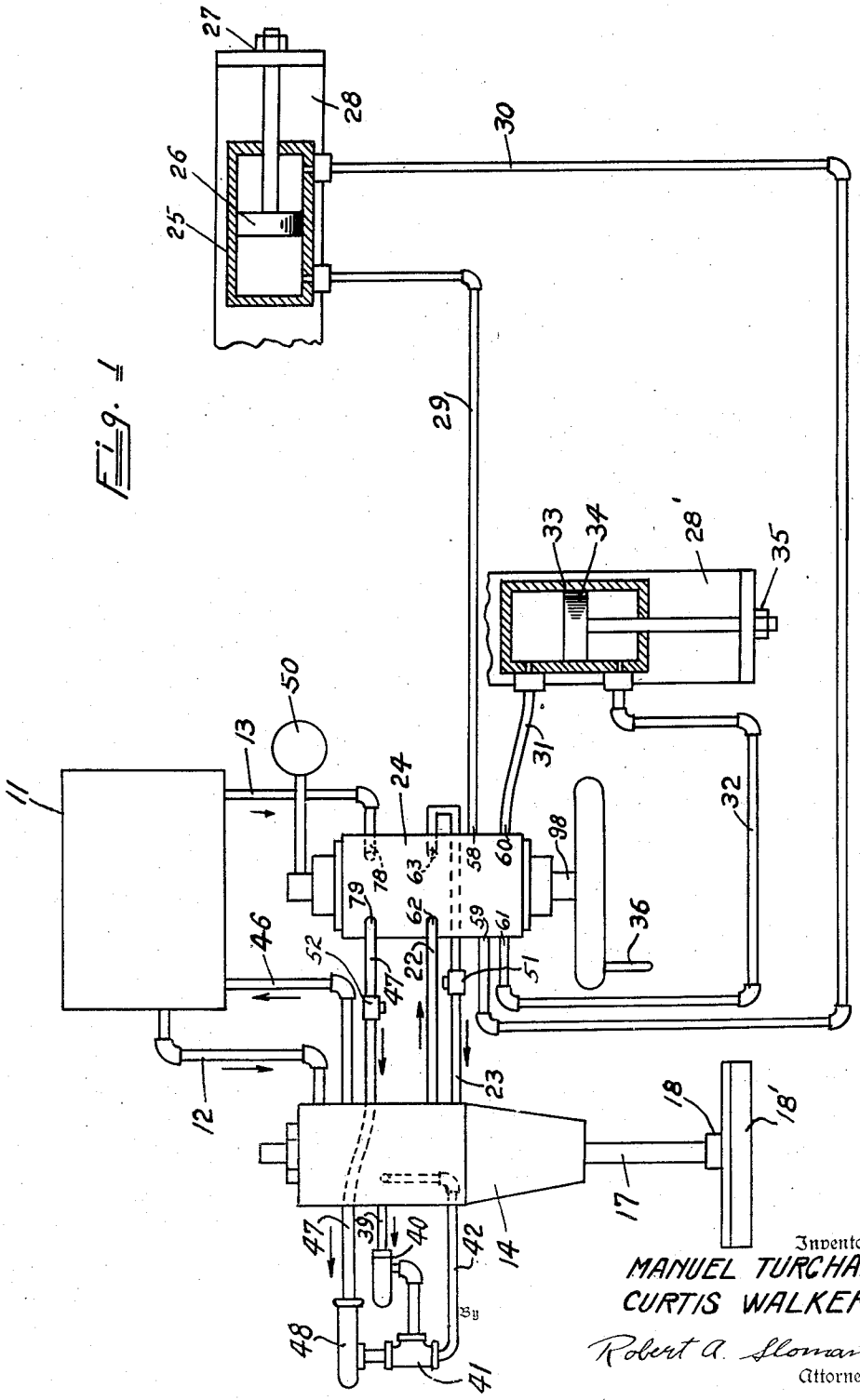
Dec. 25, 1945. M. TURCHAN ET AL 2,391,492

HYDRAULIC DUPLICATING MECHANISM AND EXHAUST GOVERNOR

Filed Nov. 5, 1942 4 Sheets-Sheet 1

Fig. 1



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HYDRAULIC DUPLICATING MECHANISM AND EXHAUST GOVERNOR

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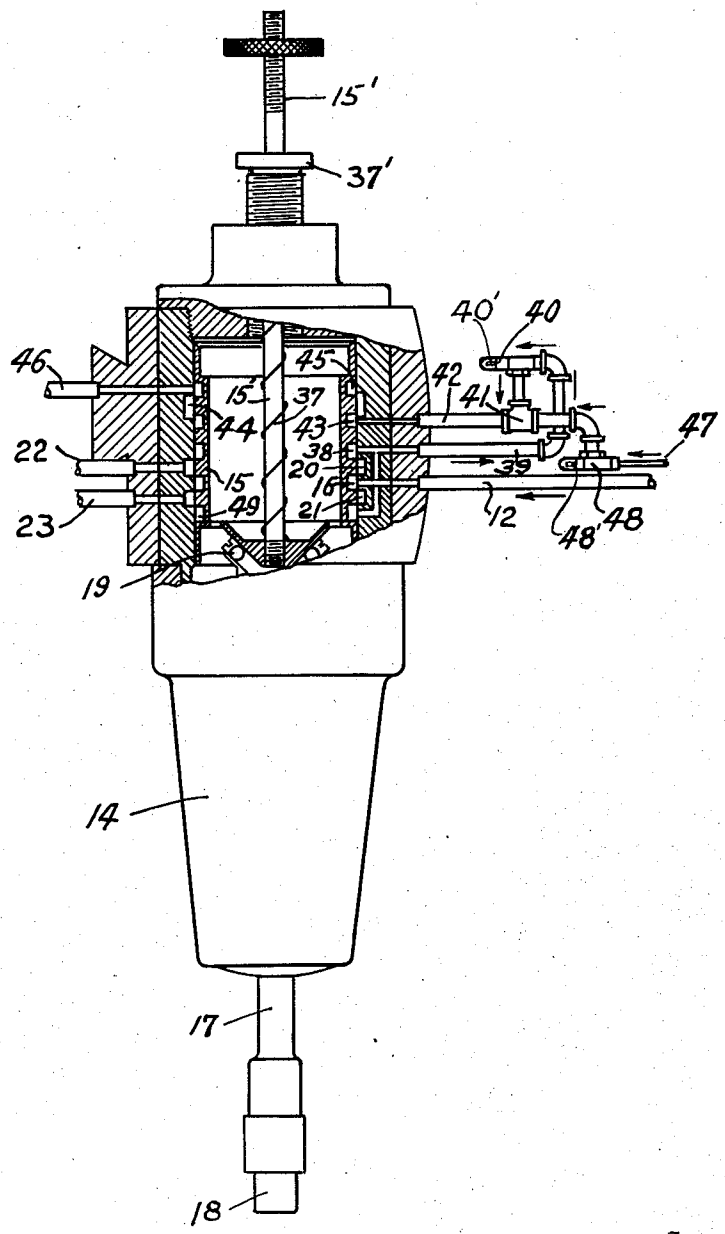

