United States Patent [19]

Krivak et al.

[11] **3,714,535**

[45] **Jan. 30, 1973**

[54] SERVO DISPLACEMENT LIMITER WITH REVERSING CAPABILITIES

[75] Inventors: **Michael T. Krivak**, Hasbrouck Heights, N.J.; **Gibson Reynolds**, Tuxedo Park, N.Y.; **Frank Prapis**, Paterson, N.J.

[73] Assignee: **The Bendix Corporation**

[22] Filed: **June 25, 1971**

[21] Appl. No.: **156,635**

[52] **U.S. Cl.**.....**318/468**, 318/626

[51] **Int. Cl.**.....**G05b 5/01**

[58] **Field of Search**.....318/266, 280, 286, 289, 466–468, 318/626

[56] **References Cited**

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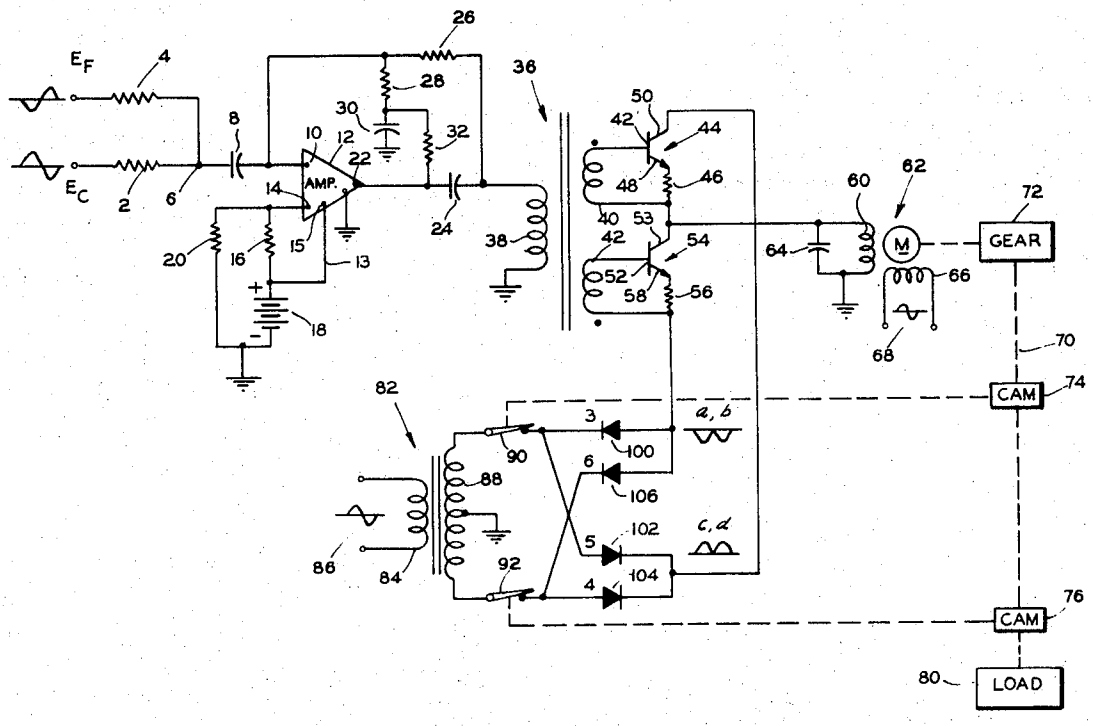
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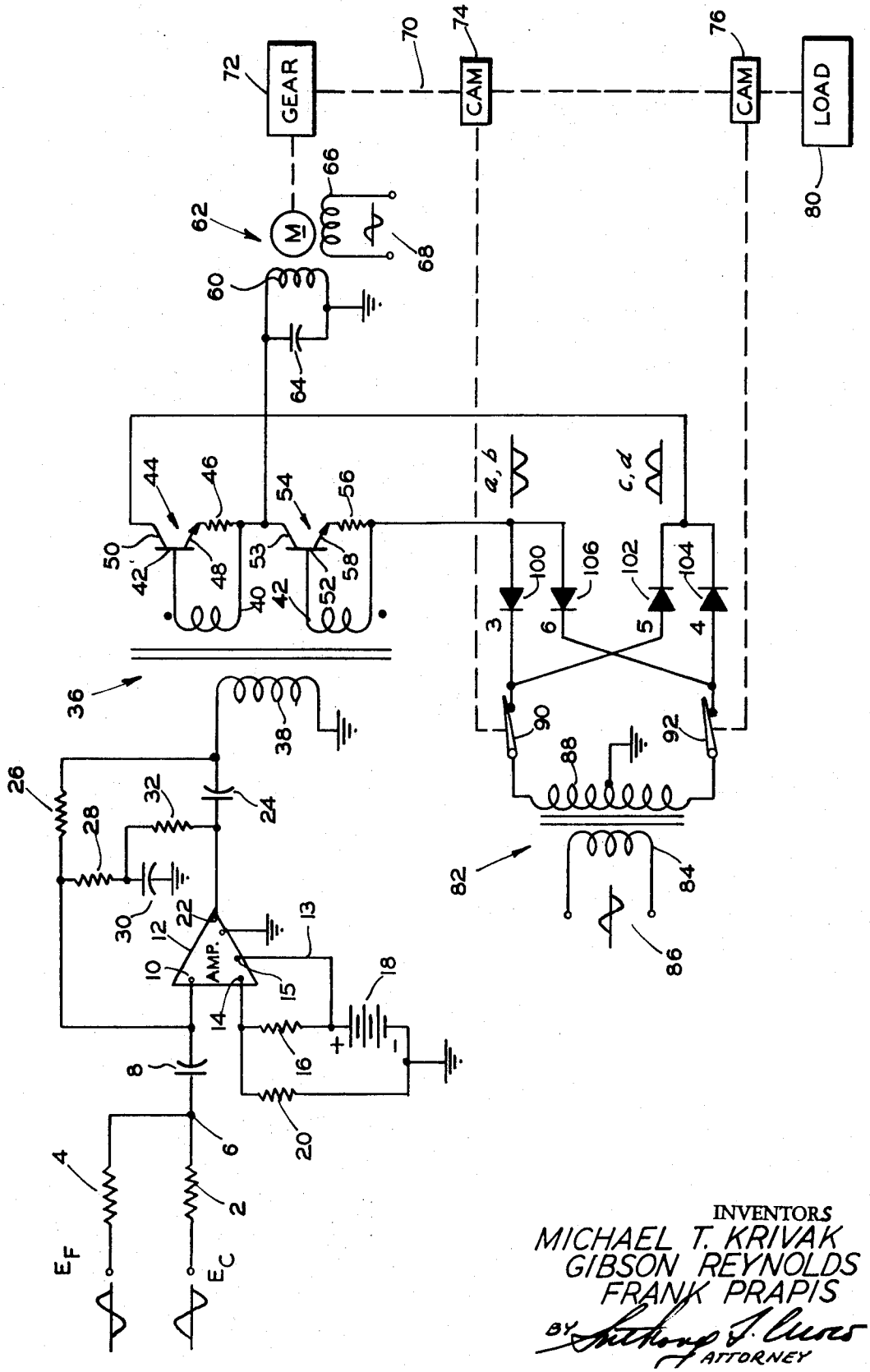
Primary Examiner—Bernard A. Gilheany
Assistant Examiner—W. E. Duncanson, Jr.
Attorney—Anthony F. Cuoco

