US005994853A

United States Patent [19]

Ribbe

[11] Patent Number: 5,994,853

[45] Date of Patent: Nov. 30, 1999

[54] **SPEED CONTROL SYSTEM FOR A REMOTE-CONTROL VEHICLE**

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[21] Appl. No.: **08/794,438**

[22] Filed: **Feb. 5, 1997**

[51] **Int. Cl.**[6] **H02P 7/29**

[52] **U.S. Cl.** **318/16**; 318/293; 388/829

[58] **Field of Search** 318/16, 293, 139; 388/825, 828, 829

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,349,986	9/1982	Tsukuda	46/254
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5,065,078	11/1991	Nao et al.	318/16
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5,136,452	8/1992	Orton	361/33
5,150,027	9/1992	Suzuki	318/581
5,216,337	6/1993	Orton et al.	318/16
5,218,276	6/1993	Yeom et al.	318/16
5,495,155	2/1996	Juzswik et al.	318/293
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5,577,154	11/1996	Orton	388/811

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TX5/RX5 Remote Controller with Nine Functions, *Product Description*(Nov. 1994).

Primary Examiner—Bentsu Ro

Attorney, Agent, or Firm—Marshall, O'Toole, Gerstein, Murray & Borun

[57] **ABSTRACT**

A remote-control vehicle includes a controller that produces a pulse-width modulated (PWM) motor control signal and a forward/reverse motor control signal in response to a transmitted digital signal specifying one of a multiplicity of speed control states, each of which has a direction and a PWM duty cycle associated therewith. A MOSFET switch turns on and off in response to the PWM signal to control the flow of current between a battery and a motor to thereby control the speed of the motor. A relay, coupled between the battery and the motor, switches in response to the forward/reverse signal to change the direction of current flow through the motor to thereby control the direction of the motor.