Fig. 2

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HYDRAULIC DUPLICATING MECHANISM AND EXHAUST GOVERNOR

Filed Nov. 5, 1942 4 Sheets-Sheet 3

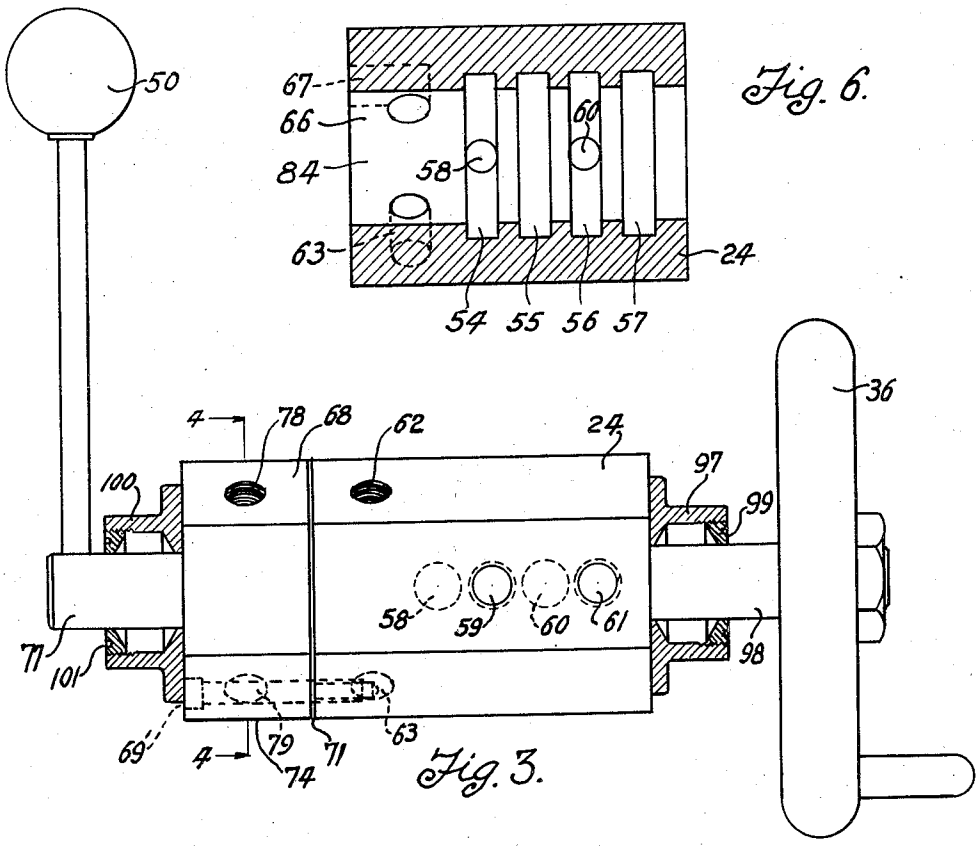

Fig. 6.

Fig. 3.

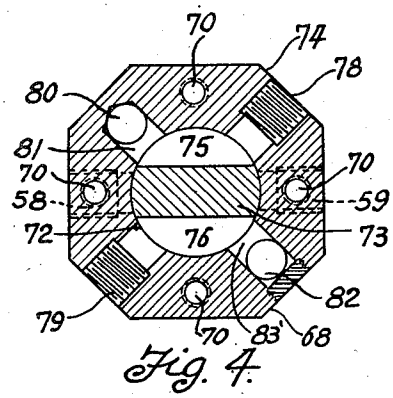

Fig. 4.

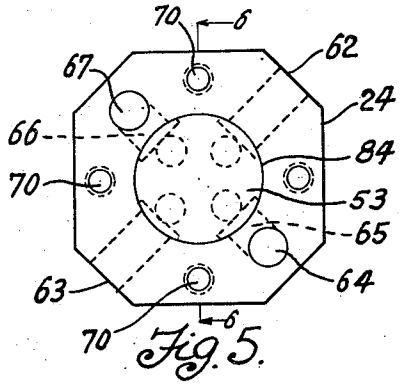

Fig. 5.

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HYDRAULIC DUPLICATING MECHANISM AND EXHAUST GOVERNOR

Filed Nov. 5, 1942 4 Sheets-Sheet 4

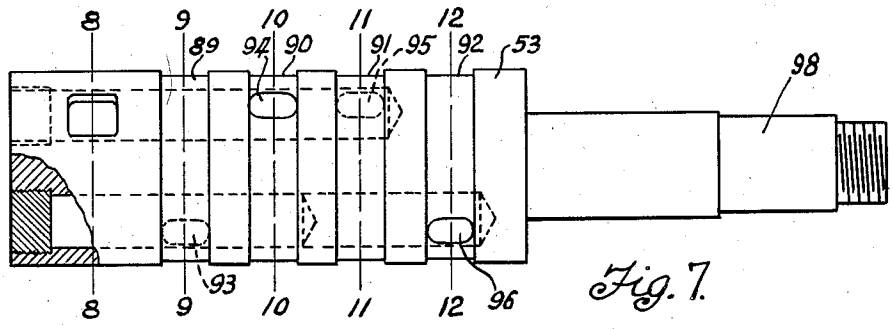

Fig. 7.

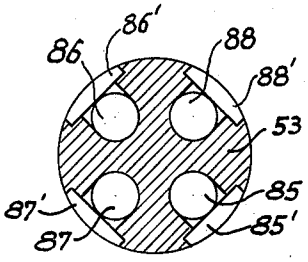

Fig. 8.

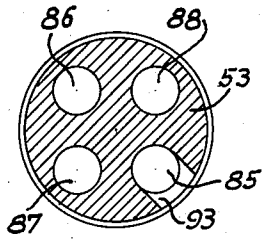

Fig. 9.

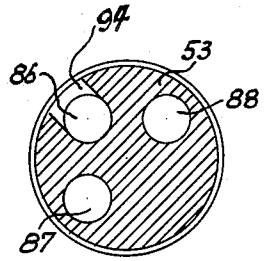

Fig. 10.

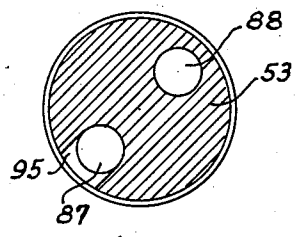

Fig. 11.