[57] **ABSTRACT**

A servo system includes power turn-off, position and direction controlled limit switching for removing excitation to the servo motor at the stop position, while permitting reversing of rotational direction upon command, to eliminate heat generation and the necessity for dissipating the heat.

7 Claims, 1 Drawing Figure





INVENTORS
MICHAEL T. KRIVAK
GIBSON REYNOLDS
FRANK PRAPIS
BY
ATTORNEY

SERVO DISPLACEMENT LIMITER WITH REVERSING CAPABILITIES

BACKGROUND OF THE INVENTION

This invention relates generally to servo systems and, particularly, to servo systems including output element limiting means. More particularly, this invention relates to a servo system of the type described, including electrical limiting means effective without generating heat which must be dissipated.

DESCRIPTION OF THE PRIOR ART

Positioning servo and torquing devices are often designed so that the excursion of the output element is limited by mechanical stops. Under stop conditions, the servo motor and its associated amplifier generate full power and the system components must be large and rugged enough to dissipate the resulting heat.

SUMMARY OF THE INVENTION

This invention contemplates position controlled limit switches in the amplifier circuit which eliminate the generation of such heat. An alternating signal is applied to the servo motor to rotate the motor shaft in a particular direction and for reversing the sense of the input signal to provide shaft rotation in the opposite direction. Rotation is stopped by position controlled limit switches actuated by cams on the motor shaft. The limit switches are further effective for commanding shaft rotation in an opposite direction.