23 Claims, 3 Drawing Sheets

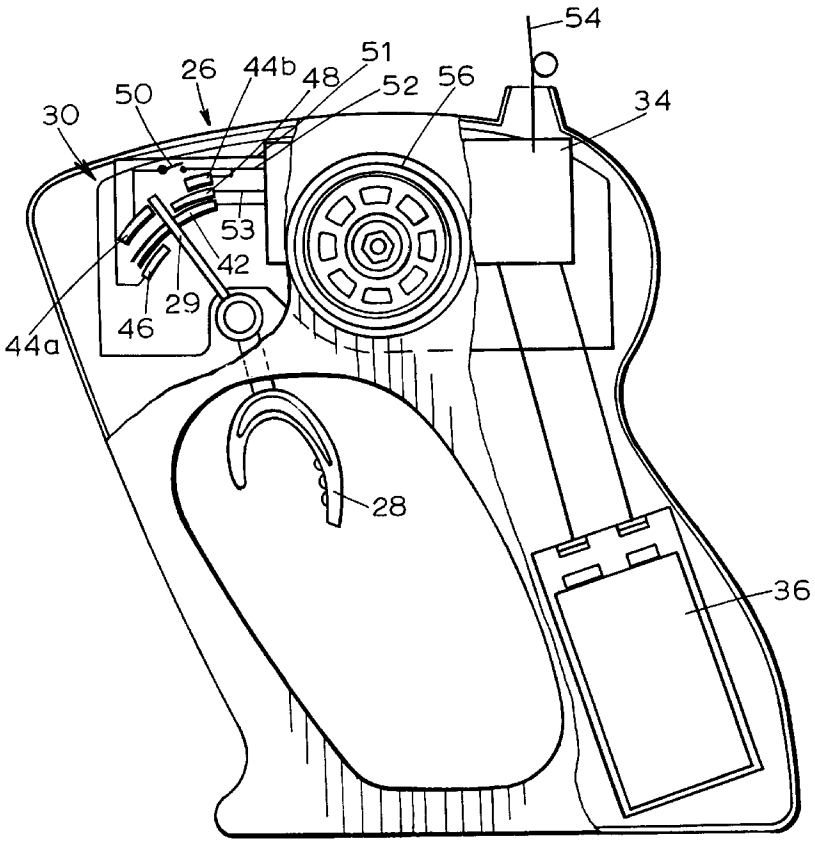


FIG. 1

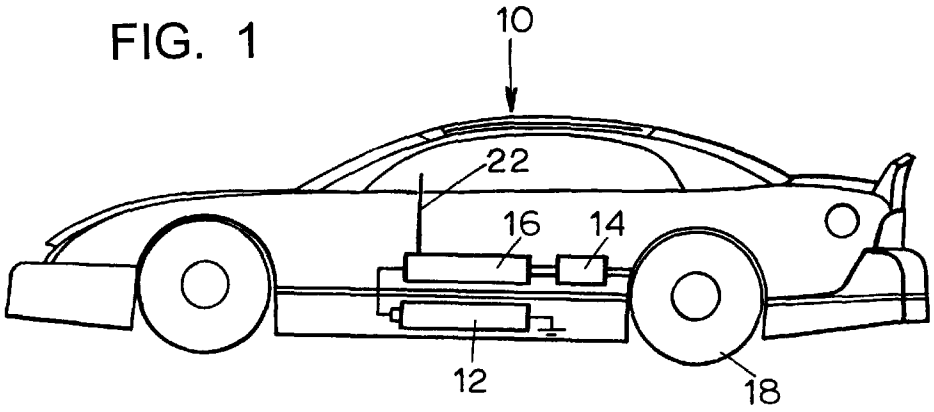
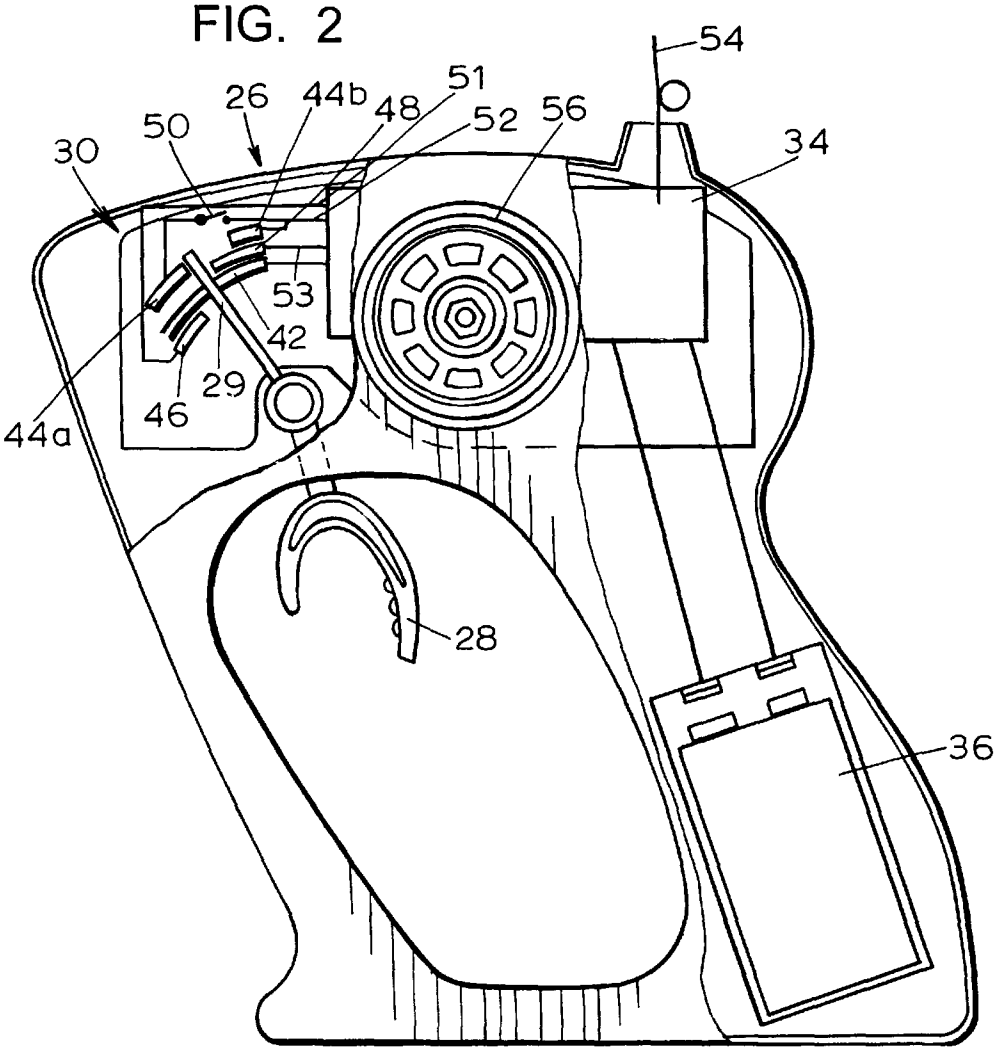