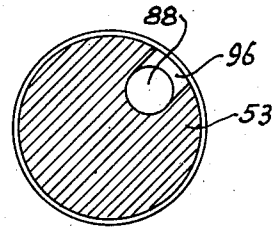

Fig. 12.

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Patented Dec. 25, 1945 2,391,492

UNITED STATES PATENT OFFICE

2,391,492

HYDRAULIC DUPLICATING MECHANISM AND EXHAUST GOVERNOR

Manuel Turchan, Dearborn, and Curtis Walker, Detroit, Mich.

Application November 5, 1942, Serial No. 464,690

12 Claims. (Cl. 60—97)

This invention relates to a hydraulic duplicating attachment for a lathe, milling machine, planer, or other device wherein there may be at least two reciprocable transverse relative feed movements between a cutting device and a work piece support.

It is contemplated also to provide tracer control alternately or intermittently to either of at least two transverse reciprocable relative feed control cylinders, and at the same time provide constant volume feeding to the other of the cylinders not under tracer control. To accomplish this semi-automatically, a manually operable directional control valve is provided of the type fully set out in our co-pending application Serial No. 366,082, filed November 18, 1940, relating to a profiling and contouring tracer mechanism, hydraulic connections and directional control, to operate in the manner therein fully set out.

The directional control valve is also fully set out in our co-pending application Serial No. 449,354, filed July 1, 1942, relating to a directional control and reverse valve. Briefly a tracer controlled fluid pressure source and a constant volume fluid source are conducted to the directional control valve, which is so designed that in one position of manual adjustment thereof, tracer controlled fluid is conducted to one end of for instance the longitudinal feed cylinder, the exhaust from the other side of the piston therein being adapted to return by suitable conduit back to the directional control valve.

At the same time by means of other conduits constant volume fluid is conducted to one end of the cross-feed cylinder, with the exhaust from the other side of the piston therein returning by conduit to the directional control valve.

By manual adjustment of said directional control valve, in the manner set out in the above mentioned co-pending applications, tracer controlled fluid can be diverted from the longitudinal feed cylinder to one end of the cross-feed cylinder, and at the same time constant volume fluid will go to one end of the longitudinal feed cylinder.

On further adjustment of the directional control valve tracer controlled fluid will be conducted again to the other end of the longitudinal feed cylinder; and at the same time constant volume fluid will go to the other end of the cross feed cylinder. Again on still further adjustment of the directional control valve tracer controlled fluid will go to the cross-feed cylinder at its other end, and constant volume fluid will be directed to the other end of the longitudinal feed cylinder.

In this manner it is seen that tracer controlled fluid will be diverted alternately from one feed cylinder to the other and also to either end thereof. The same is also true as to the constant volume feeding. In any case the opposite ends of the cylinders receiving fluid under pressure exhaust fluid back to the directional control valve.

The present invention relates particularly to the subsequent exhausting of this returned exhaust fluid from the directional control valve back to the tracer housing and through an exhaust governor mechanism which regulates the return flow of said exhaust fluid and thence it is conducted back to a fluid sump.

By running exhaust through the tracer controlled governor it will be seen that a very effective method is provided for governing feeding of both the longitudinal and cross-feed cylinders; because it will be understood that these cylinders can receive tracer controlled fluid or constant volume fluid only as fast as said cylinders can exhaust fluid from the other side of the piston not in communication with said fluids.

Heretofore without effective control of the longitudinal and cross-feeds, cutting tools have been damaged and work spoiled, both of which could have been prevented had an effective method been provided for slowing down or stopping constant feeding at the moment that there was a change in direction required in the tracer controlled feed.

It is the object of the present invention to provide an exhaust controlling governor within the tracer mechanism and operable thereby for controlling or entirely stopping the exhaust from both the transverse feed cylinders.

It is the object herein to provide suitable fluid connections from the directional control valve for conducting the exhaust fluid from the tracer controlled cylinder, whichever it may be, back to the tracer valve, together with means for then conducting the same to and through a suitable exhaust fluid governor operable by the tracer mechanism, whence said exhaust fluid is returned to a fluid sump disposed in conjunction with a fluid pressure source.

It is the further object herein to provide suitable fluid connections for the directional control valve for conducting exhaust fluid from the constant volume fluid controlled cylinder directly back to the tracer controlled governor, whence it is also returned to said fluid sump.

It is a still further object of this invention to

provide a back pressure valve means intermediate the tracer controlled exhaust fluid and the governor inlet, and also a back pressure valve means intermediate the constant volume exhaust fluid and the governor inlet, whereby vibration will be eliminated to provide smooth and continuous uninterrupted feeding and cross-feeding; and this as the directional control valve is manually adjusted for changing tracer control from one feed cylinder to the other and for changing constant volume feeding from one feed cylinder to the other.

It is the still further object herein to provide a common connection between both of said pressure relief valve means whereby the returned exhausted fluid from both the tracer controlled cylinder and the constant volume controlled cylinder are conducted through a single conduit to the governor inlet within the tracer housing.

It is the still further object herein to provide manually operable fluid metering means in a tracer controlled feed line and also in the constant volume fluid exhaust line.

This invention therefore relates to the various elements and their various combinations as more fully set out hereinafter in connection with the accompanying drawings of which:

Fig. 1 is a diagrammatic view of the hydraulic unit, tracer, directional control valve, transverse feed cylinders. and the hydraulic connections therefor.

Fig. 2 is an elevational partially sectioned view of the tracer illustrating the exhaust controlling governor therein.

Fig. 3 is a side elevational view of the directional control and reverse valves.

Fig. 4 is a sectional view on line 4—4 of Fig. 3.

Fig. 5 is a left end view of the control valve housing with the reversing mechanism removed.

Fig. 6 is a section on line 6—6 of Fig. 5.

Fig. 7 is a plan view of the plunger for the directional control valve.

Fig. 8 is a section on line 8—8 of Fig. 7.

Fig. 9 is a section on line 9—9 of Fig. 7.

Fig. 10 is a section on line 10—10 of Fig. 7.

Fig. 11 is a section on line 11—11 of Fig. 7.

Fig. 12 is a section on line 12—12 of Fig. 7.

It will be understood that said drawings illustrate merely a preferable embodiment of the invention and that other embodiments thereof are possible and contemplated within the scope of the invention hereinafter described and set out in the accompanying claims.

Referring to the drawings, a hydraulic unit 11 is indicated having therein a fluid storage sump and means for supplying fluid under pressure out through conduits 12 and 13. Conduit 12 thus supplies fluid under pressure to the tracer housing 14 within which is disposed a longitudinally movable fluid control valve piston 15.

