Aug. 17, 1954 W. I. EVANS 2,686,650

HYDRAULIC TRACING MECHANISM

Filed March 23, 1951 3 Sheets-Sheet 1

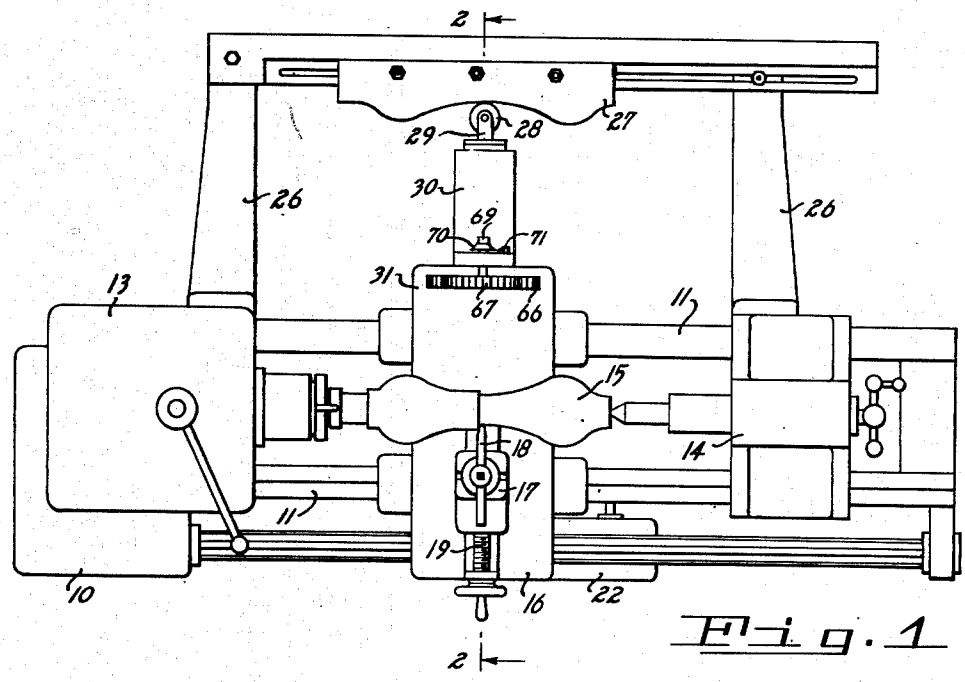


Fig. 1

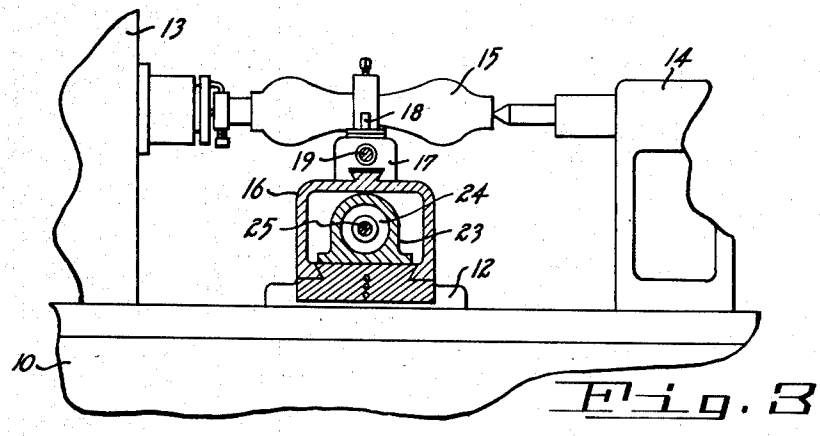


Fig. 3

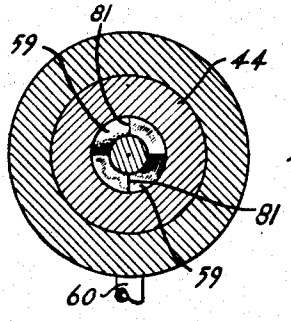


Fig. 4

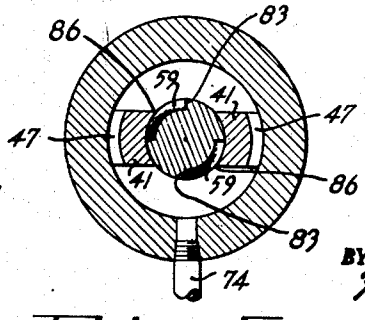


Fig. 5