FIG. 2



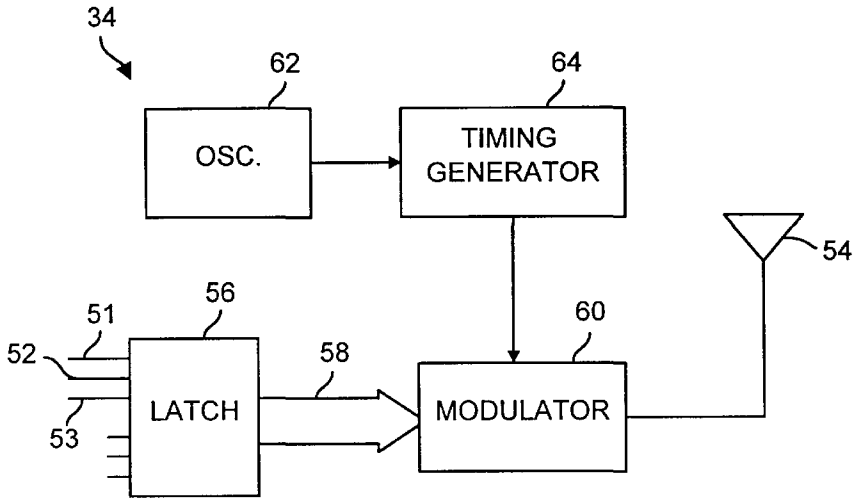


FIG. 3

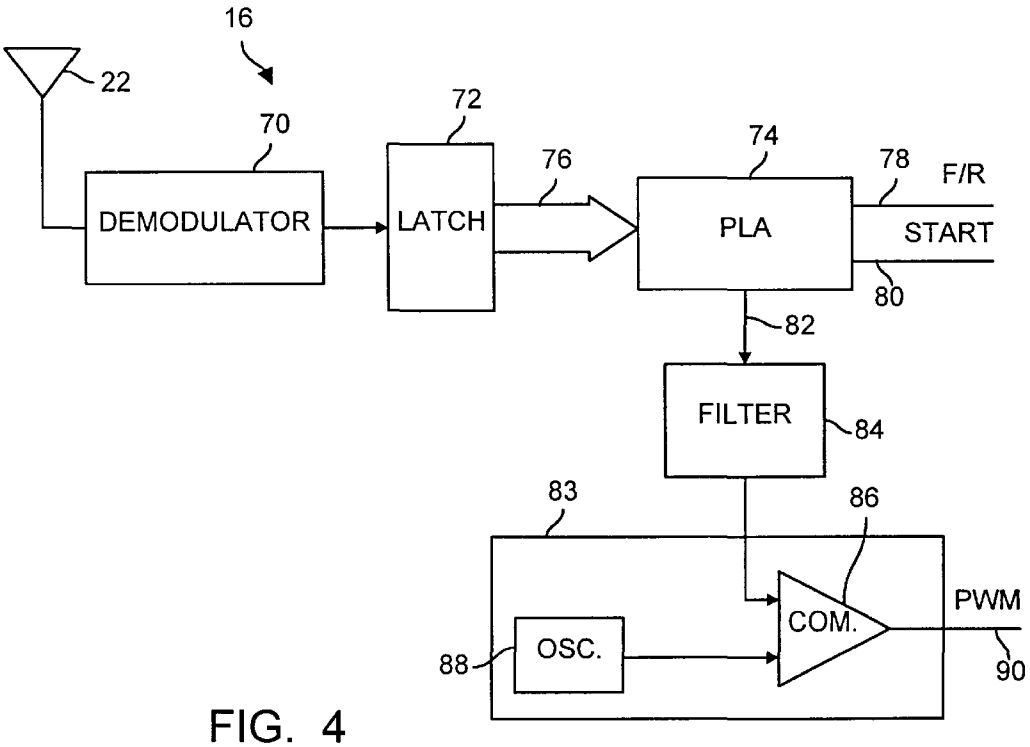


FIG. 4

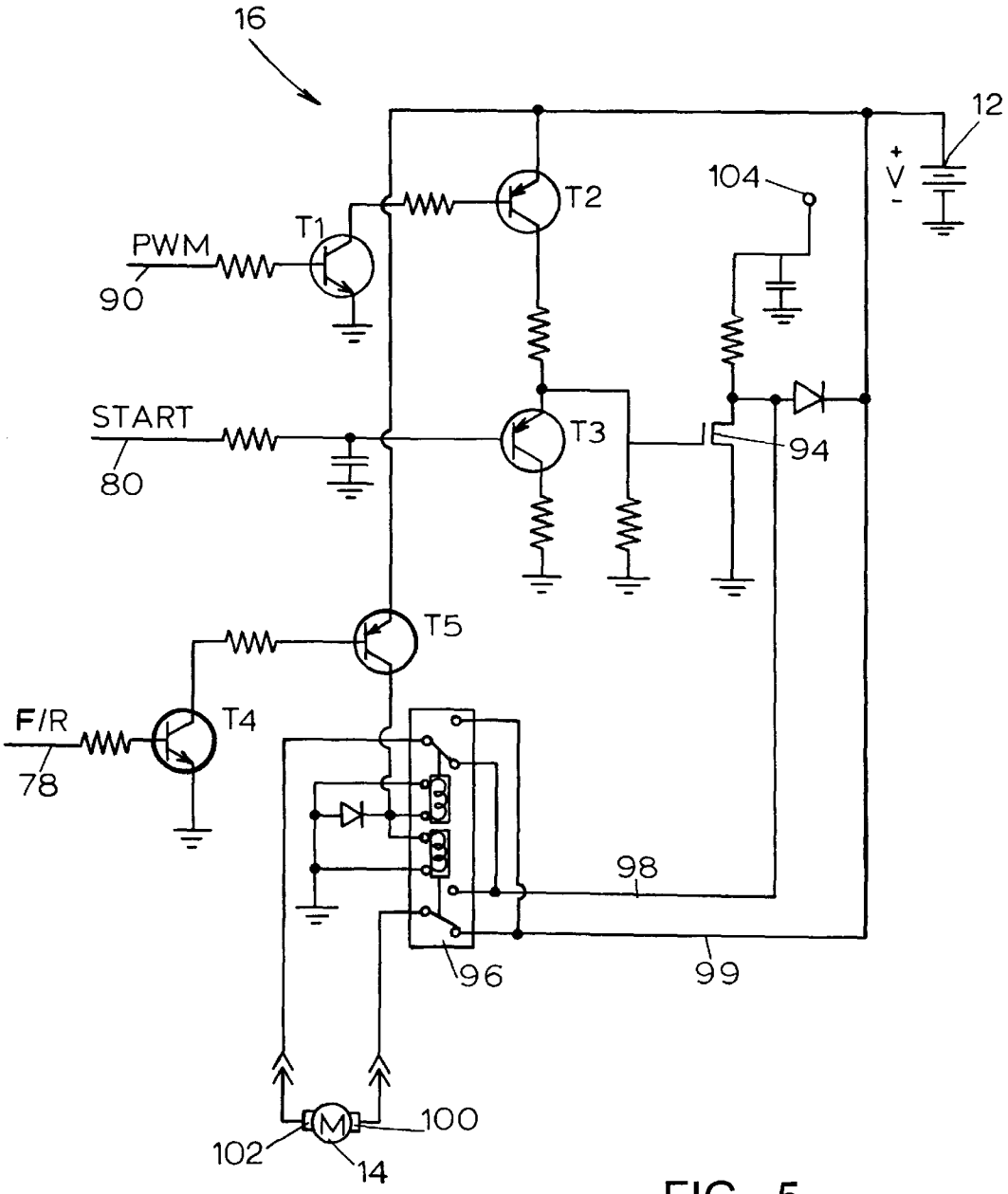


FIG. 5

SPEED CONTROL SYSTEM FOR A REMOTE-CONTROL VEHICLE

BACKGROUND OF THE INVENTION

The present invention relates generally to motor speed controllers and, more particularly, to speed controllers for remote-control toy vehicles.

DESCRIPTION OF RELATED ART

It is known to use pulse-width modulated (PWM) signals to control the flow of current through a motor in, for example, a remote-control vehicle, to thereby control the speed of the motor. For example, Nao et al., U.S. Pat. No. 5,065,078; Orton, U.S. Pat. No. 5,577,154; and Suzuki, U.S. Pat. No. 5,150,027 each discloses a remote-control device using a PWM signal to control the power provided to a motor. In these devices, the duty cycle of the PWM signal is increased to increase the speed of the motor and is decreased to decrease the speed of the motor. Typically, however, remote-control vehicles receive an analog control signal that must be demodulated and used to produce a PWM control signal of varying duty cycle. For example, the device of Nao et al. (U.S. Pat. No. 5,065,078) uses a stretched analog PWM signal developed from a received analog PWM control signal to generate a PWM motor control signal. Likewise, Suzuki (U.S. Pat. No. 5,150,027) develops an analog PWM signal from a received control signal, compares the PWM signal with a pulse signal generated by a one-shot circuit, and detects the difference between the widths of the two signals to determine the pulse width of a PWM motor control signal. Such analog decoding circuits require numerous components, which adds to the weight of the remote-control vehicle and reduces the life of a battery powering the vehicle.