Fluid from conduit 12 enters the tracer housing and through a suitable conduit is conducted to the annular opening 16 within piston 15. Tracer spindle 17 longitudinally disposed within the tracer housing 14 projects therefrom having a tracer tip 18 adapted to engage the surface of a pattern 18' sought to be reproduced by a milling machine, lathe or other device.

The upper end of spindle 17 operatively engages the bottom portion of piston 15 with suitable friction minimizing ball races 19 interposed therebetween. Consequently when tracer tip 18 engages an obstruction in the pattern, a longitudinal movement is imparted to said spindle within housing 14 for longitudinally and upwardly actuating a piston 15 within said housing, whereby it is seen that fluid entering annular opening 16 is conducted to annular opening 20 whence it is conducted out through fluid outlet conduit 22.

Referring to Fig. 2 a spring member 37 is provisioned around valve stem 15' operatively engaging at its ends the bottom surface of the reciprocable piston 15 and the adjustable nut 37' whereby with the tracer inoperative said piston is resiliently held slightly below the position shown in Fig. 2. This means that fluid under pressure entering the tracer housing and the annular opening 16 is conducted to the annular opening 21 within said tracer housing for communication with the fluid outlet conduit 23.

Referring to Fig. 1 conduits 22 and 23 are shown interconnecting the tracer housing 14 and the directional control valve 24. It will be noted also that constant volume fluid from the hydraulic unit 11 is supplied through conduit 13 to said directional control valve.

A longitudinal feed cylinder 25 is indicated with a reciprocable piston 26 disposed therein and joined by a suitable connection 27 to a diagrammatically indicated supporting work table 28 for causing longitudinal feed movement thereof relative to a rotatable cutter.

Conduits 29 and 30 interconnect directional control valve 24 and opposite ends of the longitudinal feed cylinder 25, whereby either tracer controlled fluid or a constant volume fluid may be conducted to either end of said cylinder for operatively moving the piston 26 therein. It will be understood that if fluid is supplied through conduit 29 to cylinder 25, that exhaust fluid from the other side of piston 26 will be returned through conduit 30 back to the directional control valve 24 for further subsequent exhausting in the manner hereinafter set out. Or on the other hand with fluid supplied through conduit 30, exhaust will return through conduit 29.

Conduits 31 and 32 also interconnect directional control valve 24 and the opposite ends of the cross-feed cylinder 33 within which is longitudinally and reciprocably disposed a piston 34 operatively connected at 35 to the slide 28' for supporting the work support 28. Consequently it is seen that reciprocable movement can be obtained for the cross-feed cylinder 33 with either tracer controlled fluid or constant volume fluid being conducted thereto through either conduit 31 or 32.

It will be understood that with fluid entering cylinder 33 through conduit 31 that fluid on the other side of piston 34 will be exhausted out through conduit 32 back to the directional control valve for subsequent exhaustion in the manner hereinafter described. Or with fluid entering cylinder 33 through conduit 32 exhaust will return via conduit 31. Referring to the drawings in Figs. 3 to 11, the directional control valve is comprised of a housing 24 with a cylindrical opening 84 therethrough within which is rotatably journaled the valve plunger 53 manually operated by the hand wheel 36.

Annular openings 54, 55, 56 and 57 are provisioned therein in respective communication with the cylinder ports 58, 59, 60 and 61. Ports 58 and 59 are adapted for connection by suitable conduits 29 and 30 to opposite ends of a reciprocable work table feeding cylinder, as for instance the longitudinal feed cylinder 25. Ports 60 and 61 are adapted for connection through suitable conduits 31 or 32 to opposite ends of an-

other reciprocable work table feeding cylinder, as for instance the cross feed cylinder 33.

Variable fluid port 62 adjacent the end of housing 24 is adapted for fluid connection through conduit 22 to the control valve within a suitable tracer mechanism 14 which operatively engages the pattern sought to be reproduced, whereby fluid under pressure from the tracer is directed to the directional control valve for direction to either of the two work table controlling cylinders 25 and 33, and to either end thereof depending upon the relative rotated position of the plunger 53 hereafter described in detail.

Another variable fluid port 63 is oppositely disposed from opening 62 within valve housing 24, also adapted for connection with the above mentioned tracer control valve through conduit 23. Consequently fluid from the tracer directed to port 62 goes to one end of the longitudinal feed cylinder 25 through conduit 29 going out of housing 24 through port 58, while the fluid on the other side of the piston within said cylinder is forced back through conduit 30 to the control valve through port 59 and thence to port 63. From port 63 in housing 24 said exhaust fluid is conducted back to the tracer control valve through conduit 23 whence it is suitably exhausted to a hydraulic unit 11.

If on the other hand the control valve in the tracer 14 is displaced by the operating mechanism within the tracer housing as it engages the pattern 13', fluid from the tracer may get to the directional control valve through conduit 23 and port 63, and thence to the opposite end of the longitudinal feed cylinder 25 through conduit 30; and the exhaust from said feed cylinder on the other side of the piston will then return by conduits 29 and 22 to the tracer 14 through the port 62 in the directional control valve 24.

Referring again to Fig. 5 constant fluid port 64 is seen in the end of valve housing 24 for receiving fluid under constant pressure which is conducted through a passage 65 to the valve plunger 53 whence it is conducted by said plunger to one end or the other of, for instance, the cross feed cylinder 33 through the outlet 60 in valve housing 24 and conduit 31. On the other hand exhaust from said cylinder on the other side of the piston therein returns to the directional control valve 24 through conduit 32 to outlet port 61 for communication with the plunger 53 whence it is conducted back to the outlet passage 66 and constant fluid port 67 in the end of valve housing 24, for subsequent exhaustion in the manner later to be described.

On the other hand depending upon the position of the reverse valve hereinafter described, fluid under constant pressure may enter the directional control valve 24 through port 67 and exhaust through port 64.

The flow of constant pressure fluid is governed by reverse valve member 74 shown in Figs. 3 and 4. Its housing 68 corresponding in shape to the main valve housing 24 is suitably secured thereto by threaded bolts 69' disposed through openings 70 in the reverse valve housing 68 and main valve housing 24, with a suitable separator or gasket 71 interposed therebetween.

A cylindrical opening 72 is provisioned through housing 68 for rotatably journaling a reverse valve control member 73 manually operable by handle 50. The reverse valve control member 73 cylindrical in shape and shown in Fig. 4, is slotted at 75 and 76, and has formed as a part thereof an actuating shaft 77 on the end of which is secured a manually operable handle 50.

In Fig. 4 the reverse valve 74 is shown with a constant fluid pressure inlet 78 adapted for connection through conduit 13 with a suitable fluid pressure source within the hydraulic unit 11. A similar outlet opening for constant pressure exhausting is provisioned at 79 for exhausting fluid from the particular cylinder at the moment under constant feed control through conduit 47 back to the tracer 14 for subsequent exhausting in the manner hereinafter set out.

