# United States Patent

[11] **3,550,716**


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[21] Appl. No. **766,862**
[22] Filed **Oct. 11, 1968**
[45] Patented **Dec. 29, 1970**



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[54] **AUTOMOBILE SPEED-CONTROLLING MECHANISM**
**6 Claims, 6 Drawing Figs.**


[52] **U.S. Cl.** ..... **180/98,** 318/8, 180/105
[51] **Int. Cl.** ..... **B60k 31/00**
[50] **Field of Search** ..... 180/98, 105—110, 77, 79, 79.1; 318/8, 16, 45; 246/182



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,594,739 | 4/1952 | Davis | 180/106X |
| 2,661,070 | 12/1953 | Ferrill | 180/106X |
| 3,085,646 | 4/1963 | Paufve | 180/98 |
| 3,369,161 | 2/1968 | Kaufman | 318/8X |
| 3,378,102 | 4/1968 | Collin et al. | 318/16X |
| 3,434,025 | 3/1969 | Parkinson | 318/8 |



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**ABSTRACT:** A frequency differential-accumulator for use in controlling the speed of an automobile by comparing, as to frequency, a standard signal and a signal that is derived in magnetic-flux-sensors on the automobile by passage of the sensors through a sequence of magnetic fields located along a highway according to a predetermined frequency. The frequency differential-accumulator includes two synchronous electric motors, one supplied the standard signal and the other supplied the flux-sensor-derived signal, and the motors are physically connected so that part of the motor supplied the flux-sensor-derived signal moves in proportion to any lack of correspondence between the frequency of the standard and derived signals. This movement is used to control the carburetor throttle valve of the automobile.

