United States Patent

[11] 3,593,092

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[54] MULTIPLE OUTPUT MULTIPLEX ACTUATOR
11 Claims, 6 Drawing Figs.

[52] U.S. Cl. 318/564, 318/8, 318/574
[51] Int. Cl. G05b 9/02
[50] Field of Search 318/8, 13, 564, 654, 23.5, 574

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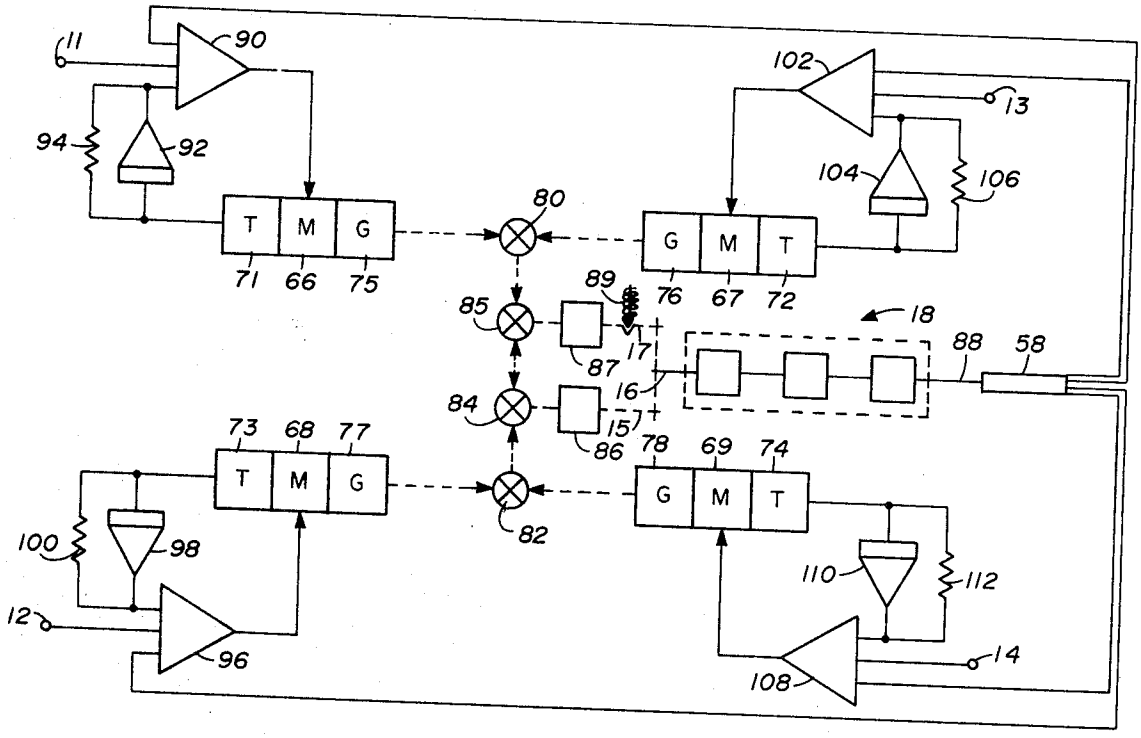
ABSTRACT: Four servomotors are coupled together in a velocity-summing arrangement to produce two output motions. These two output motions are combined in a linkage arrangement that results in a single output. Two of the four servomotors are coupled together through a differential gearset that has a single rotary output and the second servomotor pair is also coupled together through a differential gearset that produces a single rotary output. These two rotary outputs are in turn coupled through two additional gearsets that each have a single rotary output. Each of these two additional gearsets has one input connected to one of the motor pair outputs and a second input in a common coupling arrangement. The rotary output of each of the second and third gearsets may be converted into a linear motion by means of a rotary-to-linear motion transducer, or used as a rotary motion. Operation of one of the rotary-to-linear motion transducers is restrained below a preestablished force level. Each of the four servomotors is controlled individually by a separate generated control signal in a system that includes a tachometer for generating velocity feedback signals and a linear voltage differential transformer for generating position feedback signals.



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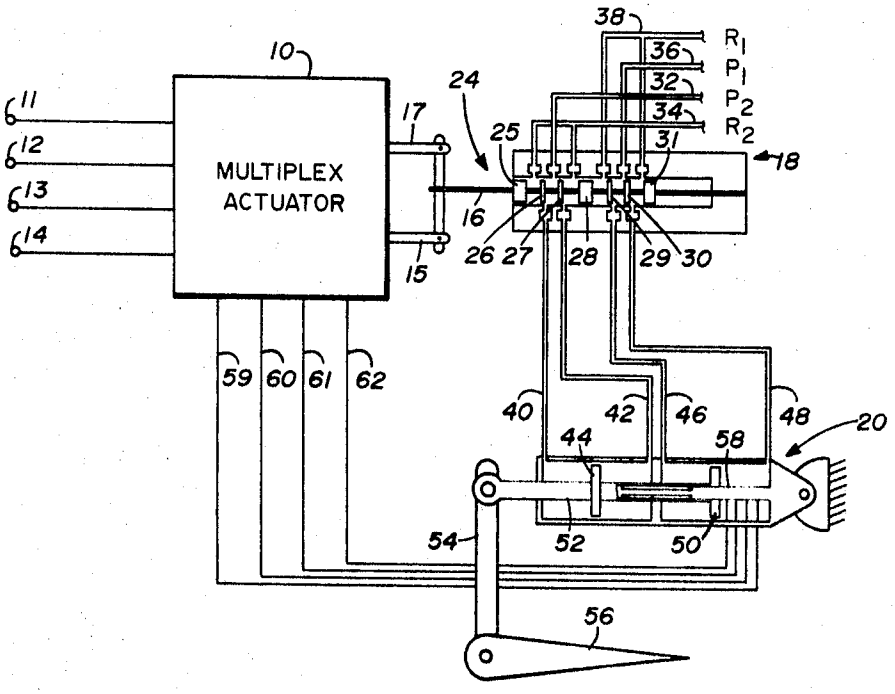