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HYDRAULIC TRACING MECHANISM

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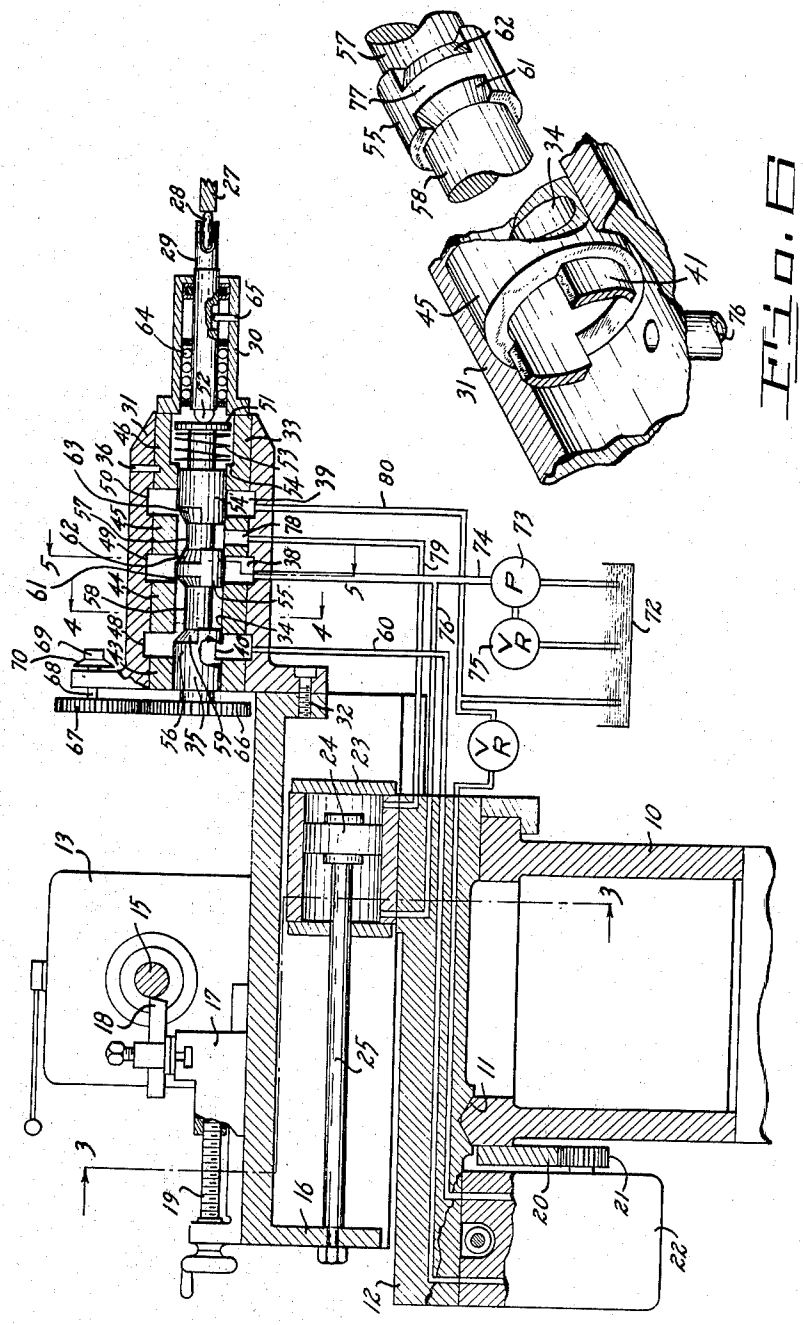


Fig. 2

Fig. 6

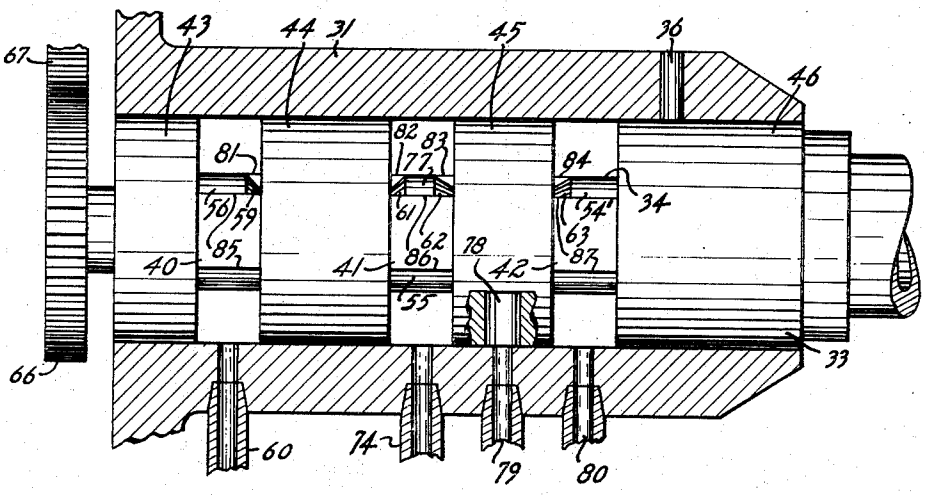
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HYDRAULIC TRACING MECHANISM