Both inlet 78 and outlet 79 communicate with the interior central opening 72. A reversing port 80 is shown in Fig. 4 joining passage 81 to the central opening 72. With the rotatable reverse valve member 73 in the position shown in Fig. 4, fluid under constant pressure from inlet 78 is conducted through slot 75 to the passage 81 and port 80.

Similarly a reversing port 82 is provided in housing 68 with a passage 83' joined thereto communicating with the central opening 72. In the position of the rotatable reverse valve member 73 as shown in Fig. 4 port 82 is an exhaust opening for the other side of the cylinder at the moment receiving constant pressure fluid. Port 82 and passage 83' thus conduct exhaust fluid through the central opening 72 through the slot 76 and to the reverse valve exhaust opening 79 whence it is suitably conducted away through conduit 47.

It is seen from Fig. 4 that by clockwise movement of the reverse valve member 73 a quarter of a turn fluid under pressure will be delivered via inlet 78 and slot 75 and through passage 83' to the pressure port 82. And in a similar manner the exhaust from the other side of the cylinder under constant pressure feeding will return through port 80, passage 81, slot 76 and outlet opening 79 for disposal through conduit 47.

Thus it is seen that by rotation one quarter of a turn of reverse valve member 73 that fluid under constant pressure is directed to either port 80 or 82, thus providing a means for quickly reversing the direction of movement of the feed cylinder which happens to be under constant fluid control. For instance in traveling around a work piece it may be desirable to back up a short distance from any point along the circumambulatory traverse.

With the reverse valve housing 74 secured in place against the left end of the main valve housing 24 by bolts 69' it is seen that reversing ports 80 and 82 in housing 74 coincide in communicating relation with constant fluid ports 67 and 64 respectively in main valve housing 24. Thus fluid under constant pressure independent of the operation of the tracer 14 may be directed through either port 64 or 67 or changed at will from one to the other.

Valve housing 24 also has a tracer controlled fluid source coming in at opening 62 from conduit 22 and returning to the tracer control valve through variable fluid port 63 and conduit 23; or fluid may come from the tracer through port 63 and return through port 62 depending upon the operation of tracer 14. On the other hand four cylinder ports 58, 59, 60 and 61 are provisioned within the valve housing with suitable conduits 29, 30, 31 and 32 joined to each providing fluid communication to both ends of each work table controlling cylinders 25 and 33 respectively.

A manually rotatable plunger 53, shown in Fig. 7, is journaled within cylindrical opening 84 for

directing the constant pressure fluid coming into the directional control valve housing 24 at either port 64 or 67, out through any of the cylinder ports 58, 59, 60 or 61, and the tracer controlled fluid pressure source coming into the valve housing at ports 62 or 63, out through any of the valve cylinder ports 60 or 61 and 58 or 59. Said control valve also provides at the same time exhaust connections for the other two ports back to one or the other of the constant pressure ports 64 and 67 and also to one or the other of the tracer controlled fluid ports 62 and 63.

Said plunger 53 has provisioned longitudinally therein non-communicating passages 85, 86, 87 and 88 all terminating at one end of the plunger in the four radially positioned passages 85', 86', 87' and 88', each of which is adapted for progressive communication with each of the ports 62, 63, 64 and 67 respectively as the plunger is manually rotated one-fourth of a turn at one time by hand wheel 36.

A plurality of annular recesses 89, 90, 91 and 92 are provisioned within plunger 53 to coincide with the corresponding annular recesses 54, 55, 56 and 57 on the inside of the valve housing 24 as shown in Fig. 6.

Longitudinal opening 85 terminates at outlet 93 within annular opening 89 to establish communication with the corresponding cylinder port 58 within the annular recess 54. Longitudinal openings 86, 87 and 88 are all of varying lengths from opening 85 and likewise respectively terminate at outlets 94, 95 and 96 within annular openings 90, 91 and 92, to establish communication respectively with the corresponding cylinder ports 59, 60 and 61 within the annular recesses 55, 56 and 57 in the valve housing 24.

Consequently in turning plunger 53 a quarter of a turn at a time it is possible to provide communication from any one of the ports 62, 63, 64 and 67 in the control valve to any desired cylinder port 58, 59, 60 or 61 in the valve housing for providing control to any particular end of either the longitudinal or cross feed cylinders; and at the same time also providing communication from the other inlets to each of the other ends remaining in said cylinders.

For example fluid under constant pressure through conduit 13 from the hydraulic unit 11 can travel via 78, 75, 81, 80, 67, 66, 86, 94, 59 and thence to one end of for instance, the longitudinal feed cylinder 25 through conduit 30. Exhaust from the other side thereof thus returns via conduit 29, 58, 93, 85, 65, 64, 82, 83, 76 and 79 and thence through conduit 47 back to tracer for subsequent exhausting.

At the same time tracer controlled fluid goes from conduit 22 into the directional control valve housing 24 at port 62 and via 88, 96, 61 and conduit 32 to one end of for instance, the cross feed cylinder 33. The exhaust from the other side thereof goes back via conduit 31 to cylinder port 60, 95, 87 and 63 and back to the tracer valve via conduit 23 for exhausting.

In operation by turning handle 50 of the reverse valve a quarter of a turn clockwise, constant pressure from conduit 13 to the longitudinal feed cylinder 25 is reversed or sent to the other end thereof through conduit 30 via 78, 75, 83', 82, 64, 65, 85, 93, 58 and conduit 29. And at the same time exhaust returns from the opposite end of said cylinder via conduit 30, 59, 94, 86, 66, 67, 80, 81, 76 and 79 and thence through conduit 47 back to tracer 14.

By turning the reverse valve handle back one-quarter of a turn counter-clockwise constant feed is again reversed in the longitudinal feed cylinder 25 as first set out. Throughout this operation there has been no change in the tracer controlled fluid supply to the cross feed cylinder 33 through conduit 32 at one end thereof and exhaust therefrom at the other end through conduit 31.

In progressively traversing around a work piece in a circumambulatory path if it is desired to change the constant feed from the longitudinal feed cylinder 25 to the cross feed cylinder 33, with tracer control changed from the cross feed cylinder to the longitudinal feed cylinder 25, all that is necessary is to rotate the plunger 53 a quarter of a turn clockwise.

Constant feed from the reverse valve at 78 goes via 75, 81, 80, 67, 66, 88, 96 and 61 and through conduit 32 to one end of the cross feed cylinder 33 while exhaust therefrom on the other side of said cylinder goes back to the directional control valve via conduit 31, 60, 95, 87, 65, 64, 82, 83', 76 and 79.