One object of this invention is to provide limit switches for stopping the rotation of a motor and for reversing the direction of rotation without the generation of large quantities of heat which must be dissipated.

Another object of this invention is to prevent the servo system from generating full power under stop conditions.

Another object of this invention is to provide, in a servo system of the type described, means for reversing servo motor shaft rotation when the motor is under stop conditions.

The foregoing and other objects and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawing wherein one embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawings are for illustration purposes only and are not to be construed as defining the limits of the invention.

DESCRIPTION OF THE DRAWINGS

The single FIGURE in the drawing is an electrical schematic diagram of a servo system according to the invention.

DESCRIPTION OF THE INVENTION

An alternating command signal E_c and an alternating follow-up signal E_f, out of phase with signal E_c, are applied through resistors **2** and **4**, respectively to a summing point **6** and summed thereat. The signal from summing point **6** is applied through a coupling **28 8** to an input terminal **10** of an operational amplifier **12**. Operational amplifier **12** has another input terminal **14** connected to a biasing circuit including a resistor **16** connected to the positive terminal of a battery **18**, and which battery **18** has a negative terminal connected to ground, and a resistor **20** connected in parallel with resistor **16** and battery **18**. A power conductor **13** is connected to an amplifier power terminal **15** and is connected intermediate resistor **16** and battery **18**.

Amplifier **12** has an output terminal **22** connected to input terminal **10** through a feedback circuit including a capacitor **24** and a resistor **26**. A resistor **28** is connected intermediate resistor **26** of amplifier **12**, and is connected to a grounded capacitor **30**. A resistor **32** is connected intermediate resistor **28**. and capacitor **30** and intermediate output terminal **22** of amplifier **12** and capacitor **24**. The feedback circuit provides d.c. bias feedback to amplifier **12**.

A transformer **36** has a primary winding **38** connected to capacitor **24** and a pair of reversing secondary windings **40** and **42** inductively coupled to primary winding **38**. Secondary winding **40** has one leg connected to a base **42** of a transistor **44** and another leg connected through a resistor **46** to emitter **48** of transistor **44**. Transistor **44** has a collector element **50**. Secondary winding **42** has one leg connected to a base **52** of a transistor **54** and another leg connected through a resistor **56** to an emitter element **58** of transistor **54**. Transistor **54** has a collector element **53**.

Emitter element **46** of transistor **44** is connected through resistor **46** to a winding **60** of a servo motor **62** and collector element **53** of transistor **54** is connected to winding **60**. A capacitor **64** is connected across winding **60**.

Motor **62** has another winding **66** connected to an energizing alternating voltage **68**. Motor **62** has an output shaft **70** connected through suitable gearing means **72** to a load **80**. Shaft **72** has mounted thereon a cam **74** and a cam **76**.

A transformer **82** has a primary winding **84** energized by a suitable source of alternating voltage **86** and a secondary winding **88** inductively coupled to primary winding **84**. Secondary winding **88** has one leg connected to a switch **90** and another leg connected to a switch **92**. Switch **90** is actuated by cam **74** and switch **92** is actuated by cam **76** on motor shaft **70**.

Switch **90** is connected to diodes **100** and **102** connected in opposing relation and switch **92** is connected to diodes **104** and **106** connected in opposing relation. Diodes **100** and **106** are connected to resistor **56** leading from emitter **58** of transistor **54** and diodes **102** and **104** are connected to collector **50** of transistor **44**. The signal applied from transformer **82** through switch **90** and diodes **100, 106** to emitter **58** of transistor **54** has a waveform *a, b* shown in the FIGURE, and the signal applied from the transformer through switch **92** and diodes **102, 104** has a waveform *c, d* as shown in the FIGURE.

OPERATION OF THE INVENTION

Assuming signal E_c is the dominant input signal, the positive half cycle of the signal drives base **42** of transistor **44** positive and base **52** of transistor **54** negative and half-cycle c is applied to motor **62**. During the negative half-cycle of input signal E_c base **52** of transistor **54** becomes positive and half-cycle b is applied to motor **62**. Thus, a full cycle is developed across

the motor to rotate the motor in a particular direction which may, for example, be clockwise. Reversing the phase of the input signal will apply half-cycles a and d to motor **62** providing counterclockwise rotation.

