

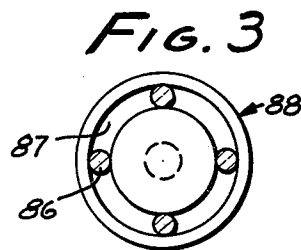
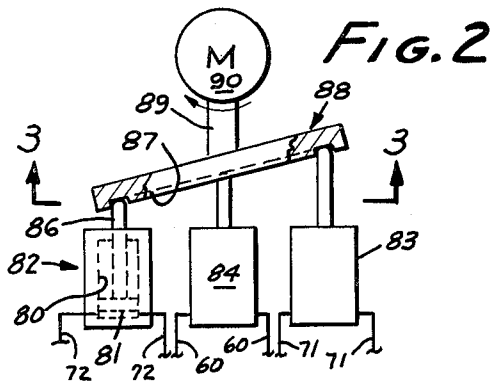
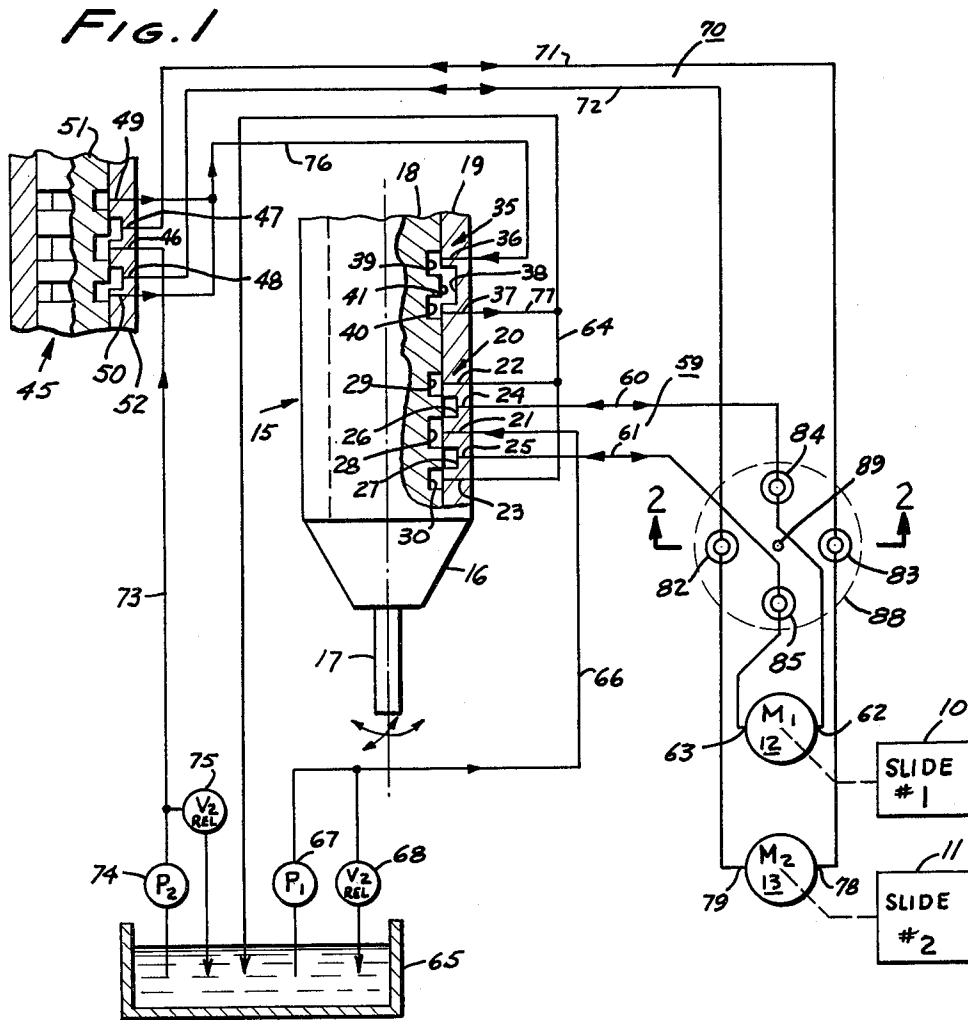
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SIGNAL INTENSIFIER

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1

3,136,127

SIGNAL INTENSIFIER

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This invention relates to machine tools, and, in particular, to a signal intensifier for power circuits in tracer-controlled machine tools.