At the same time tracer control goes to longitudinal feed cylinder 25 via conduit 22, 62, 85, 93, 58 and conduit 29; and the exhaust from the other side of said cylinder returns via conduit 30, 59, 94, 86, 63 and conduit 23 back to the tracer 14 for exhausting.

Again constant feed, now in the cross feed cylinder 33 may be reversed merely by rotating handle 50 of the reverse valve 74 one-quarter of a turn clockwise in the manner hereinabove set out.

Thus it is seen that a versatile directional control and reverse valve is provided for governing longitudinal and cross feeding of the work piece supporting table with respect to a rotatable cutter.

Constant feeding may be changed from longitudinal feed in one direction to cross feeding in one direction. By further operation of the hand wheel 36 constant feed may be again directed to the longitudinal feed cylinder in the opposite direction; and by another quarter turn of the hand wheel constant feed could go to the cross feed cylinder in the opposite direction.

The reverse valve above described is also adapted to reverse constant feeding in any one cylinder at any time without further operation of the control valve hand wheel 36, which normally would require several adjustments for accomplishing the same result.

A packing gland 97 is shown in Fig. 3 suitably bolted on one end of the valve housing 24, with the operating shaft 98 forming a part of the plunger 53 journaled therethrough. An adjusting nut 99 is disposed within the end of the packing gland for adjusting the same. Similarly a packing gland 100 is provisioned upon the outer end of the reverse valve housing 74 suitably secured thereto. The actuating shaft 77 for the reverse valve member 73 is rotatably journaled through the packing gland 100 and an adjusting nut 101 is provided as shown.

With the reverse valve handle turned at any time a quarter of a turn to reverse the direction of feed of the cylinder under constant feeding, continuous traverse in a circumambulatory path around the work may be continued in that reverse direction merely by operating the hand wheel 36 in quarter turns progressively in the opposite direction.

The directional control valve 24 is fully described in our co-pending above referred to applications has provisioned thereon a manually operable means 36 for rotatably positioning the valve

member therein. Said rotatable valve member is therefore adapted to provide tracer controlled fluid to one end or the other of either cylinder as for instance the longitudinal feed cylinder 25; and at the same time constant volume fluid from conduit 13 is conducted through said directional control valve to one end or the other of for instance the cross-feed cylinder 33.

By progressively adjusting the manually operable member 36 of the directional control valve tracer controlled fluid may be diverted from one feed cylinder to the other and to either of the ends thereof. Likewise it will be understood that constant volume fluid may be diverted from one feed cylinder to the other and also to either of the ends thereof.

In any event the exhausted fluid from both feed cylinders must return to the directional control valve 24 whence the same is returned to the tracer housing 14 through the exhaust governor hereinafter described in detail.

Referring to Fig. 2 annular opening 21 is connected by conduit 23 for delivery of fluid to the directional control valve 24, whence by adjustment thereof the same will be conducted for instance, through conduit 32 to one end of the cross-feed cylinder 33. The exhaust however from cylinder 33 receiving fluid from conduits 23 and 32 returns to the directional control valve through conduit 31 whence it is conducted through conduit 22 back to the tracer housing 14 and to annular opening 20 therein. Control governor opening 44 being enlarged at its top and bottom, it is seen that its upper edge overlaps the lower edge of annular opening 45; and that its lower edge overlaps the upper edge of annular opening 43. Thus in the neutral position shown in Fig. 2 of valve 15 exhaust fluid is free to flow through openings 43, 44 and 45.

Also slight elevation or depression of valve 15 only partially restricts the flow of fluid through governor openings 43, 44 and 45. However the more extreme upward movement of valve 15 results in opening 44 being entirely cut off from opening 45, so that fluid can go through opening 43 to 44, but cannot enter governor outlet 45.

It will be seen that with the piston 15 in its initially spring depressed position, i. e. slightly below the position shown in Fig. 2, annular opening 20 is in communication with the annular exhaust opening 38 within piston 15. Consequently exhaust fluid which returns through conduit 22 goes through annular openings 20 and 38 and thence through the exhaust conduit 39 and the back pressure relief valve 40 connected thereto.

Said exhaust fluid enters the T connection 41 and travels through conduit 42 back into the tracer housing for communication with the governor inlet opening 43. Even in the slightly depressed position of piston 15 exhaust fluid through conduits 31 and 22 from the other side of cylinder 33 flows from governor inlet 43 to annular opening 44 in the tracer housing whence it flows into the annular governor outlet opening 45, which is in turn joined by conduit 46 for returning the exhaust fluid back to the storage sump within the hydraulic unit 11.

During this operation with the valve 15 and the spindle 17 and tracer tip 18 slightly depressed by resilient action of spring 37, constant volume fluid exhaust is returning to the tracer housing 14, through the conduit 47 from the longitudinal feed cylinder 25. Conduit 47 joins back pressure relief valve 48 and the T connection 41 also returning said constant volume fluid exhaust through conduit 42 to the governor inlet opening 43.

And in a manner similar to the exhausting of the tracer controlled fluid exhaust, the constant volume fluid exhaust travels through opening 44 and the governor outlet opening 45 and thence through conduit 46 back to the hydraulic unit 11. It will be understood that in initial spring depressed position, sufficient clearance is provided between openings 43, 44 and 45 to permit the flow of exhaust fluid therethrough.

Up to now the tracer tip has not engaged the work; and with fluid flowing out through conduit 23, the cross-feed cylinder 33 for instance is causing cross-feeding of the work table slide 28' until the tracer tip 18 engages the pattern. This causes spindle 17 to elevate slightly against action of the spring 37 until piston 15 assumes the position shown in Fig. 2. At this instant fluid outflow to conduit 23 is stopped thus preventing further cross-feeding of piston 34.

It will be noted however that the constant volume exhausting from the longitudinal feed cylinder 25 and conduit 47 may still go through the governor inlet 43, opening 44, governor outlet 45, and conduit 46 for return to the hydraulic unit 11.

Just as soon, however, as further longitudinal constant feeding causes tracer tip 18 to engage a slight obstruction it is desirable to definitely slow down said constant feeding until there has been a reversal of cross-feeding to the extent that spindle 17 and piston 15 can again assume a neutral position as shown in Fig. 2.

Therefore on tracer tip 18 engaging an obstruction spindle 17 and piston 15 are elevated several thousandths of an inch above normal position partially closing off the governor outlet opening 45, and slowing down constant longitudinal cross-feeding. This is accomplished by limiting the constant volume exhaust which will move through the exhaust governor outlet 45.