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Fig. 7



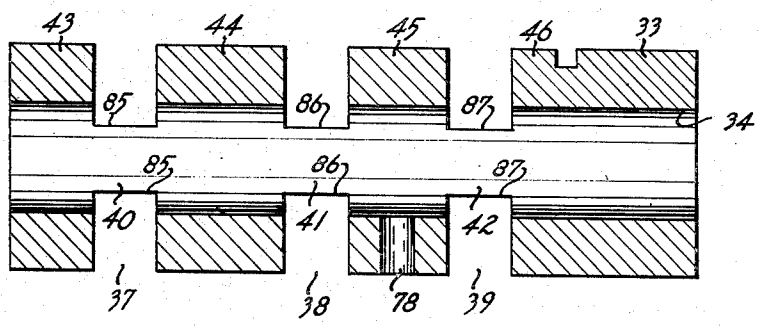


Fig. 8

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UNITED STATES PATENT OFFICE

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HYDRAULIC TRACING MECHANISM

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Application March 23, 1951, Serial No. 217,128

9 Claims. (Cl. 251—3)

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This invention relates to pattern controlled reproducing machines and has particular reference to an improved hydraulic operating mechanism for such machines.

One of the principal objects of the present invention is the provision of an improved pattern actuable control mechanism for automatic determination of the relative rates of movement of a pair of machine tool slides for determining the resultant contour path followed by a reproducing tool.

A further object of the invention is the provision of an improved automatic control mechanism for contouring machines for effecting an improved sensitivity in determintion of the relationship between the relative slide movements irrespective of the feed rates being employed for the particular contouring operation which will be particularly effective in maintaining a substantially constant cutting rate irrespective of the directional path and prevent possible rate fluctuations in the movement of individual slides due to unequal resistance to movement as respects the parts being actuated.

An additional object of the present invention is the provision of a tracer actuable control valve mechanism embodying variable resistance means capable of utilization, not only to determine the selective or proportional distribution of hydraulic actuating medium to a plurality of members but which has the additional capacity of adjustment to vary the rate of power transmittal effected by corresponding movements of the control valve mechanism.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof, and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

Figure 1 is a plan view of a lathe structure embodying the present invention.

Figure 2 is a diagrammatic vertical sectional view on the line 2—2 of Figure 1.

Figure 3 is a sectional view on the line 3—3 of Figure 2.

Figure 4 is a vertical section of the tracer body on line 4—4 of Figure 2.

Figure 5 is a vertical section on the line 5—5 of Figure 2.

Figure 6 is a fragmentary perspective view of a portion of the tracer valve mechanism.

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Figure 7 is a view in elevation of the tracer valve and bushing with the tracer housing shown in section, and

Figure 8 is a longitudinal sectional view of the tracer bushing with sliding valve removed.

In the drawings, the numeral 10 designates the bed of a lathe, supporting the headstock 13 and tailstock 14 between which are mounted the work piece 15, and having ways 11 for the longitudinally movable tool carriage 12. Transversely movable on the carriage 12 is a cross slide 16 provided with a toolhead 17 suitably supporting tool 18 for operation on the work piece 15. An adjusting screw 19 is provided intervening the cross slide and the toolhead 17 for effecting feeding or other adjusting movement of the tool with respect to the work. For effecting longitudinal movement of the carriage, the bed is provided with a rack 20 engaged by pinion 21 actuable by the reversible hydraulic motor 22 secured to the underside of the carriage.

Mounted on the carriage 12 is a hydraulic cylinder 23 containing a piston 24 provided with piston rod 25 secured to the slide 16. This structure provides a differential area piston structure in that the rod side of the piston possesses a smaller effective area than the free or opposite side of the piston. Consequently, a lesser pressure reacting on the large end of the piston will overcome a higher unit pressure reacting on the rod side or face of the piston, a feature which is advantageously utilized in connection with the specific form of invention here shown.

The bed 10 of the lathe is provided with rearwardly extending brackets 26 adjustably supporting a pattern member 27 for engagement with the tracer finger contact such as the roller 28 carried by the sliding tracer finger 29 mounted in extension 30 of the tracer body or housing 31. This housing is suitably mounted on the cross slide 16 in any conventional manner, the attachment here shown comprising a bolt 32.

Disposed within the tracer body 31 is a valve bushing designated as an entirety by the numeral 33 having a bore 34 to receive the slidable tracer valve 35. Peripherally, the bushing has a fluid tight fit with the interior of the housing and is held against rotation with respect thereto by pin 36. The bushing is turned or reduced in diameter as at the points 37, 38, and 39 and, additionally, transversely slotted to produce the diametrically opposite pairs of fingers or webs 40, 41, and 42 intervening the full diameter portions 43, 44, 45, and 46 of the bushing. The structure thus described therefore provides a complete circumscrib-

ing guide for the sliding valve 35 but interrupted at the areas 37, 38, and 39, the upper and lower interrupted areas being placed in communication with each other as by the arcuate grooves or spaces 47 intervening the reduced portions 40, 41, and 42 of the bushing and the interior of the tracer body 31. If additional space is desired for free annular flow of the hydraulic medium within the valve passages, supplemental aligned grooves 48, 49, and 50 may be formed in the inner face of the tracer body as shown in Figure 2.