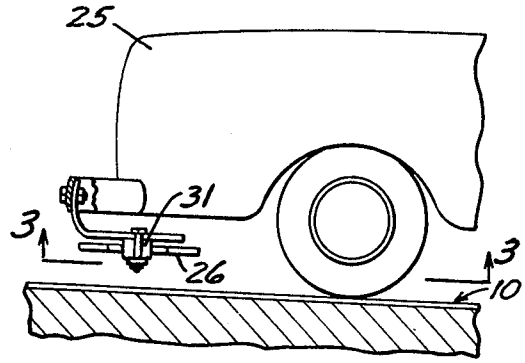



FIG. 1

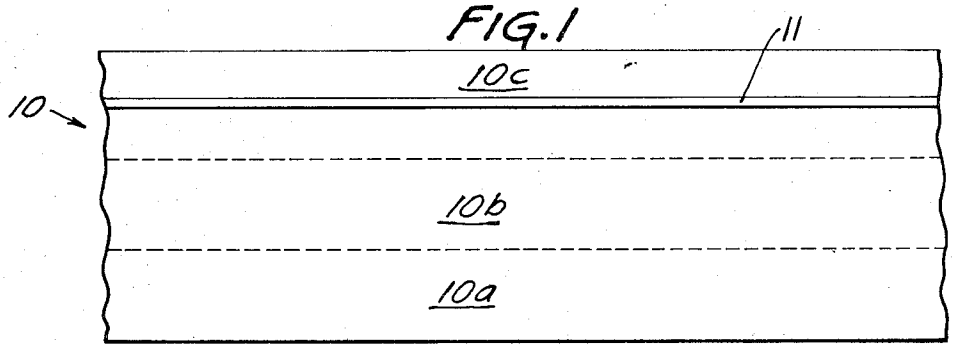



FIG. 2

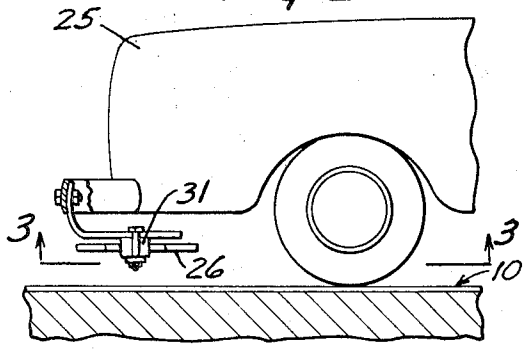



FIG. 3

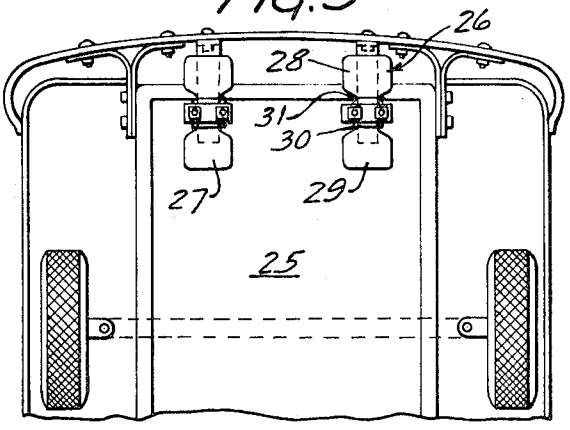



FIG. 5

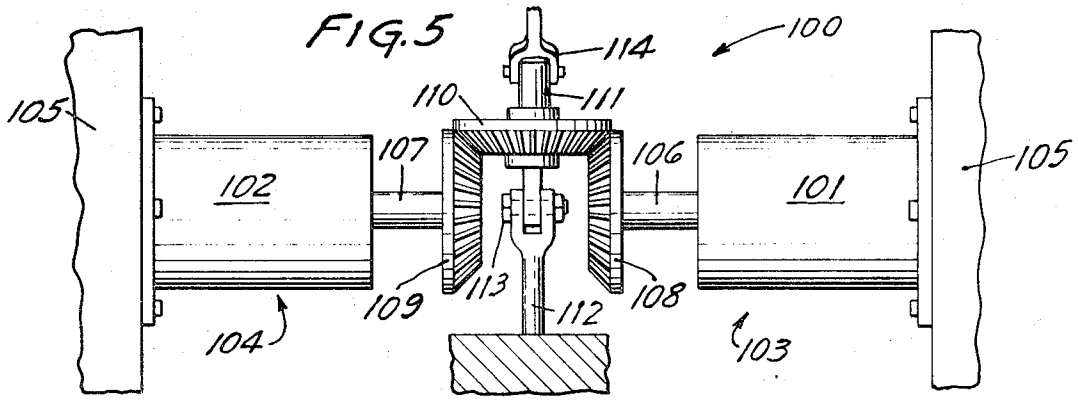
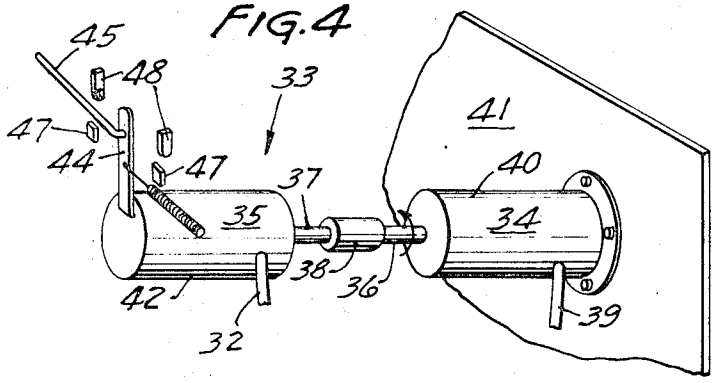
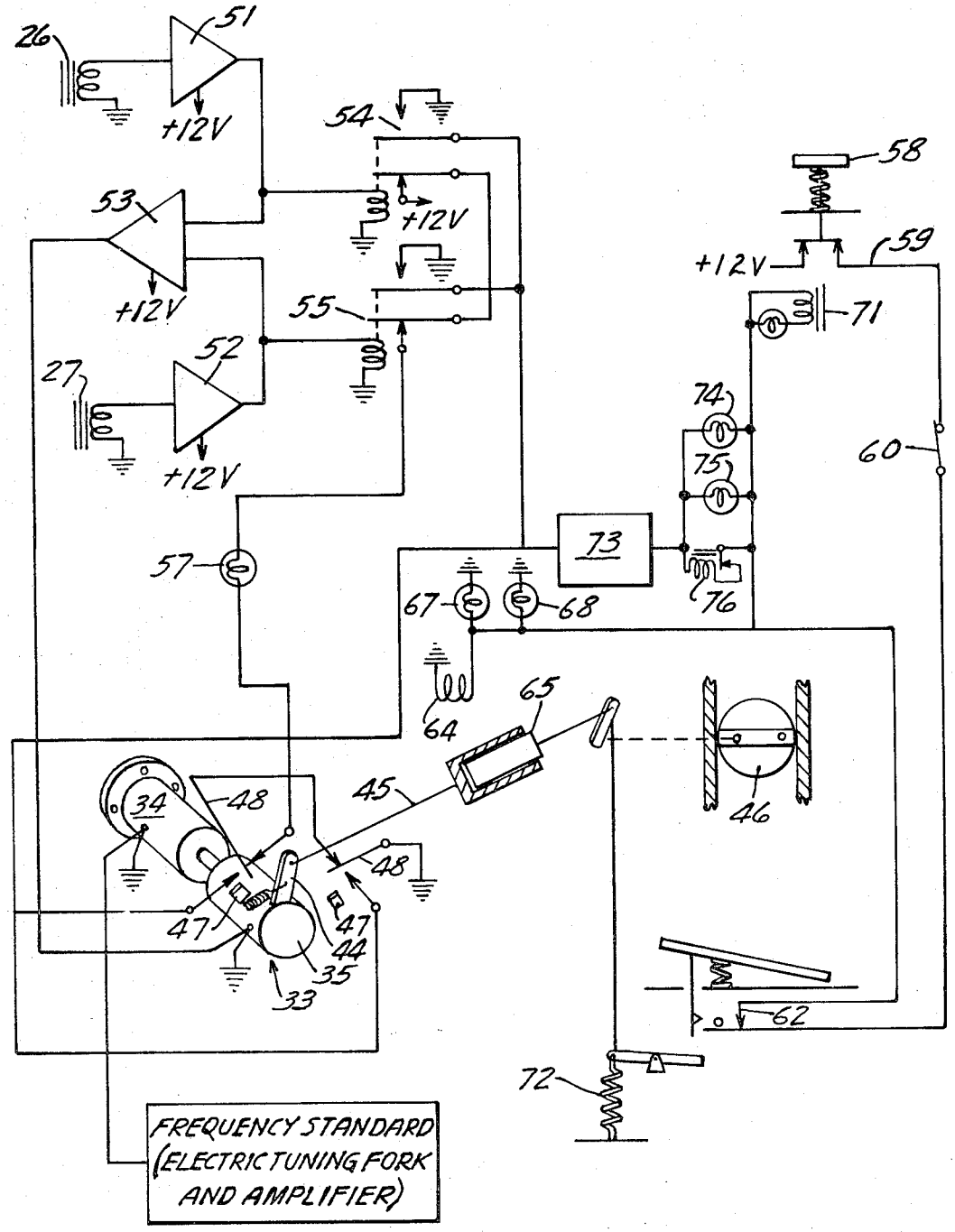