FIG. 1

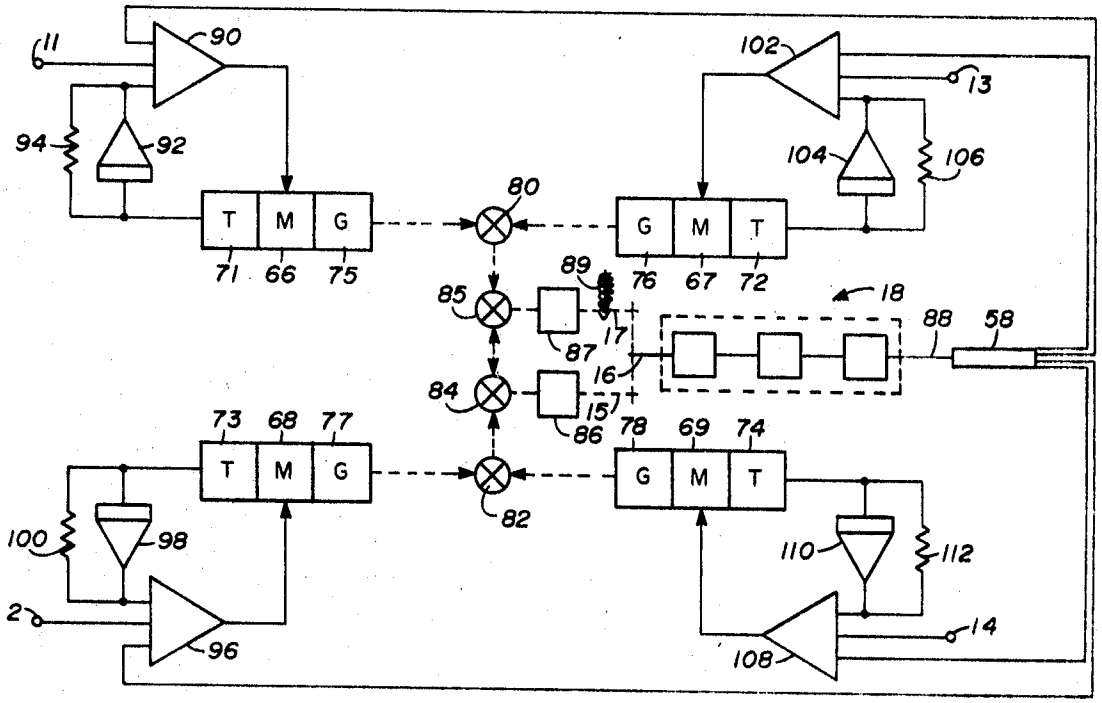

FIG. 2

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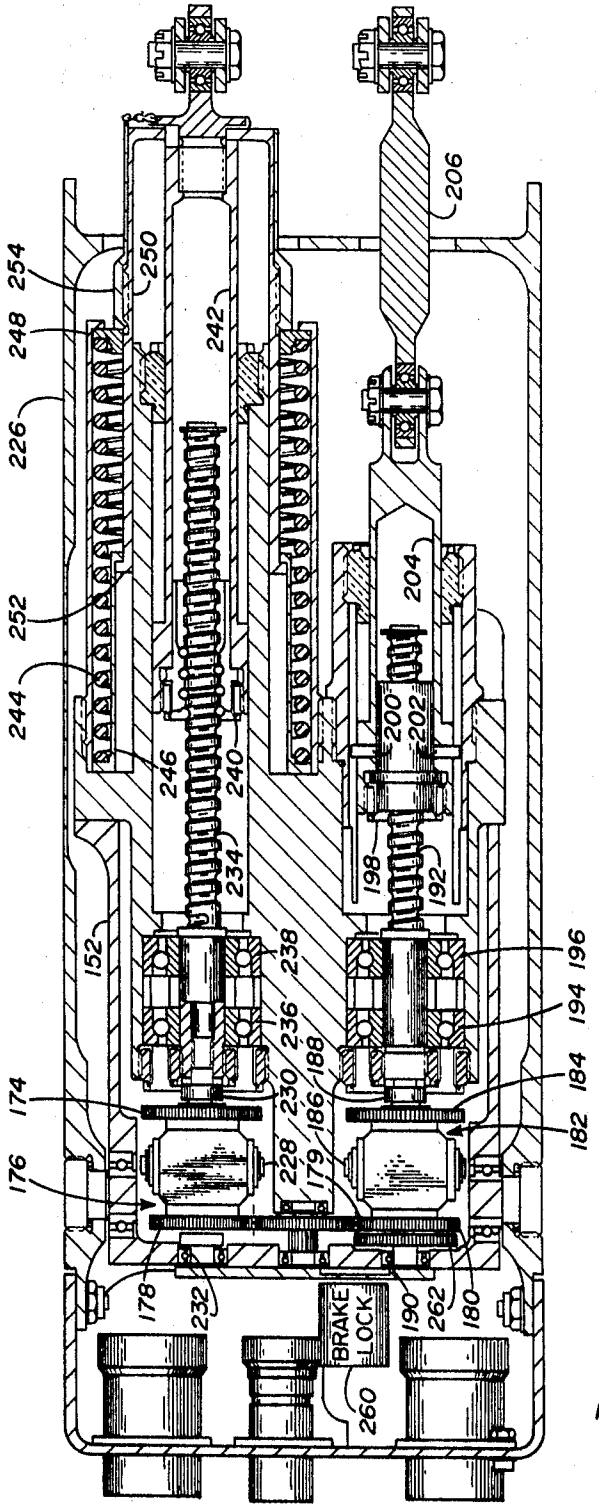