Remote-control vehicles have also used elaborate circuits to effect forward and reverse motor functions. For example, Nao et al. (U.S. Pat. No. 5,065,078) develops a stretched analog PWM signal from a received analog PWM control signal, compares the stretched PWM signal with a pulse signal generated by a one-shot circuit, and detects the difference between the trailing edges of the two signals to determine the direction of a motor. Other prior art motor control circuits, such as those disclosed in Tsukuda, U.S. Pat. No. 4,349,986, and Juzswik et al., U.S. Pat. No. 5,495,155, use an H-bridge circuit, having semiconductor devices in the legs thereof, to drive a motor in both the forward and reverse directions. Typically, the semiconductor devices of such H-bridge circuits are operated to turn one leg of the bridge circuit off while turning the other leg on which changes the direction of current flow through the motor and, thereby, reverses the direction of the motor. However, H-bridge circuits typically require a relatively high amount of power to operate and develop voltage drops across the numerous semi-conductor devices connected in series with the motor, which reduces the amount of power supplied to the motor. These circuits also tend to increase the depletion of the battery which reduces the use time of the battery.

SUMMARY OF THE INVENTION

The present invention relates to a remote-control vehicle that provides a variable duty cycle PWM signal to a motor to vary the speed of the motor while simultaneously controlling the direction of the motor using simple, lightweight, and cost effective switching networks that do not have large voltage drops associated therewith.

In particular, a remote-control vehicle according to the present invention receives a digital signal specifying one of a multiplicity of speed control states, each of which has a direction and a PWM duty cycle associated therewith. A speed controller located on the vehicle decodes the received digital signal to identify the specified speed control state and produces a PWM signal and a forward/reverse signal in response thereto. The PWM signal, which controls the speed of a motor, is coupled to a switch, preferably comprising a semiconductor switch such as metal oxide semiconductor field effect transistor (MOSFET), and controls the flow of current between a power source, such as a battery, and the motor. The duty cycle of the PWM signal is varied from speed control state to speed control state to vary the speed of the motor. The forward/reverse signal controls the operation of a further switch coupled between the motor and the battery to change the direction of current flow through the motor. Preferably the further switch comprises a dual input, quadruple output relay, such as a double pole, double throw relay. In one embodiment, the relay has two sets of two outputs connected together such that each of the connected sets of outputs is coupled through one of the relay inputs to one of a set of motor terminals.

According to another aspect of the present invention, a speed control system for use in a remote-control vehicle includes a receiver that receives a digital control signal and produces a digital state signal specifying one of a multiplicity of speed control states and a speed controller responsive to the digital state signal that develops a forward/reverse signal and a PWM speed signal based on the specified one of the multiplicity of speed control states. A first switch is coupled between a power source and a motor and is responsive to the PWM signal for delivering a power signal from the power source to the motor. A second switch is coupled between the power source and the motor and is responsive to the forward/reverse signal to control the direction of the motor. Preferably, the receiver produces a digital state signal specifying one of at least six speed control states, three of which are forward states and two of which are reverse states.

The speed control system of the present invention may include circuitry for producing a ramped duty cycle PWM signal, varying between three or more different duty cycles over a first period of time, in response to a change between two non-consecutive speed control states in a second period of time that is less than the first period of time. The speed control system may also include a switch that prevents the use of one of the speed control states when in a first position and that allows the use of the one of the speed control states when in a second position.

According to another aspect of the present invention, a remote-control vehicle includes a transmitter module having a speed position sensing device that detects one of a multiplicity of speed positions and a digital signal transmitter coupled to the speed position sensing device that produces a digital control signal indicating one of a multiplicity of speed control states corresponding to the detected one of the multiplicity of speed positions. The remote-control vehicle also includes a vehicle having a receiver that receives the digital control signal and produces a digital state signal specifying the one of the multiplicity of speed control states. A speed controller on the vehicle develops a forward/reverse signal and a PWM speed signal based on the one of the multiplicity of speed control states specified by the digital state signal. A first switch is responsive to the PWM signal for delivering a power signal to a motor on the vehicle and a second switch is coupled to the motor and is responsive to the forward/reverse signal to control the direction of the motor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view of a toy vehicle having a speed control system according to the present invention;

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