In tracer valve-controlled machine tools, it is customary for the rate of slide movement and usually also the direction of slide movement to be determined by small adjustments within tracer valves which ordinarily are of the spool valve type. The spool valve regulates the rate and disposition of the fluid flow. Such valves and their associated circuits are well known. Occasionally, difficulty is encountered in the fluid motors under tracer control at very slow speeds, particularly when the motors are of the vane type. For example, it is frequently found in a circuit whose normal pressure level is of the order of 300 to 400 lbs. per square inch, that before the motor can cause the slide to just move, a pressure drop of nearly 100 p.s.i. must be built up across the motor. This is undesirable, because in order to build up this pressure differential, the tracer valve must be opened more than it ought to be by overdeflection of the stylus, or the reaction is too sluggish. These and other complications could be avoided if the motor were responsive to lower pressure differentials in moving the slide. It is desirable in many installations to utilize rotary motors, but in comparison to piston-cylinder motors (wherein such a large pressure differential need not be built up), the fluid motors suffer by comparison and have not been used in many applications where their use is otherwise indicated.

It is an object of this invention to provide signal intensifier means which render a vane type motor responsive to differential pressures of the same order of magnitude as those which would move a comparable piston-cylinder motor, thereby enabling vane type motors to be used successfully in applications where heretofore they have not been entirely satisfactory. It has been found that this signal intensifier means also improves the performance of piston-cylinder type motors so that the invention is useful for both types, but the advantages are much more pronounced with vane type motors.

This invention is used in combination with a machine tool slide power circuit of the type which includes a motor adapted to be run by liquid under pressure, the motor including a pair of motor ports for receiving and exhausting said liquid, and being adapted to drive the slide.

A fluid circuit leg is connected to each of the motor ports, and at least one of the circuit legs includes liquid-flow control means which form a portion of the tracer valve. Conduity for conveying this liquid is included in each circuit leg to convey the liquid from a pressurized source through the leg and back to reservoir. Pressure modulating means is provided in that portion of each of the circuit legs which is fluidly contiguous to the motor ports, the pressure modulating means being adapted to modulate the pressures in the respective legs by raising and lowering them in increments which are less than the normal pressures in the respective legs. The increments are opposite between the legs, whereby when the modulating action raises the pressure in one leg, it lowers the pressure in the other.

According to a preferred but optional feature of the invention, the pressure modulating means comprises a cylinder in each line, each cylinder having a plunger, and

2

actuator means for alternately pressing the plungers to increase the pressure in the respective cylinder and leg.

According to still another preferred but optional feature of the invention, a pair of fluid circuits are provided, one for each of two motors, one fluid circuit including a two-way metering valve for establishing the rate of speed of operation of one of the motors and the other fluid circuit including a four-way valve for establishing the rate and direction of flow of pressurized fluid to the second of the motors, the two valves being controlled by a common tracer stylus. Pressure modulating means is provided in each of the fluid circuits as aforesaid.

The above and other features of this invention will be fully understood from the following detailed description and the accompanying drawings in which:

FIG. 1 is a circuit drawing showing certain elements in schematic cutaway cross-sections;

FIG. 2 is a cross-section taken at line 2—2 of FIG. 1; and

FIG. 3 is a cross-section taken at line 3—3 of FIG. 2.