FIG. 3

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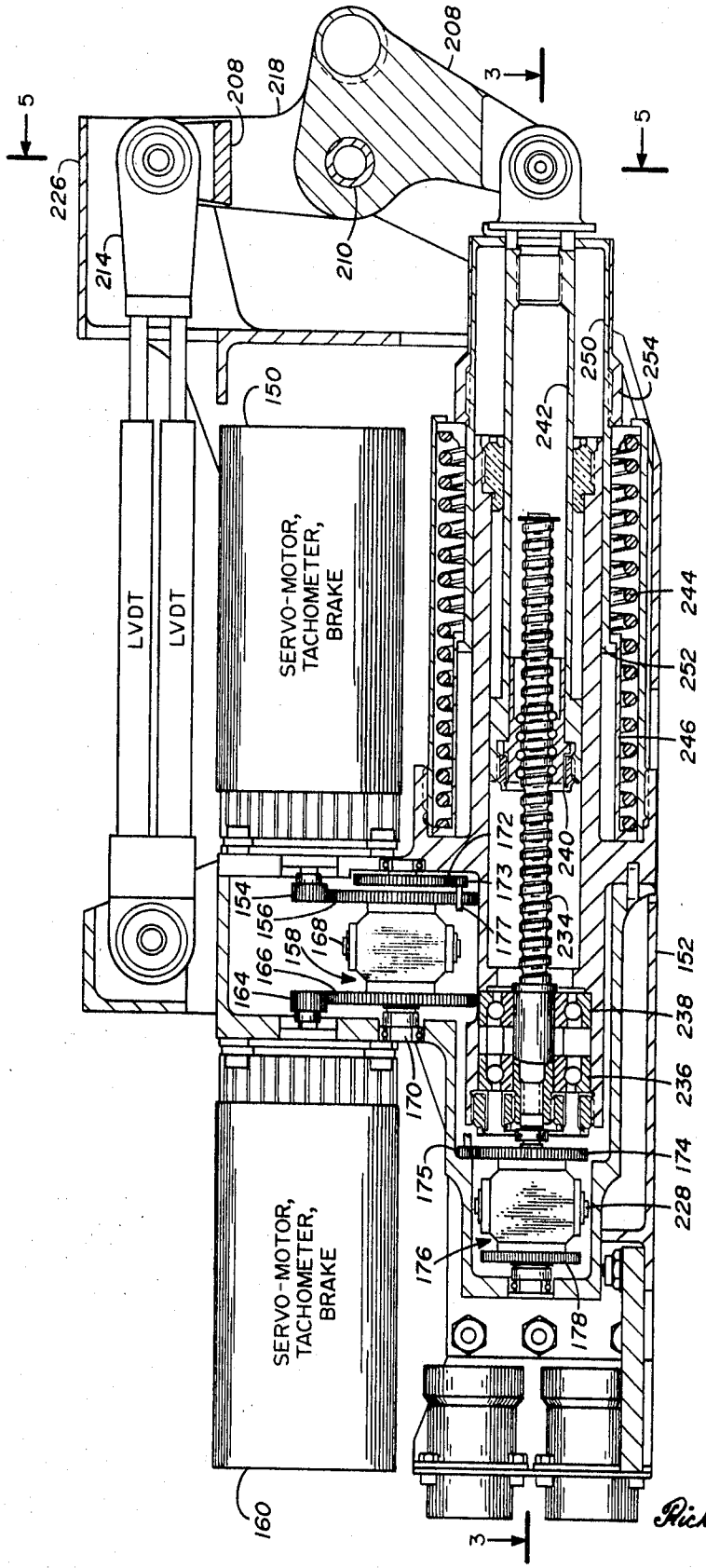

FIG. 4

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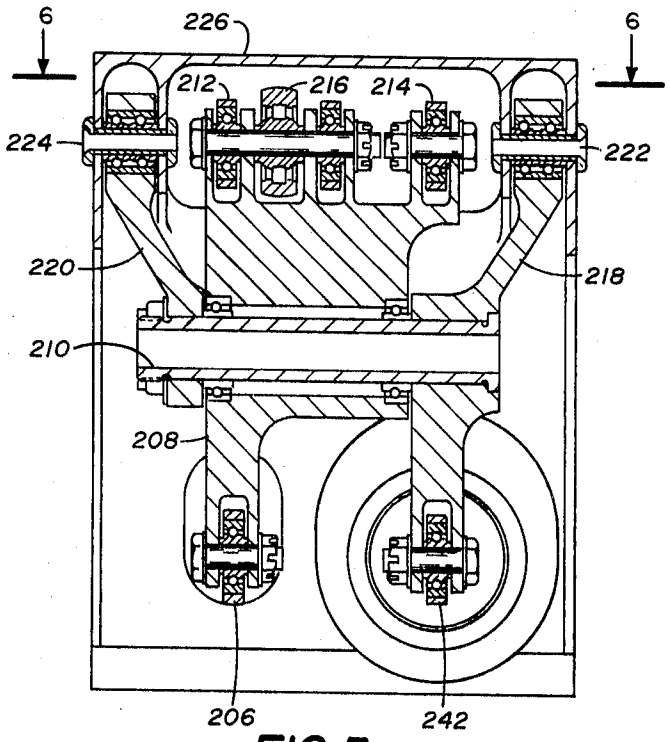

