against the periphery of the flange **4** which is thrust towards the stems by spring-loaded plungers. Within the element **2** is located a longitudinally disposed stylus carrier **9** which may be solid or hollow and projects above and below the ends of the element. This carrier also has a peripheral flange **10** between ball races **11** to have similar movements to the element **2** and centralised by spring-loaded plungers. The lower end of the carrier **9** is furnished with a collar **14** and a ball bearing mounted socket member **12** to receive a detachable disc-like or other shaped part forming a stylus **13** which will normally engage a master pattern so that the carrier **9** will have bodily deflection a predetermined distance in advance of the element **2** (due to clearance between collar **14** and element **2**) before the element **2** is contacted. The upper end of the carrier **9** is furnished with a fluid pressure control part **15** which is shown in the form of a self-aligning ball bearing mounted collar.

The aforesaid control part **15** is surrounded by a top plate **16** in which a predetermined number (twelve are shown marked "A" to "L") of radially-disposed chambers **17** are provided each with an axial outlet port opening **18** adjacent the said control part **15** and each chamber has an inlet port **19**, which may have a slightly less porting area than the outlet port. Alternatively, as shown in FIG. 5, the ports **19** each open into a chamber furnished with a plunger **19***a* having a port **19***b* which has the said slightly less porting area. Fluid pressure is supplied to all the inlet ports **19** from duct **20** in a superposed cap **21** and an annular groove **22** in the plate **16**, the duct being furnished with a pressurised fluid feed connection **23**. A sealing diaphragm **24** and other sealing means **25** are furnished below and above the space occupied by the aforesaid control part **15** of the carrier to confine hydraulic fluid that normally exhausts from the chambers. An exhaust pipe made to connection **26** leads from said space back to the supply reservoir. Connecting pipes **27** (ducts or like means) link the aforesaid chambers **17** with small cylinders **28** (twelve are shown marked "A1" to "L1") arranged radially about the hollow operating element **2** so that plungers **29** in the cylinders can be operated by fluid pressure from the chambers **17** to push the element **2** in a predetermined direction to maintain engagement with a master pattern.

The valve unit is also furnished with a settable ring **30** screw-threaded onto the lower end of the housing **3** and adapted when rotated to give axial movement to a bearing mounted sleeve **31** mounted with clearance about the lower part of element **2** and supporting ball bearings **32** surrounding a tapering annular face **33** on the element **2**. Thus by rotating the ring **30** the element **2** can be rendered inoperative in a central position and adjustment of the ring decides the amount of deflection the element **2** is allowed.

With the above arrangement the stylus **13** will first be engaged with a master pattern, this can be accomplished by manually deflecting it into engagement with the pattern, and initial lateral displacement of the carrier **9** will cause

its fluid control part **15** to close an outlet port or ports **18** from a chamber or chambers **17** and immediately cause a pressure build-up in such chamber or chambers to operate a plunger or plungers **29** which will automatically hold the stylus **13** in engagement with a master pattern for the unit to automatically follow the pattern profile. Thus the unit is capable of 360-degree control movements for valve operating purposes and thus the control of a machine tool part.

Assuming that the valve unit has been energised by manual deflection of the stylus towards the profile of a master pattern, indicated in FIGS. 2 and 3 by the line X—X, when the stylus is in contact with such profile the operation of the unit will be as follows:

The stylus will remain in contact with the pattern and a force will be applied to stylus **13** at right angles to the tangent of the pattern profile with the result that the carrier **9** is deflected and when the clearance gap "Y" (FIG. 1) is closed the element **2** will have simultaneous movement with the carrier. Deflection of the carrier will cause the upper collar **15** to close or partially close some of the ports **18** in the top plate **16**. Referring to FIG. 2 the chamber marked "G" will have its outlet **18** fully closed and adjacent chambers "F" and "H" will be partially closed. Depending on which cylinders **28** are connected to the upper chambers **17** movement will be transmitted to the element **2** in a given direction. For example, if it is required that tracing should take place in the direction of the arrow F (FIG. 3) then chamber "G" is connected to cylinder "I" (FIG. 3). Chamber "H" will be connected to cylinder "J"; chamber "F" to cylinder "H" with the remaining chambers connected to the remaining series of cylinders in this order.