The presently preferred embodiment of the invention is shown in FIG. 1. It has for its purpose the powering of a first slide 10 and a second slide 11 of a machine tool which might, for example, be the slides of a lathe or the slides supporting the worktable of a milling machine. First and second motors 12, 13 are connected to the slides to power the same. The motors may be of any desired type. For example, if this were a contour-copying milling machine and the first slide were used for the knee, it would be customary for the first motor to be a piston-cylinder motor, while the second motor would be a rotor vane type motor turning a lead screw. Both motors might, for example, be feeding horizontal axes under the control of a tracer valve such as that shown in Rosebrook Patent No. 2,753,145. Alternatively, the invention also comprehends the use of two piston-cylinder type motors.

This invention is most effective in improving the operation of vane type motors and makes them comparable to piston-cylinder type motors, particularly at low speeds of operation, where otherwise vane type motors are highly inefficient largely due to the internal friction at their vanes. However, some improvement is observed also in piston-cylinder motors, and this improvement in itself is enough to justify the use of the invention when they are used even though it is not as dramatic an improvement as when vane type motors are used.

The invention is shown being utilized with a tracer valve 15 of the type shown in the presently co-pending Paul J. Weaver application, Serial No. 748,426, filed July 14, 1958, now Patent No. 3,055,393 issued September 25, 1962 entitled "Pattern Controlled Machine Tool," which is assigned to the same assignee as the instant invention. This tracer valve includes a body 16 that supports a universally pivoted stylus 17, the deflection of which adjust the position of a spool 18 in a sleeve 19.

The body of the tracer valve is customarily mounted to the base of a milling machine and the stylus moves along the contour of a pattern or template while the motors serve also to move the workpiece relative to the cutting tool. In a lathe, the motors serve to move the cutting tool relative to the workpiece. The details of the mountings of these elements are conventional and form no part of the invention. For further details of this type, reference may be had to the aforesaid Weaver application.

The tracer valve includes a four-way valve 20 which has the property of being able to determine the rate and direction of flow of fluid therethrough. A pressure inlet port 21, two exhaust ports 22, 23, and two motor supply ports 24, 25 pass through the sleeve. Motor supply ports 24, 25, respectively, connect with motor supply grooves 26, 27 inside the sleeve. The spool makes a slid-

ing fluid-sealing fit with the inside of the sleeve. It carries a pressure groove 28 and a pair of exhaust grooves 29, 30.

The four-way valve is shown in its neutral position in FIG. 1 at which condition there is no flow through the valve. Were the spool lowered relative to the sleeve, pressure at port 21 could flow from pressure groove 28 to motor supply groove 27 and out motor supply port 25. At the same time, fluid could flow in through motor supply port 24, through motor supply groove 26, through exhaust groove 29, and out exhaust port 22.

Were the spool raised instead, the direction of flow through the motor supply ports would be reversed, pressure being supplied to motor supply port 24 instead of 25, and pressure returning to exhaust from motor supply port 25 and exhausting through exhaust port 23.

The rate of flow is determined by the amount of displacement of the spool within the sleeve from the illustrated neutral position, and the direction of flow by which way the spool is displaced from the illustrated neutral position. This is the common operation of four-way valves as used in tracer valves. Additional details will be found in Rosebrook Patent No. 2,753,145, issued July 3, 1956.

The tracer valve also includes a two-way metering valve 35. The two-way metering valve includes an inlet port 36 and an outlet port 37. A bypass groove 38 is formed inside the wall of the sleeve. A pair of grooves 39, 40 bound a central land 41 of axially lesser length than that of the bypass groove. The two valves use a common sleeve, spool, and stylus. In the neutral position shown in FIG. 1, fluid can flow from the inlet port to the outlet port through the grooves. When the spool is lowered in the sleeve, the lower edge of land 41 approaches the lower boundary of the bypass groove and meters the flow, shutting it off entirely should the spool move down until the land overlaps the lower end of bypass groove 38.