FIG. 5

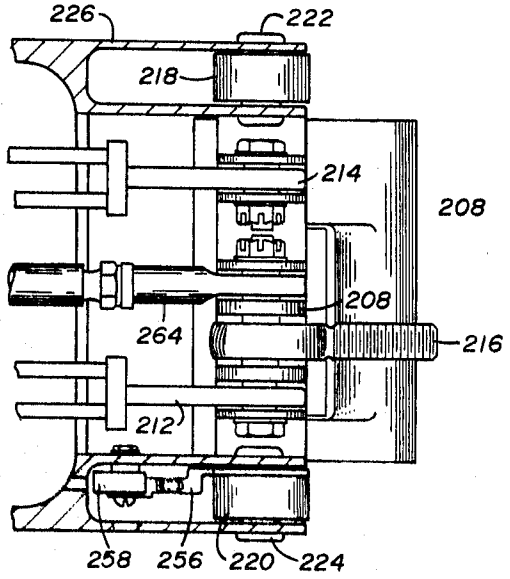

FIG. 6

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MULTIPLE OUTPUT MULTIPLEX ACTUATOR

This invention relates to a multiple output multiplex actuator and more particularly to a velocity-summing multiple output multiplex actuator.

It was early realized that as aircraft increase in size and speed that conventional cable and mechanical linkage control mechanisms are inadequate and there is a need for electrical flight control systems. There has, however, been some reluctance to accept the electrical flight control system because it is thought that mechanical systems are more reliable. To improve the reliability of electrical control, a system of redundant parallel channels has been implemented.

Heretofore, approaches for providing redundancy have typically resulted in double control chains or channels in which a failure in one channel hopefully would permit the other channels to carry on the necessary command functions. Such a system, depending upon the particular failure suffered, generally experienced at least degradation of control when the failed channel must be "dragged" by the operating channel or channels.

When redundant control channels are employed to improve the system reliability the several channels must eventually terminate at a single command that positions the control surface of the aircraft. The several channels may be brought together at the single command either in a "force-summing" configuration or a "displacement-summing" configuration. In the force-summing configuration, the outputs of the several channels are connected to a common summing point. The forces developed by each of the channels are summed at this common point into a single force motion. Upon a failure of any one of the several channels, the remaining channel will continue to position the aircraft controls through the full operating range. However, the remaining active channel must "drag" the failed channel. One of the major disadvantages of the force-summing system is that a "jam" in any one of the several channels may result in a catastrophic failure.

When the several channels of a redundant control system are "displacement summed," the output of each channel is combined in a series arrangement. Displacement summing (series summing) has the advantage that the remaining active channels do not have to drag the failed channel. In other words, the remaining operative channels do not fight each other force wise, as they can in the force-summing configurations. In the conventional displacement-summing system, the several redundant channels are combined to produce the total desired range of movement for the aircraft control surface. Upon failure of one of these channels, some loss of stroke of the master power drive results with the attendant loss in the range of movement of the control surface.

An object of this invention is to provide a multiple output multiplex actuator in a redundant control system wherein the actuator has full stroke output capabilities upon a failure of one of the output channels. Another object of this invention is to provide a multiple output multiplex actuator in a redundant control system wherein upon the failure of one of the output channels a standby channel takes over to perform the actuator function. A further object of this invention is to provide a multiple output multiplex actuator in a redundant control system capable of delivering a full force output upon a failure of one of the several output channels. Still another object of this invention is to provide a multiple output multiplex actuator in a redundant control system capable of producing a full stroke output when one of the output channels jams in a fixed position. A still further object of this invention is to provide a velocity-summing, multiple output, multiplex actuator in a redundant control system.

In a copending application of W. G. Redmond, entitled Multiplex Actuator, Ser. No. 7,676, filed Feb. 2, 1970, and assigned to the assignee of the present invention, there is described a velocity-summing multiplex actuator having a single output motion for positioning aircraft controls in accordance with generated control signals. The multiplex actuator described in this copending application includes a plurality of servomotors each responsive to a separate generated signal. Pairs of these servomotors are coupled together to produce a single rotary output for each servomotor pair. The single rotary output from several of the motor pairs is then combined in a velocity coupler to produce a single rotary output.

In accordance with the present invention, several output motions are generated from the velocity summations of the servomotor pairs. One of the several output motions normally controls the generation of a control signal that varies in accordance with the generated signals. Upon a failure of this normal output channel, a standby channel takes over the control function after a "breakout" force has been exceeded.

In accordance with a more specific embodiment of the present invention, a multiple output multiplex actuator for positioning aircraft controls in accordance with generated control signals includes a plurality of servomotors each responsive to a separate generated signal. The servomotors are coupled together to produce a single rotary output from several of the servomotors. Velocity couplers having inputs connected to either a servomotor pair, a servomotor and another velocity coupler, or two other velocity couplers are employed to reduce the output of the several servomotors to two rotary outputs. These two rotary outputs are interconnected by a velocity coupler pair having a common connection therebetween. A second input to each of the velocity couplers of this pair is one of the last two rotary outputs from the several servomotors. The output of each of the couplers of the pair is converted into a control signal that varies in accordance with the generated signals. One of the outputs is restrained from operation below a preestablished force level.

A more complete understanding of the invention and its advantages will be apparent from the specification and claims and from the accompanying drawings illustrative of the invention.

Referring to the drawings:

FIG. 1 is a schematic of a redundant control system including a multiple output multiplex actuator having a linear output coupled to a servo-valve for controlling a power ram connected to an aircraft control surface;

FIG. 2 is a block diagram of a quadruplex input velocity-summing actuator producing multiple linear outputs for coupling to a servo-valve;

FIG. 3 is a top view in section of a multiple output multiplex actuator in accordance with the present invention;

FIG. 4 is a side view in section of the actuator of FIG. 3;

FIG. 5 is a front view, partially in section, showing the interconnecting linkage between a dual output actuator; and

FIG. 6 is a top view, partially cutaway, of an actuator illustrating the interconnecting linkage between a dual output actuator.