The specific structure of the tracer valve 35 is particularly illustrated in Figures 2 and 6. By reference to these figures, it will be seen that the valve is provided at one end with a terminal head 51 engaging the contact 52 on the inner end of the sliding tracer finger 29, being urged outwardly in the housing 31 and against said finger by spring 53 interposed between the head 51 and the shoulder 54 of the bushing 33. The valve is further formed with the cylindrical portions 54', 55, and 56 separated by the reduced portions 57 and 58 which when the valve is in position within the bushing are substantially aligned with the portions 45 and 44 of the bushing.

It will be noted that the inner or right hand shoulder of the portion 56 as shown in Figures 2 and 4 has a pair of relieved or recessed portions formed by the beveled or tapered segmental faces 59 which, when the valve is in the intermediate or neutral position shown in Figure 2, form outwardly tapering throats or throttle portions providing passages intervening the area around the reduced portion 58 of the valve and the circumferential space 37, permitting flow by way of this passage and space 37 to conduit 60, leading to the motor 22. Similarly, the cylindrical portion 55, as at one side adjacent the reduced portion 58, the segmental beveled areas 61 and at its opposite face similar segmental beveled areas 62 disposed in cooperative relation respectively with the edges or shoulders bounding the adjacent bushing portions 44 and 45, while the portion 54' is provided with the segmental beveled faces 63 disposed in opposition to the opposite or forward shouldered face of the bushing portion 45.

The tracer finger 29 is supported for free axial or longitudinal movement in the forward portion of the tracer housing by the balls or antifriction members 64 but is held against rotative movement by the pin or key 65 to preserve proper tracking relation between the roller or contact 28 on the finger and pattern 27. The valve 35, is supported in the bushing for free axial and rotative movements. It is, however, provided on the end opposite to the head 51 with a gear 66 meshing with pinion 67 on shaft 68 which bears the indexing knob 69 provided with an index at 70 to denote the rotational adjusted position of the knob and thus of the valve. A pointer or index finger 71 carried by the extension of the tracer head or housing in which shaft 68 is rotatably mounted, or other suitably designating means, cooperates with the index indicia for determination of the amount of rotative adjustment imparted to the valve 35.

It will be evident that if the several tapered segmental portions of the valve stem are positioned to lie completely within the slotted portions of the bushing and between the webs or fingers 41, there will be minimum restriction as respects fluid flow within the tracer valve structure. However, as the valve 35 is rotatably adjusted to a midposition, for example, as illustrated in Figure 5, a portion of the several tapered portions will lie within and be blanked off by the portions 41, thus throttling or reducing the potential flow by way of the said tapered portions.

For effecting hydraulic operation of the piston and cylinder motor mechanism 23—24 for positioning of cross slide 16 and the actuation of the reversible hydraulic motor 22, there is provided a tank or sump 72 containing suitable hydraulic actuating medium which is drawn from the tank by pump 73 for discharge into the pressure line 74. Excess of fluid over the operating requirements is returned from the pressure side of the pump through variable relief valve 75 to the sump. Pressure line 74 has a branch 76 directly connected to the piston rod end of cylinder 23, continuously reacting when the pump is in operation to urge the tool slide 16 in a direction toward the work piece 15. The main line 74 terminates at the port area 38 between the portions 44 and 45 of the tracer valve bushing, thus introducing pressure into this general area so that in the neutral position of the tracer valve shown, a portion of the introduced pressure will flow by way of 61 around reduced valve portion 58 and spool relief 59 through conduit 60 to operate the motor 22 while at the same time the intermediate rib 77 acts as a flow divider so that a portion of the available fluid may pass by way of 62, the space surrounding 57, port 78 and conduit 79 to the larger piston area or right hand end of cylinder 23, building up a pressure adequate to counterbalance the existing pressure in the smaller area or piston rod end of the cylinder so that the carriage 16 is held in a stationary position. This pressure balancing is made possible by the fact that a portion of the pressure fluid or a partial relief condition is effected by way of the taper valve portion 63 through the area 39 and reservoir conduit 80. In other words, when the tracer finger is deflected or moved either to the left or the right from the effective neutral, an unbalanced pressure condition is created within the cylinder 23 causing a follow-up readjustment of the slide 16 until a hydraulically effective neutral is automatically established. It will be evident to those conversant with the art of hydraulic tracing that any such displacement of tracer valve 35 by finger 29, normally quite minute in amount, while determining the forward or back movement of the slide 16 will at the same time move either the taper throttle 61 toward the shoulder of valve bushing 44 or alternatively the taper portion 59 toward the opposite porting edge of 44, in either event restricting the circuit flow from 74 to 60 and slowing down or stopping the traverse movement during the accelerated in or out movement of the tool and tool slide.