To stop clockwise rotation, it is merely required to interrupt half-cycles *c* and *b* by opening limit switch **90** through cam **74**. Half-cycles *a* and *d* remain connected to the transistor in preparation for applying power to the motor upon a reverse rotation command. Similarly, limit switch **92** may be opened to interrupt counterclockwise power while switch **90**, remaining closed, applies half-cycles *c* and *b* for clockwise commanded rotation.

It will now be seen from the foregoing description of the invention that the inclusion of position controlled limit switches **90** and **92** in the amplifier circuit is effective for eliminating generation of heat during stop conditions, and thus eliminates the necessity for dissipation of said heat in the motor and amplifier. Moreover, the system is capable of reverse rotation when in the stop position.

While one embodiment of the invention has been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. Various changes may also be made in the design and arrangement of the parts without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art.

What is claimed is:

1. A servo system, comprising:

a motor having a shaft connected to a load for driving the load;

means for providing a control signal;

means for providing a motor driving signal;

means connected to the control signal means and to the driving signal means and responsive to the signals therefrom for applying a signal to the motor for rotating the motor shaft in a predetermined direction;

motor shaft displacement responsive means associated with the motor driving signal means and effective upon a predetermined shaft displacement for disconnecting the driving signal means from the signal applying means to stop the motor; and

said control signal means including means for providing a servo command signal; means for providing a servo follow-up signal; means for combining the command and follow-up signals; and operational amplifier having a first input terminal, a first output terminal connected to the signal applying means, a grounded second output terminal and a power terminal; an amplifier biasing circuit connected to the second input terminal; a feedback circuit connected to the first output terminal and to the first input terminal; and a power conductor connected to the biasing circuit and to the power terminal.

2. A servo system as described by claim **1**, wherein:

the control signal is an alternating signal having positive and negative half-cycles;

the means for providing driving signals includes means for providing a first signal having positive half-cycles and means for providing a second signal having negative half-cycles;

the means connected to the control signal means and to the driving signal means and responsive to the signals therefrom for applying a signal to the motor for rotating the motor shaft in a predetermined direction includes a first current flow control device affected by the positive half-cycle of the alternating signal for applying a positive half-cycle of the first signal to the motor and a second current flow control device affected by the negative half-cycle of the alternating signal for applying a negative half-cycle of the second signal to the motor; and

the motor is responsive to the full cycle signal including the positive and negative half-cycles of the first and second signals so that the motor shaft rotates in the predetermined direction.

3. A servo system as described by claim **2**, wherein the means for providing driving signals including means for providing a first signal having positive half-cycles and means for providing a second signal having negative half-cycles comprises:

means for providing an alternating signal;

a transformer having a primary winding connected to the alternating signal means and a secondary winding inductively coupled to the primary winding;

a third current flow control device connected to one of the legs of the secondary winding and a fourth current flow control device connected to the other leg in opposing relation to the third device;

a fifth current flow control device connected to the one leg in opposing relation to the third device and a sixth current flow control device connected to the other leg in opposing relation to the fourth device; and

the fourth and fifth devices cooperating to provide the first signal having positive half-cycles and the third and sixth devices cooperating to provide the second signal having negative half-cycles.

4. A servo system as described by claim **3**, wherein the motor shaft displacement responsive means associated with the motor driving signal means and effective upon a predetermined shaft displacement for disconnecting the driving signal means from the signal applying means to stop the motor includes:

a normally closed first switch connected between the one leg of the secondary winding and the third and fifth current flow control devices;

a normally closed second switch connected between the other leg of the secondary winding and the fourth and sixth current flow control devices;

first switch actuating means coupled to the motor shaft and to the first switch for opening the first switch when the motor shaft displacement is at a predetermined limit in one sense; and

second switch actuating means coupled to the motor shaft and to the second switch for opening the second switch when the motor shaft displacement is at a predetermined limit in an opposite sense.

5. A servo system as described by claim **1**, wherein the biasing circuit includes:

a first resistor connected to the second input terminal;

a power supply serially connected to the first resistor; and

a second resistor connected in parallel with the first resistor and the battery.

6. A servo system as described by claim 6, wherein:

the power conductor is connected to the biasing circuit between the first resistor and the power supply.

7. A servo system as described by claim 1, wherein the feedback circuit includes:

a first capacitor connected to the first output terminal;

a first resistor connected to the capacitor and to the first input terminal;

a second resistor and a second capacitor connected in series between the first resistor and the first input terminal; and

a third resistor connected between the second resistor and the second capacitor and connected between the first output terminal and the first capacitor.

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