Although the invention will be described with reference to a quadruplex velocity-summing actuator, it should be understood that other degrees of multiplexing may be employed to produce a single motion output in a velocity-summing arrangement. Further, the system to be described employs servomotor coupling in pairs by means of a differential gear set. By employing other gearing arrangements, the servomotors may be coupled together in other configurations. It should be further understood that although the output of the multiplex actuator described is in the form of a linear displacement, the actuator may produce a rotary output as a control signal.

Referring to FIG. 1, there is shown a multiple output, multiplex actuator 10 having four electrical control signals applied to input terminals 11 through 14. These control signals may be generated in a conventional manner by a stick transducer that converts a mechanical input from a pilot's control stick into electrical signals. The pilot's control input, converted into electrical signals by the stick transducer, are transmitted to the terminals 11 through 14 by a parallel arrangement of wires which may be located at different paths in the airframe to minimize the possibility of a disruption of all the pilot generated control signals to the actuator 10. In addition

to pilot generated signals, the electrical signals on terminals 11 through 14 may be received from autopilot sensors, a stability augmentation system, or from other systems, such as for navigation.

The multiple output, multiplex actuator 10 produces a linear motion output on a connecting rod 15 that normally varies in accordance with the electrical control signals on lines 11 through 14. The actuator 10 also produces a standby linear motion output on a connecting rod 17 that varies in accordance with the electrical control signals after a "break out" force has been exceeded on the rod 17. Connecting rods 15 and 17 are interconnected to a connecting rod 16 through a linkage 19.

Coupled to the connecting rod 16 is a dual tandem servo-valve 18 providing a fluid pressure-flow signal to a dual tandem power ram 20. The servo-valve 18 includes a cylinder 22 having a spool valve 24 slidably disposed therein and including interconnected lands 25 through 31. Conduits 32 and 34 interconnect the first section of the tandem valve 18 to a pressure supply and reservoir (neither shown), respectively. Similarly, conduits 36 and 38 connect the second section of the valve 18 to a source of fluid pressure and a fluid reservoir (neither shown), respectively. Conduits 40 and 42 interconnect the first section of the valve 18 to the first stage of the power ram 20 on opposite sides of a piston 44. Conduits 46 and 48 similarly interconnect the second section of the valve 18 to the second stage of the power ram 20 on opposite sides of a piston 50.

Pistons 44 and 50 of the power ram 20 are interconnected on a piston rod 52 that has an external coupling to a link 54. Link 54 is intended to represent the mechanical linkage between a power ram and one of the control surfaces 56 of an aircraft. The piston rod 52 is in the form of a hollow shaft and is positionable over a linear voltage differential transformer 58 that generates four separate but equal position feedback signals on lines 59 through 62. These signals are applied to the multiple output multiplex actuator 10 to balance the pilot generated signals on the terminals 11 through 14 to stop the motion of the control surface 56 at a new desired position.

Referring now to FIG. 2, there is shown a quadruplex velocity-summing multiple output actuator wherein the electrical control signals are applied to the terminals 11 through 14. At present, quadruplex actuators provide the most favorable degree of redundancy for many actuator applications, but any degree of redundancy may be used with the velocity-summing system of the present invention.

Referring to FIG. 2, the system consists of four sets and includes electric servometers 66 through 69, tachometers 71 through 74, gear drives 75 through 78, and electronic circuitry, all combined to develop a linear motion for driving the dual tandem servo-valve 18 to provide position signals to the power ram 20 (FIG. 1). Output shafts of the motors 66 and 67, through the respective gear drives 75 and 76, are coupled to a differential 80 and the output shaft of the motors 68 and 69, through the respective gear drives 77 and 78, are fed into a differential 82. The single rotary motion output of the differentials 80 and 82 are fed to a pair of differentials 84 and 85. The rotary output of the differential 84 is converted by a rotary-to-linear motion transducer 86 into linear motion for driving the dual tandem servo-valve 18 under normal conditions through the connecting rods 15 and 16. A rotary-to-linear motion transducer 87 converts the output of the differential 85 into a linear motion when a force developed at the output of the differential 85 exceeds a preestablished limit as determined by the fishmouth lock 89. If the transducer 86 jams and fails to provide the linear motion required to position the spool valve 24, the transducer 87 produces the required motion through the connecting rods 16 and 17.

The four-channel linear voltage differential transformer (LVDT) 58 is illustrated responsive to movement of the servo-valve 18 through a linkage 88 that is intended to represent the operation of the piston rod 52 in response to signals from the servo-valve 18. The four-unit LVD transformer 58 is used to provide electrical signals which are proportional to the position of the control surface 56 for the system follow up or feedback loop. Typically, a four-unit LVDT is a cluster of four separate transducers in a common housing. If the actuator drives something other than the valve shown, the actuator output is measured directly to produce a position feedback signal.

In operation, an electrical control signal at the terminal 11 is applied to a summing amplifier 90 having an output for energizing the servomotor 66. Tachometer 71 responds to the speed of the motor 66 and generates a velocity feedback signal applied to a synchronizer circuit that includes an integrator 92 with a feedback resistor 94. The output of the synchronizer circuit is applied to a second input of the summing amplifier 90. The tachometer 71 provides velocity feedback to accomplish two functions. First a velocity signal is sent back to the summing amplifier 90 through the first order lag (synchronizer) circuit in order to reduce steady state motor speeds. The velocity feedback signal also permits use of a higher loop gain than a system with no rate feedback. This higher loop gain in turn enables better positioning accuracy and higher closed loop frequency response (i.e., band-pass). The signal on the input terminal 11 thus produces a rotary motion at the output of the gear drive 75 at a desired velocity which continues until a feedback signal from the LVDT 58 neutralizes the effect of the input terminal signal. This is completed when the position of the surface 56 is at the command location.