FIG. 4




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FIG. 6




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# AUTOMOBILE SPEED-CONTROLLING MECHANISM

## BACKGROUND OF THE INVENTION

The desire to make automobile driving on highways more safe and easy has led to various suggestions for automatically guiding automobiles. Several of these suggestions have involved forming a path just above the surface of the highway of individual, short, closely spaced magnetic fields that alternate in polarity. An automobile to be guided is equipped with magnetic-flux-sensors which pass through the fields as the auto travels along the highway so that an electric signal is generated in the sensors that is dependent as to frequency on the spacing of the fields and the rate of travel of the auto. This generated signal is then compared as to frequency with a standard frequency and any difference is used to control the speed of the auto.

The devices proposed for controlling the speed of the automobile with the signal derived in the flux-sensors have not been wholly satisfactory for their job. One type of previously suggested speed-controlling device incorporates a frequency discriminator. The discriminator is tuned to a standard frequency, and whenever the frequency of the derived signal fed to the discriminator is either greater or lower than the standard frequency, a direct current is developed in the discriminator. This direct current signal is fed to a servomechanism that operates the car's throttle, slowing the car when the frequency of the derived signal is higher than the standard frequency and accelerating the car when the frequency of the derived signal is lower than the standard frequency.

A major disadvantage of use of a frequency discriminator in an automobile speed-controlling device is that the discriminator has no "memory" for the error that may have developed between the location a car should have at any time and the position it actually has. Thus, when a car is lagging behind the speed that it should have—because it is traveling uphill, for example—the discriminator will develop a signal that will cause the automobile to increase its speed to the speed it should be traveling. But the car will not necessarily make up the ground it lost while traveling at the slow speed. Thus, if adjacent cars travel for many miles under the control of speed-controlling devices based on a frequency discriminator, the distance between the cars will not be precisely controlled. An even flow of traffic will not be obtained, and instead of the traffic being guided wholly automatically, some operation may be required by the drivers.