During such sliding movement of the valve, gear 66 will move axially with the valve and relative to gear 67, the amount of possible movement, however, being insufficient to move these gears out of mesh one with the other, and as there is no tendency toward rotation of valve 35 during its axial movement the frictional resistance effected by gear 67 will be insufficient to interfere with proper operation of the valve 35. It is to be noted that, as distinguished from known prior art tracer controlled structures in which it has been necessary to provide special balancing valve, rate valve, and other mechanisms intervening the pump or pressure source and the tracer valve to insure constant pressure conditions for rate operating purposes, that the present invention provides in the tracer control structure itself a first throttling means determining the potential

maximum rate of operation of one of the directional control motors and a second independent throttle means for determining the maximum potential rate of actuation of the motive means for effecting an angularly related directional movement of the machine parts. Additionally, attention is invited to the fact that whereas known prior art structures having tracer valve mechanisms constructed to take care of a certain maximum rate of flow to one or the other of the controlled parts were subject to certain operational difficulties and inaccuracies in control when reduction was made in the amount of available actuating fluid by decrease in its potential rate of supply, that the present invention involves no decrease in the rate of supply or availability of volume of actuating fluid, but independently throttles and controls separately the amount available to the individual motor control valve systems, thus insuring the correct controlled functioning of each of said motors for both fast and slow feed rate operations.

It is well understood in connection with tracer valve mechanisms that the matter of neutral, maximum opening, and intermediate relationships of the control elements of tracing valve mechanisms are determined primarily by the hydraulic reaction through the valve mechanisms rather than by strict consideration of physical relationship of the parts, and that such valves are so constructed that a thousandth of an inch or less of axial movement of a tracer valve will cause appreciable variation in the flow and pressure effects of the hydraulic system controlled thereby. It will, therefore, be understood that the principles of the present invention and the physical relationship of the parts have of necessity been diagrammatically exaggerated for clarity of understanding but that the clearances in actual use will ordinarily be much less than those physically indicated in the drawings. Attention, however, is invited to the fact that the taper angle of the control portions 62 and 63 in the form illustrated is of the nature of about 30 degrees while the taper angle of the faces 59 and 61 have been shown with a steeper taper in the nature of 50 degrees.

In practice, valves of the present invention are constructed as indicated and described so that when the tracer valve 35 is in its hydraulic neutral position as respects in and out or cross feed movement of the tool slide or rotatively adjusted to effect maximum delivery by way of the valve portions 59 and 61 that a maximum traverse or feed rate actuation of the motor 22 will be effected.

This relationship having been determined, 62 and 63 can then be changed or modified to the extent desired, as by varying their angularity, so that when 59 or 61, depending on the direction of axial movement of the valve 35, blocks off or stops flow to motor 22 and the feed of the carriage, these portions will pass enough fluid into or permit its exhaust from the large end of cylinder 23 so that the cross slide 16 will move at its maximum rate.

This rate is preferably, although not necessarily, equivalent to the selected maximum longitudinal rate of movement of the carriage. These maximum potential rates having been determined by proper formation or adjustment of the relationship of the valve configurations, the respective rates can then be correspondingly reduced by rotation of member 35 which serves to throttle down correspondingly the respective flows, thus determining the particular rate to be utilized for longitudinal feed and for cross movement or the

rate in any particular contouring or angularly related direction of movement of tool and work resultant from combined utilization of the two flows. Due, however, to the provision of the rate control means within the tracer valve and individual to the respective motors as distinguished from employment of a rate control valve in the input line determining the general flow only to the tracer mechanism, there is no drop in pressure at the shoulder 77 effective as respects the flow dividing faces 61 and 62, and, therefore, no loss of tracer valve sensitivity or accuracy of control attendant upon appreciable reduction in feed rates employed.

From the foregoing description it will be evident that the spaces 48, 49, and 50 in communication with and forming continuations of the respective conduits 60, 74, and 80 form the terminal ports for these conduits, each of which ports is individually bounded by a pair of walls formed by radial planes intersecting the axis of the valve and the bore in which the valve slides to provide the arcuate or peripheral edges or shoulders bounding the bore for cooperation as respects each port with the shoulders on the valve member.