An electrical control signal appearing at the terminal 12 is applied to one input of a summing amplifier 96 having an output for driving the servomotor 68. The tachometer 73 responds to the speed of the motor 68 to produce a velocity feedback signal to a synchronizer circuit consisting of an integrator 98 with a feedback resistor 100. The output of the synchronizer circuit is applied to a second input of the summing amplifier 96. This channel is similar to the channel responding to the signal on the terminal 11. An electrical control signal on the terminal 12 thus provides rotary motion at the output of the gear drive 77 at a desired velocity until the feedback signal from the LVDT 58 neutralizes the input terminal signal, as explained.

An electrical control signal at the terminal 13 is applied to one input of a summing amplifier 102 having an output for energizing the servomotor 67. The tachometer 72 responds to the speed of the servomotor 67 to produce a velocity feedback signal applied to a synchronizer circuit consisting of an integrator 104 having a feedback resistor 106. An output of the synchronizer circuit is applied to a second input of the summing amplifier 102. Similarly, an electrical control signal on the terminal 14 is applied to one input of a summing amplifier 108 having an output for energizing the servomotor 69. The tachometer 74 generates a velocity feedback signal applied to a synchronizer circuit including an integrator 110 and a feedback resistor 112. The output of this synchronizer circuit is connected to a second input of the summing amplifier 108.

A third input to each of the summing amplifiers 90, 96, 102 and 108 is the position feedback signal from the LVD transformer 58. The summing amplifiers each produces an output signal related to the three inputs applied thereto.

Electrical control signals at the terminals 11 through 14 produce rotary motion at the output of the gear drives 75 through 78, respectively, at a desired velocity. Outputs of the gear drives 75 and 76 are combined in the differential 80 to produce a single rotary motion at a velocity related to the input thereto. Outputs of the gear drives 77 and 78 are combined in the differential 82 to produce a single rotary motion output at a velocity related to the inputs thereto. The single rotary outputs of the differentials 80 and 82 are combined, during the normal operation of the system, by the differential 84 which in turn produces a rotary motion output at a velocity related to the pilot generated signals appearing at the terminals 11 through 14. An output of the differential 84 is converted into a linear motion in the transducer 86 to position the

spool valve 24, as explained. Should a jam occur in the differential 84 or the transducer 86, the single rotary outputs of the differentials 80 and 82 are combined by the differential 85 which likewise produces a rotary motion output at a velocity related to the electrical control signal appearing at the terminals 11 through 14. An output of the differential 85 is converted into linear motion in the transducer 87 to position the spool valve 24 through the connecting rod 17. Differential 85 combines the outputs of the differentials 80 and 82 only when the linear motion force at the output of the transducer 87 exceeds a limit as established by the fishmouth lock 89. In normal operation, the fishmouth lock holds the output of the differential 85 in a fixed position resulting in the output of the differential 80 being applied through the differential 85 to the differential 84. By properly setting the normal output direction of the servomotors 66 and 67, the output polarity of the linear motion for driving the spool valve 24 is preserved. When a jam does occur, for example, in the transducer 86, a force is built up through the transducer 87 to overcome the preload spring of the fishmouth lock 89, thereby positioning the spool valve 24 through the linkage 17.

In the system of FIG. 2, mechanical differentials, either with bevel gears or spur gears, provide a suitable system for summing the velocity output of each of the four independent control channels. In addition to differential gearsets, other velocity-summing devices may be employed to combine the output of the several servomotors into a single rotary motion output at a velocity related to the servomotor control signals. Where an even number of servomotors are employed in the system, they may be velocity summed in pairs. Where an odd number of redundant channels are employed, the sum of one servomotor pair is combined with the output of a single servomotor pair.

As explained in the previously referred to application of W. G. Redmond, a jamming or locking or otherwise stopping rotation of any one of the four channels will not interfere with the operation of the remaining active channels or degrade the output performance of the actuator by restricting the output stroke or force. Even though one of the channels has failed, the motion of the differential 84 will not be affected. The rotary motion of the differential 84 will likewise not be affected by a failure of both servomotors coupled to one differential, for example, the failure of motors 66 and 67 coupled to the differential 80. In this situation, the output of the differential 84 will be related to the velocity of the servomotors 68 and 69. This failure analysis can be further carried to a failure of three of the four servomotors.

Although a failure of three of the four servomotors will produce a full stroke output for positioning the servo-valve 18, a jam in the differential 84 or the transducer 86 will cause a complete breakdown of the actuator without the dual output implementation of the present invention. As explained, upon a failure of the normal output channel, the standby output channel comprising the differential 85 and the transducer 87 will take over to produce the required linear motion for positioning the spool valve 24. Thus, in accordance with the present invention, an additional degree of reliability has been added.

Referring to FIGS. 3 through 6, there is shown in various sectional views one form of a dual output multiplex actuator wherein the dual output is combined to produce a single linear motion. A servomotor, tachometer and brake unit 150 attaches to a housing 152 and has a spur gear 154 attached to the output shaft thereof. The motor spur gear 154 engages a spur gear 156 which is direct coupled to one of the input bevel gears of a differential gearset 158. A servomotor, tachometer and brake unit 160 is also attached to the housing 152 and has a spur gear 164 coupled to the output shaft. Spur gear 164 engages a spur gear 166 that is direct coupled to a second input bevel gear of the differential gearset 158. A similar arrangement of two servomotor, tachometer and brake units having spur gears on the output shafts, such spur gears being coupled to the input bevel gears of a differential gearset, are included in the cutaway portion of the actuator not illustrated in FIGS. 3 through 6.