Now in elevated position of piston 15 fluid under pressure from conduit 12 is free to enter annular opening 20 causing fluid to flow out through conduit 22 to the directional control valve 24. The latter directs this fluid through conduit 31 to the opposite end of the cross-feed cylinder 33. This immediately starts a cross-feeding in the opposite direction gradually permitting spindle 17 and piston 15 to descend to neutral position until no further upward pressure is exerted upon spindle 17 other than that required to keep the piston in a neutral position.

With fluid under pressure from the tracer going to cylinder 33 through conduit 31, exhaust fluid is returned via conduit 32 to the directional control valve and thence through conduit 23 back to annular opening 21. With the piston 15 elevated annular opening 21 is in communication with the annular exhaust opening 49 which in turn joins the exhaust conduit 39 for subsequent exhausting through the governor openings 43, 44 and 45.

By the provision of the above described means for causing both exhausts, i. e. from the tracer controlled cylinder and from the constant volume fluid controlled cylinder to return through governor inlet 43, opening 44, and governor outlet 45 for subsequent exhaustion back to the hydraulic unit, it is seen that at the moment any obstruction in the pattern is reached causing an upward movement of the piston that the governor outlet 45 partially closes slowing down all feeding movement of either cylinder. This pre-

vents the breaking of the cutter or damaging of the work piece; and also provides that increment of time which is necessary to obtain the reversal of feeding so that the tracer tip 18 overcomes the obstacle in the pattern and the piston 15 is permitted to return to neutral position.

It will be understood that this operation is the same with the tracer controlling longitudinal feeding and with constant feeding in the cross-feed cylinder, all of which is accomplished by the manual adjustment of wheel 36 of the directional control valve 24.

The invention therefore provides a safety mechanism for directing the exhausts from both transverse feed cylinders through a tracer controlled governor, so that for any change in direction required of the cylinder under tracer control, both feed movements are slowed down until that change can be effected.

When the invention herein is employed in conjunction with two directional contouring and profiling as fully set out in our co-pending application Serial No. 366,082, it is desired that the cutter relatively walk entirely around the work piece in a path corresponding to the path taken by the tracer tip around the pattern sought to be reproduced in the work.

As set out therein the directional control valve is intermittently manually actuated for alternately changing tracer control from one feed cylinder to the other as the cutter approaches certain critical points in its relative circumambulatory path around the work. For instance, tracer control is directed to the feed cylinder which at the moment governs the greatest change in direction of relative movement between the cutter and the work. Also the feeds are reversed from one end of the feed cylinders to the other.

Consequently with such continuous operation of the tracer it becomes necessary to incorporate a safety device therein to regulate and govern the return of exhaust fluids from these cylinders. By so controlling the exhausts therefrom it is seen that a very effective control of feed movement may be obtained, which is directly responsive to movements of the tracer spindle as it engages a pattern.

As set out in our co-pending application Serial No. 366,082, the directional control valve 24 must be under the constant supervision of a skilled operator. This means that if the cutter is to progress in a circumambulatory path with respect to the work, the rotatable valve member within said directional control valve must be intermittently and progressively rotated by the actuating handle 36.

As above described, by actuating member 36 tracer control is alternately changed from one cylinder to the other, and alternately changed from one end of each cylinder to the other end thereof. At the same time constant volume feeding is intermittently and alternately changed from one cylinder to the other, and also from one end of each cylinder to the other.

By this operation of the directional control valve as set out in detail in the above mentioned co-pending application, a smooth and continuous relative circumambulatory traverse of the work by the cutter is obtained. If however the operator should not be alert, or has his attention otherwise directed, he may not properly operate the directional control valve actuating means at the proper time. But for the above described governor this inattention would cause the breaking off of the cutter tool, or possible damage to the work piece.

However with the governor mechanisms 43, 44 and 45 controlling the exhausts at all times from both cylinders this danger is eliminated in the following manner. With the tracer spindle 17 engaging a sudden obstruction, the same is projected upwardly but because the directional control valve member 36 has not been properly adjusted, the reversal of feed movement caused by upward movement of valve piston 15 does not eliminate the obstruction to the tracer tip 18 but merely causes further upward movement of piston 15.

This immediately closes governor opening 44 from the governor inlet 43 with the result that all feeding in both directions is immediately stopped. It will be understood that normal tracer movement causes a mere reversal in the cross feeding, for instance, that the movement of the piston 15 is slight and consequently the governor is only slightly restricted, at most merely slowing down the relative feed movements.

However when the operation is not normal due to inattention of the operator, the movement of piston 15 upward upon the tracer tip 18 reaching an obstruction in the pattern is greater which in turn immediately completely constricts the communicating openings 43, 44 and 45 through the governor.

This stops all exhausting from both feed cylinders which results in immediately stopping all feeding movement. Thus the operator is given an opportunity to reset the directional control valve before again starting a relative traverse of the cutter with respect to the work.

It will be noted that the two back pressure valves 40 and 48 are interposed between the two return exhaust conduits 47 and 39 and the governor inlet opening 43. It was found that with these back pressure valves absent that considerable vibration occurred in conjunction with the operation of the pistons 26 and 34 within their respective cylinders. By employing these back pressure release valves, a cushion is provided or a certain amount of resistance set up against the return flow of the exhaust fluid from the cylinders, which has been found to eliminate vibration and permit a very smooth operation thereof.

It will be noted that both exhausts after going through the back pressure valves 40 and 48 go into the T connection 41 for subsequent entry into the governor inlet 43. This provides a simplified means for joining the two exhausts from the tracer controlled cylinder and from the constant volume fluid control cylinder, and returning said exhaust together to and through the tracer controlled governor for return to the hydraulic storage sump. It is seen that back pressure relief valves 40 and 48 are respectively provided with spring tension adjusting screws 40' and 48'.

Referring to Fig. 1 a reversing mechanism 50 is provisioned upon one end of the directional control valve, whereby the direction of flow of constant volume fluid from conduit 13 may be reversed. This will cause, when operated manually, a reversal only in the direction of feed of the cylinder at the time under constant feeding. This enables the operator to back up the work relative to the cutter at any point along the work without otherwise manipulating the manual control 36 to a reverse position.

Referring to Fig. 1, manually operable metering valves 51 and 52 are respectively interposed

in the tracer controlled fluid supply or exhaust conduit 23, and the constant volume exhaust line 47. Thus at any moment the operator may vary the volume of fluid flowing therethrough to speed up or slow down either or both cylinder feed movements.

For instance, in traveling a substantially straight longitudinal traverse under constant feeding, where the cross-feeding will be slight, it is desirable to speed up the longitudinal feed movement throughout substantially the length of the traverse. This is done merely by manually adjusting the metering valve 52 in the constant volume exhaust line 47. Or on the other hand the feed in the other direction can be accelerated by manually operating metering valve 51 in line 23.

Having described our invention reference should now be had to the claims which follow for determining the scope thereof.