It will also be evident that the major measurement of each of the spools on the valve member is such as to physically overlap its associated port but that the double taper on the central or intermediate valve spool, as respects the relieved or recessed portion of this valve spool and the relieved or tapered portions of the other spools facing the intermediate spool provide arcuate or peripheral shoulders on the valve spools which cooperate with the shoulders of the port areas. It will further be evident that these valve shoulders, whether of physically overlap or underlap characteristic, are so arranged as to have a hydraulic underlap so that there may be flow from one port to another by way of the recessed or reduced intermediate portions of the valve while the cooperative relation of these annular or peripheral shoulders provide variable hydraulic resistances depending upon axial movement of the valve to control the proportioning of the flow from the port area 49 to the port areas 48 and 50. Also, it will be evident that the central or intermediate spool 55 is positionable either to divide the flow or completely to shut off the flow in one direction or the other, while the end spools 54' and 56 in this respect are equally inversely effective to provide a resistance cutting down or shutting off flow into the port areas 50 and 48. At the same time the bounding shoulders of the several relieved portions on the valve member 35, such as 81—82—83—84, which are disposed in axial planes cooperative with the axial plane bounding shoulders 85—86—87 of the webs 40—41—42 variably limit or restrict the effective pressure or fluid transmitting areas or resistances under control of the first set of shoulders, dependent upon the relative rotative adjustment of the valve 35 and its support. This latter variation is, of course, dependent upon the particular positional relationship of the various relieved portions such as 59 of the valve spools as respects the positional location of the corresponding axial web shoulders. Consequently, different relationships may be established and different types of variation effected upon rotation of the valve, dependent upon such structural relationships, although in the present instance the parts have been shown so dimensionally constructed and arranged that axial movement produces inverse variations in resistance effects as respects adjacent arcuate

port shoulders, while rotative adjustment effects corresponding modifications or throttlings of the effective resistance areas.

It will be understood that while for simplicity of manufacture and assembly the tracer body or housing has been shown as a two-part member embodying the outer shell or housing 31 with a contained bushing 33, the parts being tightly fitted and pinned together, that when so assembled these constitute a unitary or one piece structure, the prime essence of the invention therefore being the configuration and relationship between the outer member having the described shoulders and ports and the sliding inner member or valve with its cooperating configurations.

The tracer valve structure shown in Figure 2 is indicated in what may be termed its static position, that is, a position in which balanced pressure conditions lock the piston 24 and thus the tool slide 16 against in and out movement, and the entire flow of motion producing fluid is to the motor 22 to effect traverse of the carriage. This is the condition existing when the movable valve member is held by the tracer finger in its neutral position as when following a straight or plane surface. In the relationship here illustrated it will be noted that the inner valve member is provided with the grooved or relieved portions at 57 and 58 disposed in staggered relation with respect to the cooperating relieved or port areas such as 37, 38, and 39 of the bushing, thus providing by means of these staggered relieved portions fluid receiving spaces with intervening shoulders or cooperating portions providing resistance to flow in a tortuous path of the hydraulic actuating medium from inlet to outlet by way of such resistances. In this relationship the relative rotation of the inner and outer valve elements serves to vary the effective area of the resistances and thus the static flow conditions in the absence of tracer finger controlled relative movement of the parts in an axial direction and establish the maximum flow available.

Additionally, however, when the valve is in a live or dynamic condition caused by tracer finger determined relative axial adjustment or variance in the position of the parts, the arcuate cooperating shoulders in their varying positional arrangements as effected by deviations of the controlling pattern from a straight line traverse path cause automatic variations in the dynamic flow resistances for determination of the relationship of the carriage and slide movements.

What is claimed is:

1. A tracer valve structure including a supporting housing having a central bore formed with a plurality of internal grooves providing axially spaced annular areas circumscribing the bore and radially extending surfaces bounding said areas to provide throttling shoulders, said bore having additional axiallly extending portions intervening said surfaces to provide additional throttling shoulders, and a control valve slidably mounted within the bore, said control valve having a flow dividing portion positionable intermediate a pair of said radially extending bounding surfaces having segmental lateral shoulders disposable in cooperative relation with the radially extending surfaces and axially extending shoulder portions for cooperation with the axially extending throttling shoulders of the bore, whereby relative axial movement of the housing and valve will vary the proportional flow by way of the radial shoulders and relative rotation will vary the volumetric flow past the shoulders for any relative axial positioning.

2. A tracer valve structure including a supporting housing having a central bore formed with a plurality of internal grooves providing axially spaced annular areas circumscribing the bore and radially extending surfaces bounding said areas to provide throttling shoulders, said bore having additional axially extending portions intervening said surfaces to provide additional throttling shoulders, and a control valve slidably mounted within the bore, said control valve having a flow dividing portion positionable intermediate a pair of said radially extending bounding surfaces having segmental lateral shoulders disposable in cooperative relation with the radially extending surfaces and axially extending shoulder portions for cooperation with the axially extending throttling shoulders of the bore, whereby relative axial movement of the housing and valve will vary the proportional flow by way of the radial shoulders and relative rotation will vary the volumetric flow past the shoulders for any relative axial positioning, the supporting housing having additional similarly arranged shouldered portions axially spaced from the first set of shoulders and the valve having additional axially spaced corresponding shoulders for cooperation with the additional shoulders of the supporting housing and connected with the first shouldered portion of the valve by reduced portions providing circumscribing passages, the additional radially shouldered portions of the valve being disposed in opposed relation to the adjacent central radial shoulders of the valve and the axially extending shoulders being disposed in corresponding relation to the axially disposed shoulders on the central portion of the valve whereby relative axial movement of the housing and valve will inversely vary the resistance effects of the opposed radial sets of shoulders while rotation of the valve will correspondingly vary the resistance effects of the axially extending shoulder portions of the valve.