Differential gearset 158 includes two output bevel gears mounted on a shaft 168 as part of a spider carrier. The spider carrier is mounted to rotate with a shaft 170 that carries an output spur gear 172. By operation of the differential gearset 158, the velocity of the spur gears 154 and 164 is summed and appears as a single rotary motion imparted to the output spur gear 172. This summing action is accomplished by the interaction of the input and output bevel gears of the differential 158.

The rotary motion of the spur gear 172 is transferred to a spur gear 174 through the idler gears 173 and 175 fixed to opposite ends of a shaft 177. Spur gear 174 is direct coupled to an input bevel gear of a differential gearset 176 that has a second input bevel gear coupled to a spur gear 178. Gear 178 engages an idler gear 179 which in turn engages a spur gear 180 of a differential gearset 182. Spur gear 180 is direct coupled to an input bevel gear of the differential 182 that has a second input bevel gear coupled to a spur gear 184. Gear 184 engages the output spur gear corresponding to spur gear 172 for transferring the velocity sum of the two motor units not shown in the figures to the differential 182.

Differential gearset 182 has two output bevel gears rotatably mounted on a shaft 186. Shaft 186 is part of a spider carrier that rotates with a shaft 188 journaled in a bearing 190.

In the normal operation of the actuator, the velocity sum of the two motor units not shown is imparted to the spur gear 184 and the velocity sum of the units 150 and 160 is imparted to the spur gear 180 through the differential 176. This velocity summation appears as rotary motion at the shaft 188 which engages a lead screw 192 of a ball screw assembly. Lead screw 192 is rotatably supported in the housing 152 by means of bearings 194 and 196. In a conventional manner, a ball nut 198 is fitted to the lead screw 192. The ball nut 198 is restrained from rotation in the housing 152 by means of dowel pins 200 and 202 and is fixed to an extension 204 that terminates at a coupling with a linkage 206.

The linkage 206 couples the extension 204 with an output assembly 208. The output assembly 208 is rotatably mounted to a shaft bolt 210 and carries connections 212 and 214 to linear voltage differential transformers (not shown). Also carried at the top portion of the output linkage 208 is a rod end 216 that will be coupled to a servo-valve through mechanical linkage, as illustrated by the rod 16 in FIG. 1 connected to the servo-valve 18, or to a load directly where the power requirements are small.

The shaft bolt 210 also passes through a standby output linkage 218 and a support linkage 220. Both the standby output linkage 218 and the support linkage 220 are rotatably supported, such as by shafts 222 and 224, respectively, carried by an actuator frame 226. The output assembly 218 is also rotatably attached to the output of the rotary-to-linear motion transducer for the standby channel. During normal operation, this attachment point remains stationary thereby providing a fixed pivot in the form of the bolt 210 for the output assembly 208. Thus, the operation of the lead screw 192 and the ball nut 198 along with the linkage 218 functions to convert the rotary motion of the shaft 188 into linear motion at the rod end 216. This then comprises one form of the transducer 86 of FIG. 2, and the linkages 15 and 17 of FIG. 1.

The standby channel of the actuator includes the differential 176. Differential 176 includes two output bevel gears rotatably mounted on a shaft 228. Shaft 228 is part of a spider carrier that rotates with a shaft 230 journaled in a bearing 232.

During a jam in the normal output channel, the velocity sum of the two motor units not shown is imparted to the spur gear 178 and the velocity sum of the units 150 and 160 is imparted to the spur gear 174. A rotary output of the differential 176 then equals the velocity sum of the four motor units. This velocity summation appears as rotary motion at the shaft 230 which engages a lead screw 234 of a standby channel ball screw assembly. The lead screw 234 is rotatably supported in the housing 152 by means of bearings 236 and 238. In a conventional manner, a ball nut 240 is fitted to the lead screw 234. The ball nut 240 is restrained from rotation in the housing 152 by means of dowel pins (not shown) and is fixed to a

rod extension 242. Extension 242 terminates at a coupling with the standby output linkage 218, as explained previously.

Before the standby channel takes over the operation of positioning the servo-valve 18, the force developed on the extension 242 by operation of the lead screw 234 must exceed a "break out" force as established by a spring 244. Spring 244 establishes the break out force by engaging spring guides 246 and 248. The spring guides 246 and 248 engage an actuator 250 that is attached to the extension 242. As the ball nut 240 moves the extension 242 toward the right, the actuator 250 compresses the spring 244 through the spring guide 246 engaging the actuator lip 252. The spring guide 248 remains in engagement with the housing 152 and separates from the shoulder established by the nut 254 which moves with the actuator 250. When the ball nut 240 moves the extension 242 toward the left from the position shown, the actuator 250 compresses the spring 244 by the engagement of the spring guide 248 with the shoulder established by the nut 254. Thus, to move the extension 244 in either direction from that shown, requires a force to overcome the spring 244.

When the standby channel takes over operation of the servo-valve 18, the normal output channel is jammed in a fixed position to establish a pivot point about which the output linkage 208 rotates. Upon the initial movement of the extension 242, the output linkage 218 rotates about the shaft 222 which likewise causes the linkage 220 to rotate about the shaft 224. As the linkage 220 rotates about the shaft 224, it moves an actuator 256 to trip a switch 258. Switch 258 energizes alarm circuitry (not shown) to warn the pilot the normal channel has jammed. To check out the operation of the standby channel, a brake 26 (FIG. 3) is energized which locks a spur gear 262 in a fixed position. Gear 262 is rigidly mounted to the shaft 188 thereby fixing the differential 182 in a stationary position and also locking the lead screw 192 in a nonrotating position. This then holds the end of the linkage 206 in a fixed position establishing a pivot point for the output linkage 208 during system check out.