## SUMMARY OF THE INVENTION

The present invention provides a speed-controlling device that accurately and simply controls the speed of an automobile with a signal derived in flux-sensors as described above, and that also has a "memory" for any difference between the actual and correct positions of the controlled automobile; as a result of this "memory," a speed-controlling device of this invention returns the controlled auto to its correct position. This speed-controlling device incorporates a frequency differential-accumulator, which is a device that includes two synchronous electric motors, with the windings of one of the motors, called the "reference" motor, being supplied with a reference signal having a standard frequency and the windings of the other, "actuating," motor being supplied by the flux-sensor-derived signal. It will be seen that the rates at which the rotating parts of the motors are driven by the motors correspond and lack correspondence when the frequency of the derived and standard signals correspond and lack correspondence, respectively. Connection means physically connect the reference and actuating motors so that one of the stator and armature of the actuating motor is fixed with respect to one of the stator and armature of the reference motor, and so that the rotation of the other of the stator and armature of the actuating motor differs from the rotation of the other of the stator and armature of the reference motor (which may be no rotation) in proportion to any lack of correspondence between the driving rates of the actuating and reference motors. An output member is drivingly connected to the other of the stator and armature of the actuating motor so that the output member is moved in proportion to any lack of correspondence between the driving rates of the actuating and reference motors. Linkage means link the output member to the carburetor throttle valve of the automobile so that movement of the output member opens or closes the throttle valve when the frequency of the flux-sensor-derived signal is lower or higher, respectively, than the frequency that corresponds with the frequency of the standard signal.

In a specific, exemplary embodiment of the invention, the stator of the reference motor is fixed with respect to the automobile body by fastening the external housing of the motor to the automobile body. A rigid couple connects the armature of the reference motor to the armature of the actuating motor; the stator of the actuating motor is supported by the armature of the actuating motor and is otherwise unfixed. Whenever the frequency of the flux-sensor-derived signal deviates from the frequency of the standard signal supplied to the windings of the reference motor, the frequency of the electromotive force developed in the actuating motor—that is, the driving rate of that motor—does not correspond with the rate at which the armature of that motor is actually being turned through its connection to the armature of the reference motor. The result is that the stator of the actuating motor rotates slightly to maintain the relationship to the armature of that motor that is consistent with the frequency of the electromotive force, or the driving rate, developed within the actuating motor. As will be seen, the rotation of the stator of the actuating motor is proportional to any lack of correspondence between the driving rates of the actuating and reference motors.

The output member is connected to the stator of the actuating motor, and is also linked to the carburetor throttle valve; thereby the turning of the stator of the actuating motor controls the speed of the auto. As will subsequently be explained in more detail, the angle, if any, through which the output member has turned at any instant in time is a measure of the extent to which the auto is displaced from the position it actually should have at that instant. Whenever the speed of the auto has been corrected sufficiently that the output member has returned to its original position, the auto then also will have returned to the position it should have at that instant in time. Since the stator of the actuating motor, and the output member connected to it, always tend to return to their original position, the auto always tends to return to its "correct" position.

## DRAWINGS

FIG. 1 is a top view of one-half of a limited-access, six-lane, divided highway on which travel of an automobile equipped with a speed-controlling device of this invention may be controlled;

FIG. 2 is a schematic elevation of a portion of an auto automatically guided according to this invention;

FIG. 3 is a view of the auto of FIG. 2 taken along the line 3–3 in FIG. 2;

FIG. 4 is a schematic perspective view of a frequency differential-accumulator of this invention;

FIG. 5 is a schematic elevation view of a different frequency differential-accumulator of the invention; and

FIG. 6 is a schematic wiring diagram of electric circuitry useful to operate a frequency differential-accumulator of this invention.

## DETAILED DESCRIPTION

FIG. 1 shows a top view of the right-hand half 10 of a limited-access, six-lane, divided highway of this invention. Of the three lanes 10*a*, 10*b*, and 10*c* that form the right-hand half of the highway, two, 10*a* and 10*b*, are not controlled and cars may travel along them at any desired speed within the range established by statutory speed limits, and cars may pass one

another. The inside lane, that is, the lane 10c which is next to the center divider of the highway, is controlled.