Should the spool be moved upwardly in FIG. 1, the upper edge of land 41 will meter flow between it and the upper edge of bypass groove 38, shutting it off should the spool be deflected far enough that the land overlaps the upper edge of the bypass groove. This valve is therefore a two-way metering valve in the sense that it exerts a metering action whenever the spool is moved either of two ways inside the sleeve.

A direction selector valve 45, which is preferably a four-way valve as illustrated, is similar to four-way valve 20, having similar internal grooves which will not be described again. It includes a pressure inlet port 46, a pair of motor supply ports 47, 48 and a pair of exhaust ports 49, 50. This valve is not intended for metering purposes but only for selector purposes.

Moving spool 51 downwardly relative to sleeve 52 will connect the pressure port to motor supply port 48 and motor supply port 47 to exhaust port 49. Raising the spool relative to the sleeve in FIG. 1 will connect motor supply port 47 to pressure inlet port 46, and motor supply port 48 to exhaust port 50. It will thereby be seen that this constitutes a selector valve determining which of the motor supply ports will be connected to the pressure inlet port and which will be connected to the exhaust ports.

The fluid circuitry to the motors will now be described. A first fluid circuit 59 includes conduits 60, 61, which are connected to motor ports 62, 63 of the first motor respectively. At their other end, they are respectively connected to motor supply ports 24, 25 of four-way valve 20.

The first fluid circuit also includes exhaust conduit 64 which connects to exhaust ports 22 and 23 and discharges to reservoir 65. The first fluid circuit additionally includes conduit 66, which connects pressure inlet port 21 to a first pump 67, the pump withdrawing fluid from the reservoir and placing it under pressure in conduit 66. A conventional relief valve 68 in conduit 66 between the tracer valve and the pump tends to keep the pressure in conduit 66 at some normal supply pressure.

Exhaust and pressure conduits 64 and 66 form portions of the first fluid circuit. The first fluid circuit has a pair of legs extending from the motor. The first leg includes conduit 60, and the second leg includes conduit 61. The four-way valve 20 determines which of the pressure or exhaust conduits forms the remainder of the respective first and second legs, but except in the null position shown where there is no flow through the circuit, and in effect no operative leg, each leg has either a pressure or an exhaust connection to complete it.

The second fluid circuit 70 includes conduits 71, 72, which are respectively connected to motor supply ports 47, 48 of the direction selector valve 45.

Pressure conduit 73 connects pressure inlet port 46 to a second pump 74 which withdraws fluid from the reservoir and supplies it under pressure to conduit 73. A conventional relief valve 75 is disposed in conduit 73 between the pump and the pressure inlet port 46, which tends to maintain pressure in conduit 73 at some normal level.

Both exhaust ports 49 and 50 are connected by exhaust conduit 76 to inlet port 36 of the two-way metering valve 35. The outlet port of the two-way metering valve is connected by conduit 77 to reservoir.

The second fluid circuit has two legs with reference to the motor ports of the second motor, conduits 71 and 72 being respectively connected to motor ports 78, 79 of the second motor. These legs respectively include either the pressure circuit including conduit 73, or the exhaust circuit including conduits 76 and 77, the choice depending on the setting of the direction selector valve 45.

The aforesaid circuitry is essentially common to tracer systems of the type shown in the aforesaid Paul J. Weaver application and is ample to select the direction of coordinated feed under the control of the two-way metering valve and powered by the second motor, with the vertical control exerted by the four-way valve and powered by the first motor.

As heretofore stated, simply to keep the slide moving at a minimum rate has required an excessive pressure drop across motors, particularly vane motors, which is inherently unsatisfactory. In order to overcome this, the invention provides pressure modulating means to intensify the effect of the tracer valve's signals and thereby render the motors more responsive thereto. These means are adapted to raise and lower the pressure in their respective legs by some increment of pressure which is less than the normal pressure level. In a system operating at a normal pressure between 300-400 p.s.i., the increment is preferably about 20 p.s.i. The presently preferred embodiment of pressure modulating means is shown in FIGS. 2 and 3. A typical device includes a cylinder 80 with a plunger 81 therein. The cylinder is connected in the respective conduit, pressure modulating means 82, 83, 84, 85 being respectively connected in conduits 72, 71, 60 and 61.