In case of a total failure of the actuator, a centering assembly positions the rod end 216 to a neutral position. The centering assembly includes a spring arrangement coupled to the housing 152 and a centering rod 264 which is rotatably carried by the output linkage 208. Upon failure of the actuator, the centering springs (not shown) return the rod end 216 to a neutral position.

As explained previously, a multiple output multiplex actuator may include an odd number of servomotors, the velocities of which are to be summed. Assume that only three motor units were considered for the system of FIG. 2. If the servomotors 66, 67 and 68 are to be velocity summed, the motors 66 and 67 are connected as illustrated. Servomotor 68, on the other hand, is connected directly to the differential 84. The velocity of the motor 68 is then summed with the velocity of the rotary motion of the output of the differential 84. If more than two motor pairs are to be velocity summed, additional gearsets are required. The number of differential gearsets required in a dual output system is equal to the number of servomotor outputs to be summed. The end result, in any case, is a single rotary output at the differential 84 during normal operation or a single rotary output at the differential 85 during a malfunction of the normal output channel.

While only one embodiment of the invention, together with modifications thereof, has been described in detail herein, and shown in the accompanying drawings, it will be evident that various further modifications are possible without departing from the scope of the invention.

What I claim is:

1. A multiple output multiplex actuator for developing outputs that vary in accordance with generated control signals comprising:

a plurality of servomotors with each motor responsive to a separate generated signal,

means for velocity coupling the output of each of said servomotors to produce two rotary outputs each equal to the velocity sum of said plurality of servomotors,

means for converting one of the rotary outputs of the velocity-coupling means into a first output that varies in accordance with the generated signals, and

means for converting the second rotary output of the velocity-coupling means into a second output that varies in accordance with the generates signal when a force developed at the second rotary output exceeds a preestablished level.

2. A multiple output multiplex actuator for developing several outputs as set forth in claim 1 wherein said means for velocity coupling includes differential gearsets for combining two velocity inputs into a single velocity output, the two rotary outputs are generated by two differential gearsets having a common input connection.

3. A multiple output multiplex actuator for developing several outputs as set forth in claim 1 wherein said first and second converting means includes means for converting a rotary motion into a linear displacement.

4. A multiple output multiplex actuator for positioning aircraft controls in accordance with generated control signals comprising:

a first plurality of servomotors with each motor responsive to a separate generated signal and velocity coupled in a manner to produce a single rotary output,

a second plurality of servomotors with each motor responsive to one of the generated signals not connected to first plurality of servomotors and velocity coupled in a manner to produce a single rotary output,

a velocity-coupling pair with the velocity couplers of said pair having one input interconnected and the second input of one coupler connected to the rotary output of said first plurality of servomotors, and the second input of the second coupler of said pair connected to the rotary output of said second plurality of servomotors, each velocity coupler of said pair developing a single rotary output from the two inputs connected to said pair,

means for converting the rotary output of one of the velocity couplers of said pair into a control signal that varies in accordance with the pilot generated signals, and

means for converting the rotary output of the second velocity coupler of said pair into a control signal that varies in accordance with the generated signals when the force of the second velocity coupler output exceeds a preestablished limit.

5. A multiple output multiplex actuator for positioning aircraft controls as set forth in claim 4 including means for inhibiting the operation of the second converting means when the force at the output of the second velocity coupler of said pair is below a preestablished level.

6. A multiple output multiplex actuator for positioning aircraft controls as set forth in claim 5 wherein said first and second converting means includes means for converting a rotary motion into a linear displacement.

7. A multiple output multiplex actuator for positioning aircraft controls as set forth in claim 6 wherein the velocity couplers of said pair includes two differential gearsets having one input of each interconnected and the second input of one connected to the rotary output of said first plurality of servomotors and the second input of the other connected to the rotary output of said second plurality of servomotors.

8. A multiple output multiplex actuator for positioning aircraft controls as set forth in claim 4 wherein said means for converting the rotary output of each of the velocity couplers of said pair includes a lead screw and ball nut assembly.

9. A multiple output multiplex actuator for positioning aircraft controls in accordance with generated control signals, comprising:

a first servomotor pair with each motor responsive to a separate generated signal,

a first differential gearset having inputs individually connected to the servomotors of said first pair for coupling said servomotors together and producing a single rotary output therefrom,

a second servomotor pair with each motor responsive to one of the generated signals not connected to said first servomotor pair,

a second differential gearset with inputs individually coupled to the servomotors of said second motor pair for coupling said motors together to produce a single rotary output therefrom,

a third differential gearset having one input connected to the rotary output of said first differential gearset and having a second input, said third differential gearset developing a single rotary output from two inputs connected thereto,

a fourth differential gearset having one input connected to the rotary output of said second differential gearset and having a second input connected to the second input of said third differential gearset, said fourth differential gearset developing a single rotary output from two inputs connected thereto,

means for converting the rotary output of the third differential gearset into a control signal that varies in accordance with the generated signals, and

means for converting the rotary output of the fourth differential gearset into a control signal that varies in accordance with the generated signals when the force developed at the output of said fourth gearset exceeds a preestablished level for controlling said aircraft controls upon a failure of the first output.

10. A multiple output multiplex actuator for positioning aircraft controls as set forth in claim **9** wherein said converting means connected to the rotary outputs of the third and fourth differential gearsets each includes a lead screw and a ball nut assembly.

11. A multiple output multiplex actuator for positioning aircraft controls as set forth in claim **9** including means for restraining the operation of the converting means connected to said fourth differential gearset below the preestablished force level.