3. A tracer valve structure including a supporting housing having a central bore formed with a plurality of internal grooves providing axially spaced annular areas circumscribing the bore and radially extending surfaces bounding said areas to provide throttling shoulders, said bore having additional axially extending portions intervening said surfaces to provide additional throttling shoulders, a control valve slidably mounted within the bore, said control valve having a flow dividing portion positionable intermediate a pair of said radially extending bounding surfaces having segmental lateral shoulders disposable in cooperative relation with the radially extending surfaces and axially extending shoulder portions for cooperation with the axially extending throttling shoulders of the bore, whereby relative axial movement of the housing and valve will vary the proportional flow by way of the radial shoulders and relative rotation will vary the volumetric flow past the shoulders for any relative axial positioning, the supporting housing having additional similarly arranged shouldered portions axially spaced from the first set of shoulders and the valve having additional axially spaced corresponding shoulders for cooperation with the additional shoulders of the supporting housing and connected with the first shouldered portion of the valve by reduced portions providing circumscribing passages, the additional radially shouldered portions of the valve being disposed in opposed

relation to the adjacent central radial shoulders of the valve and the axially extending shoulders being disposed in corresponding relation to the axially disposed shoulders on the central portion of the valve whereby relative axial movement of the housing and valve will inversely vary the resistance effects of the opposed radial sets of shoulders while rotation of the valve will correspondingly vary the resistance effects of the axially extending shoulder portions of the valve, means for effecting a resilient axial urge of the valve in one direction, and a tracer actuable finger slidable within the supporting housing and opposing the resilient actuation of the valve to dictate the axial position thereof.

4. A tracer valve structure including a supporting housing having a central bore formed with a plurality of internal grooves providing axially spaced annular areas circumscribing the bore and radially extending surfaces bounding said areas to provide throttling shoulders, said bore having additional axially extending portions intervening said surfaces to provide additional throttling shoulders, a control valve slidably mounted within the bore, said control valve having a flow dividing portion positionable intermediate a pair of said radially extending bounding surfaces having segmental lateral shoulders disposable in cooperative relation with the radially extending surfaces and axially extending shoulder portions for cooperation with the axially extending throttling shoulders of the bore, whereby relative axial movement of the housing and valve will vary the proportional flow by way of the radial shoulders and relative rotation will vary the volumetric flow past the shoulders for any relative axial positioning, the supporting housing having additional similarly arranged shouldered portions axially spaced from the first set of shoulders and the valve having additional axially spaced corresponding shoulders for cooperation with the additional shoulders of the supporting housing and connected with the first shouldered portion of the valve by reduced portions providing circumscribing passages, the additional radially shouldered portions of the valve being disposed in opposed relation to the adjacent central radial shoulders of the valve and the axially extending shoulders being disposed in corresponding relation to the axially disposed shoulders on the central portion of the valve whereby relative axial movement of the housing and valve will inversely vary the resistance effects of the opposed radial sets of shoulders while rotation of the valve will correspondingly vary the resistance effects of the axially extending shoulder portions of the valve, means for effecting a resilient axial urge of the valve in one direction, a tracer actuable finger slidable within the supporting housing and opposing the resilient actuation of the valve to dictate the axial position thereof, a rotary adjuster for the valve carried by the housing, and a positive drive axially sliding connection between the adjuster and the valve for effecting rotary adjustment of the valve while permitting independent axial movement thereof.

5. A tracer valve structure including a supporting housing, a valve bushing contained within the housing having a central bore and having formed therein a plurality of transverse axially spaced slots providing segmental spaces each bounded by a first set of shoulders, each formed by the intersection of a plane normal to its axis with the bushing and a second series of shoulders formed by the intersection of a plane parallel with its axis with the bushing, input and output distribution conduits communicating with respective slotted areas of the bushing, and a control valve member slidable and rotatably mounted within the bushing and formed with a plurality of axially spaced segmental tapered portions providing as to each segment a peripheral shoulder for cooperation with one of the radial plane shoulders of the slotted bushing and additional bounding end shoulders for cooperation with the axial plane shoulders of the bushing, the spacing between the peripheral shoulders on the valve being greater than the spacing between adjacent radial plane shoulders of the bushing and the tapers of the tapered portions extending in the direction of the cooperating shoulders on the bushing, a tracer finger carried by the housing and disposed in cooperative engagement with the valve for dictating the axial positioning thereof to vary the relationship between the radial plane shoulders and the valve to vary the resistance effecting spacing of said shoulders, and additional means for rotating the valve to vary the relationship between the axial plane shoulders of the valve and the bushing to vary the effective arcuate length of the radial plane shoulders.