Means 82 is shown in detail in FIG. 2. Its plunger is connected to a rod 86 which projects above the cylinder and is abutted by a cam track 87 on the lower surface of a wobble plate 88. The wobble plate is mounted to a rotary shaft 89, which is turned by a motor 90. As the wobble plate rotates around the shaft, it sequentially presses down the rods so as to place the fluid in the cylinders, and thereby the respective legs under an increased increment of pressure. As the plate continues to turn, it releases the pressure increment and, in backing off, slightly increases the volume of the leg, thereby permitting the pressure to drop by an increment. In practical operation, as the pressure increases, it works against the respective relief valve in one leg and against the controlling edge in the two-way metering valve or the four-way valve in the other leg.

As can best be seen in FIGS. 1 and 2, the individual pressure modulating means is disposed out-of-phase relative to the wobble plate so that as one increment is positive, the other is negative in a sort of push-pull relationship. In the preferred embodiment, when this feature is

5

being supplied to both circuits, they are provided in a square pattern so that a single wobble plate can attend to all.

The pressure modulating means is fluidly contiguous to the respective motor port, meaning that there are no restrictions between them.

In a system operating at between 300 and 400 p.s.i., it has been found satisfactory to use a modulating means wherein the cylinder has a $\frac{3}{4}$ " diameter bore with the total stroke of the plunger being 0.030 inch, operating at a speed of about 1700 cycles per minute.

The results of this device have been most surprising. For example, utilizing fluid motors which heretofore have required a 100 p.s.i. differential between conduits 71 and 72 to operate a vane type motor such as motor 13, utilizing the pressure modulating means has caused the required differential pressure requirement to drop to 30 p.s.i. at which time the motor will start to move its respective slide. If motor 12 is a piston-cylinder type motor, modulating means 84 and 85 need not be provided. However, some improvement is found even in piston-cylinder motors and because the device is so simple, it is believed that even the lesser benefits make it worthwhile to include these latter two modulating means. However, utilizing the pressure modulating means with vane type motors renders them responsive to differential pressures of the same order of magnitude as those of cylinder motors and greatly improves the performance of machinery. It is theorized that this result is attained by causing lubrication to flow between the wall of the chamber of the vane type motor and the vane, thereby keeping it lubricated. However, whatever the cause, the results speak for themselves.

The essence of this invention resides in the use of pressure modulation means of the class shown in fluid contiguity with a motor under tracer control. The effectiveness of the circuitry shown in FIG. 1 is much improved by the invention, and constitutes one embodiment of its use. However, other tracer valves could also be used, which control movement along one, two or even three axes. For example, a tracer valve utilizing only a four-way valve could be used. This would be a device including only the first fluid circuit.

Alternatively, the tracer valve of Rosebrook Patent No. 2,753,145, issued July 3, 1956, could be used, placing the pressure modulation means in the conduits connected to the motor ports contiguous to the motors.

Also, this could be extended to three-axis tracer valves such as that shown in Rosebrook Patent No. 2,835,466, issued May 20, 1958, by placing the pressure modulation means in the conduits connected to the motor ports contiguous to the motors.

This invention is not to be limited to the embodiment shown in the drawings and described in the description which is given by way of illustration and not of limitation, but only in accordance with the scope of the appended claims.