The lane 10c of the illustrated controlled highway, has a continuous stripe 11 of magnetizable material down the center, magnetized with a sequence of magnetic poles that are generally spaced from one another between 3 and 16 inches. Preferably the stripe 11 is formed from a magnetizable paint that comprises magnetizable particles such as ferromagnetic oxides or iron filings dispersed in a vehicle that includes an organic polymeric film-forming binder material dissolved in a volatile solvent. The magnetizable stripe 11 can also comprise a metal foil or a performed organic polymeric sheet in which magnetizable particles are embedded or on which they are coated. On other controlled highways the sequence of magnetic fields may be formed by conductors buried in the highway or other means.

An automobile or other vehicle adapted to be controlled according to this invention, such as the vehicle 25 shown in FIGS. 2 and 3, includes at least one magnetic-field or flux-sensor, generally located near the surface of the highway 10 (preferably within 8 inches) so as to minimize the strength of field that must be established by the stripe 11 and minimize the amplification required for the signal developed by the flux-sensor. The vehicle 25 shown in FIGS. 2 and 3 has two flux-sensors 26 and 27, laterally spaced as shown in FIG. 3. The flux-sensors may take various forms, but those illustrated each include two large vanes 28 and 29 of ferromagnetic material formed from the same plate or a sandwich of plates. The vanes, which gather and concentrate the magnetic field through which they pass, are connected by a narrow intermediate portion 30 of the plate or sandwich of plates, and a conductive coil 31 is wrapped around this connecting intermediate portion of the plates.

The signals developed in the two flux-sensors 26 and 27 by passage through the magnetic fields above a magnetized stripe 11 are amplified and combined and then fed to a frequency differential-accumulator of this invention. One frequency differential-accumulator of this invention, 33, is illustrated in FIG. 4 and includes reference and actuating synchronous electric motors 34 and 35, respectively, whose armatures are fixed with respect to one another by connecting their shafts, 36 and 37, respectively, with a rigid coupling 38. The external housing 40 of the reference synchronous motor 34 of this illustrative frequency differential-accumulator is mounted on and fixed with respect to the body 41 of the automobile 25, and the windings of the stator of the reference motor are supplied through conductors 39 from a source of alternating current having a standard reference frequency (such as a reference oscillator that incorporates a precision tuning fork). The actuating synchronous motor 35 is supported only by the connection of its shaft 37 with the shaft 36 of the reference motor, and the windings of the stator of the actuating motor are supplied through conductors 32 by the signal developed in the flux-sensors 26 and 27. The shaft of the reference motor 34 is driven at a constant rate determined by the reference frequency of the signal supplied the first motor. As previously explained, if the frequency of the flux-sensor-derived signal is different from the frequency of the standard signal, the frequency of the electromotive force developed in the stator of the actuating motor 35 does not correspond to the rate at which the actuating motor shaft is actually being driven by the reference motor. The result is that the housing or body 42 of the actuating motor 35 rotates to maintain its proper relationship to its shaft 37.

A lever 44 serving as an output member is fixed to the body 42 of the actuating synchronous motor 35 and turns as the body of the motor turns. A linkage 45, including an electromagnetic coupling 65 (not shown in FIG. 4) that may be deenergized when the auto is not being controlled by the automatic guidance mechanism, extends from the lever 44 to the throttle valve 46 of the automobile's carburetor so that rotation of the body 42 of the actuating motor 35 causes an opening or closing of the carburetor throttle valve. If the vehicle 25 is traveling at a speed below the standard one for the highway being traveled, the frequency of the signal generated in the flux sensors 26 and 27 will be less than the standard frequency and the body of the actuating motor will rotate counterclockwise in FIG. 4 to open the throttle valve. The speed of the vehicle 25 will then increase until the frequency of the derived signal is slightly more than the frequency of the standard signal whereupon the body of the actuating synchronous motor will rotate clockwise in FIG. 4 to close the throttle valve somewhat. After a short time, the body of the actuating motor will find its proper location to maintain the speed of the automobile at the standard speed, after which the lever and carburetor throttle valve will tend to remain at a steady position so long as the standard speed for the highway remains constant.