With the above arrangement, chamber "G" being totally closed at its outlet port, a pressure will be exerted in the connecting pipe **27** through cylinder "I" to its plunger and a reduced pressure will be placed on the plungers in cylinders "H" and "J" and slightly less pressure on plungers in "G" and "K." Since the remainder of the chambers **17**, as shown in FIG. 2, will not have their outlet ports restricted there will be no build-up of pressure in such chambers or the cylinders connected thereto and consequently there will be no pressure on the plungers in these latter cylinders. Thus the stylus will be thrust not only towards the pattern face X—X but at an angle that will give a tracing direction indicated by arrow F.

As the two valve units **6** have their plunger stems **7** in engagement with the flange **4** deflection of the element **2** in the above manner will operate both valve units **6**, and the workpiece will be moved in the direction of arrow "N" (FIG. 3). When sufficient movement has taken place for clearance gap "Y" (FIG. 1) to be taken up, the valve in unit **6** controlling the cross traverse cylinder **34** will reach a central position and no further movement by the cross traverse cylinder will take place. However, the longitudinal component of the force applied by the small plungers **29**, behind which there is a pressure build-up will maintain the deflection to the valve in unit **6** which controls the longitudinal traverse cylinder **35** and thus there will be movement along the pattern profile, line X—X, in the direction of arrow F.

Should the pattern profile, indicated as X—X, alter direction, then the force applied to the carrier **9** and thus to the collar **15** will remain always at right angles to the profile which the stylus **13** is contacting. This alteration will alter the position of the collar **15** and therefore uncover the outlet ports **18** of the chambers which have previously been closed or partially closed and cover outlet ports which were previously open. The small plungers **29** will then exert their pressure in accordance with the pressure build-ups in their connected chambers. Therefore the resultant force on the flange **4** will alter in order that the signal to either the longitudinal traverse cylinder **35** or cross traverse cylinder **34** should maintain correct movement relative to the profile which the stylus is contacting.

The above construction, wherein the pipes **27** are connected from chambers to cylinders in a given order, provides for a stylus to be moved in relation to a pattern face in a given direction. In order to enable adjustment to be made to change the direction of force without altering the pipe connections, control means may be furnished which can be rotated, say from a central inoperative position in one direction or the opposite direction, i.e. clockwise or anti-clockwise, according to which direction the stylus has to have relative movement in relation to a pattern profile. Conveniently an adjusting ring may be rotatably mounted about the housing **3** and the pipes **27** from the upper chambers **17** connected to ports, i.e. twelve according to the drawings, in such ring. This ring would in effect be a rotatable plate valve in relation to a fixed plate having ports therein to which pipes **27** would be connected and from thence to the lower cylinders **28**. Thus with the ports in the ring and plate spaced equally apart, when the blank spaces between such ports in the ring are in register with the ports in the fixed plate, no fluid pressure can pass and the automatic action would be inoperative. Then by rotation of the plate valve clockwise or anti-clockwise the upper chambers would be connected to required cylinders to give a required setting for stylus movement to the left or right of a pattern profile.

If desired, the carrier **9** may be hollow and have an axially movable member mounted therein to be operated according to contact with a master pattern face and control a hydraulic system through valve means when depth control is required for a cutter or tool.