6. A tracer control valve structure for machine tools or the like including a supporting housing, bushing means within the housing having a central tracer valve receiving bore and a plurality of axially spaced internal annular spaces communicating with the bore connected by intermediate shouldered portions, the bushing having arcuate shoulder portions bounding the annular areas, and a tracer valve mounted in the bore of the bushing for rotative and axial sliding movements relative thereto, said valve having central and terminal spool portions spaced in correspondence with the spacing intervening the annular areas of the bushing and reduced passage providing portions intervening said spools, the central of said spools having segmental relieved portions on both faces thereof providing circumferentially disposed shoulders for cooperation with the internal shoulders of the bushing adjacent the annular recesses and having additional axially extending shoulders for cooperation with the axially extending shoulders on the connecting portions of the bushing intermediate said spaces, and the terminal spools of the valve having corresponding segmental relieved portions providing peripheral shoulders for cooperation with spaced annular shoulders of the bushing and axially extending shoulders for cooperation with the axially extending shoulders of the connecting portions of the bushing, means for rotating the valve with respect to the bushing to vary the length of effective resistance area between the axially extending shoulders of the bushing and valve, and additional means for axially relatively shifting the bushing and valve inversely to vary the resistance effects of the respective cooperating peripheral shoulders of the valve spools and the bushing.

7. A hydraulic tracer control mechanism for machine tools, said control mechanism including a tracer housing having a pressure inlet port, a first axially spaced outlet port, a second outlet port, and a third outlet port axially remote as respects the inlet and second outlet port, said ports having bounding faces providing resistance shoulders, the housing member having a central bore intersecting said shoulders, and a control

valve mounted within said bore having a central spool portion overlying the inlet port and terminal spool portions overlying the remote outlet ports, the spool overlying the inlet port having arcuate relieved portions on its opposite faces providing hydraulically underlapped shoulders positionable intermediate the bounding shoulders of the inlet port, and the other spools each having an arcuate relieved portion opposing the central spool and providing a resistance shoulder for cooperation with an outlet port shoulder, the spacings between the opposing spool shoulders being greater than the spacing between their confronting port shoulders whereby relative shifting of the spools and ports will increase the hydraulic resistance effect between one set of the shoulders while decreasing said effect as respects the confronting set of shoulders, radially extending bounding shoulders determining the arcuate extent of the ports, shoulders on the spools bounding the arcuate relieved portions of the spools, and means to effect relative adjustment of the last-mentioned shoulders of the ports and spools to vary the arcuately effective length of the relieved portions of the spools.

8. A hydraulic tracer control mechanism for machine tools, said control mechanism including a tracer housing having a pressure inlet port, a first axially spaced outlet port, a second outlet port, and a third outlet port axially remote as respects the inlet and second outlet port, said ports having bounding faces providing resistance shoulders, the housing member having a central bore intersecting said shoulders, and a control valve mounted within said bore having a central spool portion overlying the inlet port and terminal spool portions overlying the remote outlet ports, the spool overlying the inlet port having arcuate relieved portions on its opposite faces providing hydraulically underlapped shoulders positionable intermediate the bounding shoulders of the inlet port, and the other spools each having an arcuate relieved portion opposing the central spool and providing a resistance shoulder for cooperation with an outlet port shoulder, the spacings between the opposing spool shoulders being greater than the spacing between their confronting port shoulders whereby relative shifting of the spools and ports will increase the hydraulic resistance effect between one set of the shoulders while decreasing said effect as respects the confronting set of shoulders, radially extending bounding shoulders determining the arcuate extent of the ports, shoulders on the spools bounding the arcuate relieved portions of the spools, and means to effect relative adjustment of the last-mentioned shoulders of the ports and spools to vary the arcuately effective length of the releived portions of the spools, the valve portions intermediate the spools having reduced areas providing passages interconnecting the respective opposed relieved faces of the spools.

9. A tracer valve mechanism for control of the relative movements of a plurality of reproducing machine tool slides, said valve mechanism including a pair of telescoping valve elements, a pattern actuable tracer finger carried by one of said valve elements and movable relative thereto for reaction on the other of said valve elements to control the relative positions of the valve elements, one of said valve elements having formed therein an inlet port and pressure inlet areas and spaced outlet ports and pressure outlet areas, and the pair of valve elements having relieved portions with bounding shoulders forming resistance areas, said relieved portions and resistance areas providing tortuous passages from inlet to outlet ports by way of the shoulders and relieved portions, whereby relative tracer finger determined adjustment of the parts will vary the resistance effects of the areas between said shoulders, and means to vary the extent of such areas available for tracer controlled flow within the valve.

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