I claim:

1. In a machine tool slide power circuit: a motor adapted to be run by liquid under pressure, said motor including a pair of motor ports for receiving and exhausting said liquid; a fluid circuit leg connected to each of said motor ports, at least one of said circuit legs including liquid-flow control means which form a portion of a tracer valve, conduitry for conveying said liquid, a source of pressurized liquid, and a reservoir for liquid; and pressure modulating means in that portion of each of said circuit legs which is fluidly contiguous to the motor ports, said pressure modulating means being adapted to modulate the pressures by raising and lowering said pressures in the respective legs by increments less than the normal pressures in said legs, the increments being opposite between the legs, whereby when the modulating action raises the pressure in one leg, it lowers the pressure in the other leg.

2. A combination according to claim 1 in which the

6

power source is a pump, and in which a relief valve fluidly adjacent to said pump tends to maintain pressure in one of said legs at a normal level.

3. A combination according to claim 1 in which the motor is a vane type motor.

4. A combination according to claim 1 in which each pressure modulating means comprises a cylinder and a plunger in the cylinder, and actuator means for alternately pressing said plungers to increase the pressure in the respective cylinder and leg, one such cylinder being connected in each leg.

5. A combination according to claim 4 in which the actuator means comprises a wobble plate.

6. In a machine tool slide power circuit: a pair of motors, each adapted to power an individual machine tool slide and to be run by liquid under pressure, each motor including a pair of motor ports for receiving and exhausting said liquid; a first and a second fluid circuit, one for each motor, each fluid circuit including two circuit legs, one being connected to each motor port of the respective motor, one circuit leg of each fluid circuit including liquid-flow control means, both liquid-flow control means forming a portion of a single tracer valve of the class in which a stylus responsive to a pattern contour simultaneously adjusts the condition of both of said liquid-flow control means, conduitry for conveying said liquid, a source of pressurized liquid, and a reservoir for liquid; and pressure modulating means in that portion of each of said circuit legs which is fluidly contiguous to the respective motor port, said pressure modulating means being adapted to modulate the pressure in each leg by raising and lowering the same by increments less than the normal pressure in said leg, the increments in the legs of each fluid circuit being opposite between the legs, whereby when the modulating action raises the pressure in one leg, it lowers the pressure in the other leg of the same fluid circuit.

7. A combination according to claim 6 in which the power source is a pump, and in which a relief valve fluidly adjacent to said pump tends to maintain pressure in one leg of each fluid circuit at a normal level.

8. A combination according to claim 6 in which one of the motors is a vane type motor.

9. A combination according to claim 6 in which each pressure modulating means comprises a cylinder connected in each of said legs, a plunger in each of said cylinders, and actuator means for sequentially pressing said plungers to increase the pressure in the respective cylinders and legs.

10. A combination according to claim 9 in which the actuator means comprises a wobble plate, the actuator means respective to each fluid circuit being oppositely disposed relative to said wobble plate.

11. A combination according to claim 7 in which the liquid-flow control means in the first of said fluid circuits is a four-way valve connected to both legs and adapted to select the rate and direction of liquid flow in the legs of said first fluid circuit, the pressure source and reservoir being connected to said four-way type valve, and in which the liquid-flow control means in the second of said fluid circuits is a two-way metering valve connected to the leg which receives exhaust fluid from the second motor.

12. A combination according to claim 11 in which both legs of the second fluid circuit are connected to a direction selector valve, said direction selector valve having an inlet connected to the pressure source and an outlet connected to the inlet of said metering valve, the outlet of said metering valve being connected to the reservoir, the direction selector valve being adapted to connect a selected one of the legs of the second fluid circuit to the pressure source, and the other to the inlet of the metering valve.

13. A combination according to claim 12 in which one of the motors is a vane type motor.

14. A combination according to claim 12 in which each pressure modulating means comprises a cylinder, a plunger in the cylinder, and actuator means for sequentially pressing said plungers to increase the pressure in the respective cylinders and legs.

15. A combination according to claim 14 in which the actuator means comprises a wobble plate, the actuator

means respective to each fluid circuit being oppositely disposed relative to said wobble plate.

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5

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