What we claim is:

1. Hydraulic tracer valve unit, including a housing; a hollow valve-operating element mounted in said housing, said element having means to positively guide it in bodily lateral movements in any direction in one plane; fluid system control valve units mounted to be operated by said hollow valve-operating element; a stylus carrier located in said element, said carrier also having guide means for it to have bodily lateral movements similar to those of the said element; a stylus for said carrier at its bottom end; said stylus carrier having a fluid control part, a series of fluid pressure chambers in annular arrangement about said fluid control part, small outlet ports from and inlet ports to said chambers, a pressure feed source to said inlet ports, plunger means in annular arrangement about and adapted to operate said hollow operating element; and fluid supply connections from said chambers to said plunger means, the arrangement being such that the engagement of the stylus with a master pattern and consequent lateral deflection of the stylus carrier causes fluid pressure to be directed from at least one chamber to at least one predetermined plunger to operate the said valve-operating element for automatically maintaining the stylus in contact with the pattern for valve operating purposes, with the element and stylus carrier moving in unison.

2. Hydraulic tracer valve unit according to claim 1, wherein the guide means for the hollow operating element comprises a peripheral flange on said element located between upper and lower ball bearings, said flange having flat upper and lower parallel faces engaged by said ball bearings, said flange being engaged on its periphery by the valve stems of said valve units controlling the hydraulic systems of hydraulic motors, and spring loaded means also engaging the periphery of said flange for holding the flange towards said valve stems.

3. Hydraulic tracer valve unit according to claim 1, in which the stylus carrier has a circular part of the head thereof for controlling the fluid in said pressure chambers according to deflections of the stylus, and in which the circular part lies in a circular chamber into which a predetermined number of outlet ports radiate from the pressure chambers, said circular part having peripheral clear-

ance in said circular chamber when centralised and being capable of deflection into contact with the wall of the chamber for closing or partially closing any of said ports.

4. Hydraulic tracer valve unit, including a housing; a hollow valve-operating element mounted in said housing, said element having means to positive guide it in bodily lateral movements in any direction in one plane; fluid system control valve units mounted to be operated by said hollow valve-operating element; a stylus carrier located in said element, said carrier also having guide means for it to have bodily lateral movements similar to those of the said element; a stylus for said carrier at its bottom end; said stylus carrier having a fluid control part, a series of fluid pressure chambers in annular arrangement about said fluid control part, small outlet ports from and inlet ports to said chambers, a pressure feed source to said inlet ports, plunger means in annular arrangement about and adapted to operate said hollow operating element; and fluid supply connections from said chambers to said plunger means, the arrangement being such that the engagement of the stylus with a master pattern and consequent lateral deflection of the stylus carrier causes fluid pressure to be directed from at least one chamber to at least one predetermined plunger to operate the said valve-operating element for automatically maintaining the stylus in contact with the pattern for valve operating purposes, with the element and stylus carrier moving in unison, said hydraulic tracer valve unit being further characterized in that the inlet ports of the fluid pressure chambers have a smaller porting area than the outlet ports to prevent operating pressure for the plungers in the lower cylinders being built up until any outlet port is restricted or closed by movement of the stylus carrier.

5. Hydraulic tracer valve unit according to claim 1, wherein the stylus, or a stylus receiving member, is furnished with an annular part surrounding with clearance the lower end of the hollow valve operating element, said annular part providing the means for moving the element in unison with the stylus carrier.

6. Hydraulic tracer valve unit according to claim 1 including control means for varying the fluid connection between the fluid pressure chambers and the cylinders of the operating plungers.

7. Hydraulic tracer valve unit according to claim 6, wherein the control means comprise a ported fixed plate and a ported annular plate valve rotatable in relation to said ported fixed plate, said valve and fixed plate being connected to the upper chambers and lower cylinders whereby the fluid pressure connection between the chambers and cylinders can be closed or varied.

8. Hydraulic tracer valve unit according to claim 1, wherein the bodily deflections of the hollow operating element are controlled by ball bearings engaging an annular tapered face on the element, said ball bearings being adjustable in relation to the face by a rotatable adjusting means which is screw-threadable on the unit housing.

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