We claim:

1. In combination, a fluid pressure source, a tracer actuated fluid control valve, a directional control valve adapted to direct tracer controlled fluid alternately to either end of either one of two transverse feed cylinders, and constant volume fluid to either end of the other feed cylinder, conduits for supplying and exahusting tracer controlled fluid to and from said directional control valve, a conduit for supplying constant volume fluid to said directional control valve, a constant volume fluid exhaust conduit between said directional control valve and said tracer, a tracer actuated exhaust fluid governor valve, and means for conducting the exhausts from both feed cylinders through said governor valve whereby upon movements of said tracer actuated governor restricting the openings therein, relative feed movements may be controlled.

2. In combination, a fluid pressure source, a tracer actuated fluid control valve, a directional control valve adapted to direct tracer controlled fluid alternately to either end of either one of two transverse feed cylinders, and constant volume fluid to either end of the other feed cylinder, conduits for supplying and exhausting tracer controlled fluid to and from said directional control valve, a conduit for supplying constant volume fluid to said directional control valve, a constant volume fluid exhaust conduit between said directional control valve and said tracer, an exhaust fluid governor valve forming a part of said tracer actuated valve, and means for conducting the exhausts from both feed cylinders through said governor valve whereby upon movements of said tracer actuated valve, restricting the openings through said governor valve, relative feed movements may be controlled.

3. In combination, a tracer actuated fluid control valve, a directional control valve adapted to alternately direct tracer controlled fluid from a pressure source to either end of either one of two transverse feed cylinders, and constant volume fluid from said pressure source to either end of the other feed cylinder, a tracer actuated exhaust fluid governor valve, having fluid openings therein, and exhaust conduits from said directional control valve for conducting the exhausts from both feed cylinders through said governor valve whereby upon movements thereof restricting the openings therein, relative feed movements may be controlled.

4. In combination, a tracer actuated fluid control valve, a directional control valve adapted to alternately direct tracer controlled fluid from a pressure source to either end of either one of two transverse feed cylinders, and constant volume fluid from said pressure source to either end of the other feed cylinder, an exhaust fluid governor valve having fluid openings therein and forming a part of said tracer actuated valve, and exhaust conduits from said directional control valve for conducting the exhausts from both feed cylinders through said governor valve whereby upon movement of said tracer actuated valve causing a restriction in said openings, relative feed movements may be stopped.

5. In combination, a tracer actuated fluid control valve, a directional control valve adapted to alternately direct tracer controlled fluid from a pressure source to either end of either one of two transverse feed cylinders, and constant volume fluid from said pressure source to either end of the other feed cylinder, a tracer actuated exhaust fluid governor valve having fluid openings therein, exhaust conduits from said directional control valve for conducting the exhausts from both feed cylinders through said governor valve whereby upon movements of said tracer actuated valve causing a restriction in said openings, relative feed movements may be controlled, and back pressure relief valves interposed in said exhaust conduits.

6. The combination, a tractor actuated fluid control valve, a directional control valve adapted to alternately direct tracer controlled fluid from a pressure source to either end of either one of two transverse feed cylinders, and constant volume fluid from said pressure source to either end of the other feed cylinder, a tracer actuated exhaust fluid governor valve having fluid openings therein, means for conducting the exhausts from both feed cylinders through said governor valve whereby upon movements of said tracer actuated valve causing a restriction in said openings, relative feed movements may be controlled, said means consisting of separate conduits from the directional control valve conducting exhaust fluid from each of said feed cylinders converging at a T pipe connection, a conduit therefrom to said governor valve, and back pressure relief valves interposed in said exhaust conduits.

7. In combination, a tracer actuated fluid control valve, a direction control valve adapted to alternately direct tracer controlled fluid from a pressure source to either end of either one of two transverse feed cylinders, means for alternately conducting constant volume fluid to either end of the other feed cylinder, a tracer actuated exhaust fluid governor valve having openings therein and exhaust conduits from said directional control valve for conducting the exhausts from both feed cylinders through said governor valve whereby upon movements of said tracer actuated valve causing a restriction in said opening, relative feed movements may be controlled.

8. In combination, a tracer actuated fluid control valve, a direction control valve adapted to alternately direct tracer controlled fluid from a pressure source to either end of either one of two transverse feed cylinders, means for alternately conducting constant volume fluid to either end of the other feed cylinder, a tracer actuated exhaust fluid governor valve having openings therein, exhaust conduits from said directional control valve for conducting the exhausts from both feed cylinders through said governor valve whereby upon movements of said tracer actuated valve causing a restriction in said open-

ing, relative feed movements may be controlled, and back pressure relief valves interposed in said exhaust conducting means.

9. In combination, a tracer housing, a spindle disposed therein and projecting outwardly therefrom, adapted to longitudinal movement upon receiving a thrust from a pattern, a fluid control valve operably connected to said spindle, a directional control valve adapted to alternately direct tracer controlled fluid from a pressure source to either end of either one of two transverse feed cylinders, and constant volume fluid from said pressure source to either end of the other feed cylinder, a tracer actuated exhaust fluid governor valve, having fluid openings therein, exhaust conduits from said directional control valve for conducting the exhausts from both feed cylinders through said governor valve whereby upon movement of said tracer actuated valve causing a restriction in said openings, relative feed movements may be controlled.

10. In combination, a tracer actuated fluid control valve, a directional control valve adapted to alternately direct tracer controlled fluid from a pressure source to either end of either one of two transverse feed cylinders, and constant volume fluid from said pressure source to either end of the other feed cylinder, a tracer actuated exhaust fluid governor valve having fluid openings therein, exhaust conduits from said directional control valve for conducting the exhausts from both feed cylinders through said governor valve whereby upon movement of said tracer actuated valve causing a restriction in said openings, relative feed movements may be stopped, and manually operable metering means for limiting the flow of tracer controlled and constant volume fluid to said directional control valve.

11. In combination, a tracer actuated fluid control valve, a directional control valve adapted to alternately direct tracer controlled fluid from a pressure source to either end of either one of two transverse feed cylinders, and constant volume fluid from said pressure source to either end of the other feed cylinder, a tracer actuated exhaust fluid governor valve having fluid openings therein, separate exhaust conduits from each of said feed cylinders converging at a T pipe connection, a conduit therefrom to said governor valve, whereby upon movements of said tracer actuated valve causing a restriction in said openings, relative feed movements may be controlled.

12. In combination, a fluid pressure source, a tracer actuated fluid control valve, a directional control valve adapted to alternately direct tracer controlled fluid from said pressure source to either end of either one of two transverse feed cylinders, and constant volume fluid from said pressure source to either end of the other feed cylinder, and means for conducting exhaust fluid from said feed cylinders back to said fluid pressure source.

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