As will be understood, the body 42 of the actuating motor 35 and the attached lever 44 must rotate freely for satisfactory operation of the frequency differential-accumulator 33. Stops 47 are fixed on both sides of the lever 44 in the path that the lever travels to define the extent of pivoting of the lever. In the ordinary course of control of an auto with the frequency differential-accumulator 33, the lever should never reach the stops 47. Electric switches 48 are mounted adjacent each stop, and, as subsequently described in more detail, operate devices that warn the driver to deactivate the automatic guidance mechanism.

As previously noted, a frequency differential-accumulator of this invention has a "memory" for small differences between the location that a controlled automobile actually has along the highway and the location the automobile should have at any instant in time. In the embodiment of the invention shown in FIG. 4, this memory manifests itself as the angle which the lever 44 assumes at any particular instant. As an example, assume that the actuating and reference synchronous motors 34 and 35 each have 72 poles. For each polarity reversal of the electric signals supplying the motors, the rotating parts of the motors will rotate 5 degrees. Suppose that the magnetic poles along the highway are spaced at 9 inch intervals. If for some reason such as travel uphill, the vehicle loses speed so that it lags 27 inches (3 reversals) in comparison to the location it should have at that instant, the armature of the actuating motor 35 would ordinarily have rotated 15 degrees less than the armature of the reference motor 34. But, since the armature of the actuating motor 35 is rigidly coupled to the armature of the reference motor, the armature of the actuating motor rotates through the same angle as the armature of the reference motor. To maintain the proper relationship between the stator and armature of the actuating motor, the stator or body of the motor must therefore turn 15 degrees from its original position, thereby advancing the throttle valve to increase the speed of the auto. The speed of the auto remains higher than its original speed until the stator or body of the actuating motor 35 returns to its original position. At that point, the actuating motor has experienced the same number of polarity reversals as the reference motor; that is, the three lagging pole intervals have been recovered, and the automobile is in the exact position that it should be in. The "memory" for the three lagging pole reversals has thereby been satisfied.

With an automobile that has traveled constantly under the control of a frequency differential-accumulator of this invention, the number of rotations of the rotating parts of the synchronous motors will be directly proportional to the number of changes in polarity traversed by the automobile, and that number will be directly proportional to the distance traveled by the car if the standard speed does not vary over the course. Accordingly, odometers that will measure distance traveled independently of tire inflation or wheel slip may be driven by the frequency differential-accumulator of this invention. Whether or not the speed of the auto varies over the route, a totalizing counter may be used to accurately inform the driver of his arrival at various exits, for which he has learned the number that should appear on the counter from a map, signs, or brochures received at a tollway entrance.

If the frequency of the standard current is derived from an electrically driven tuning fork having an accuracy of 0.001 percent, which is readily obtainable, two adjacent cars traveling under the control of speed controlling devices of this invention over a course having poles at approximately 9-inch intervals should not change distance by more than 11 feet in 100 miles. Instead of a source of standard frequency in an automobile, the standard frequency could be broadcast by radio and received by a radio receiver in the auto, thereby eliminating even this small error.

Frequency differential-accumulators of the invention can take several forms other than the one illustrated in FIG. 4. Instead of being directly connected to the body 42 of the synchronous motor, the lever 44 may be connected to the body 42 by a gear train that reduces the angular travel of the lever 44 for a given angle of rotation of the body 42. Such a reduction in the travel of the lever 44 is especially desirable where synchronous motors having a small number of poles are used, in which case the lagging or advancing of the car by several intervals between the poles along the magnetizable stripe means a large angular rotation of the body 42. Further, if the shaft, rather than the body, of the reference synchronous motor is fixed with respect to the automobile, and the bodies of the two motors coupled to one another, then the shaft of the second synchronous motor carries the lever that controls the carburetor throttle valve. Or, if the body of the first motor is fixed to the automobile body, but the shaft of the first motor is coupled to the body of the second motor, then the lever 44 will be carried on the shaft of the second motor.

Also, the reference and actuating motors need not have the same number of poles; if, for example, the actuating motor has twice the number of poles that the reference motor has, the frequency of the flux-sensor-derived signal that corresponds to the frequency of the standard signal when the automobile is traveling at the control speed will be twice the standard frequency. Further, instead of using a rigid coupling to connect the parts of the reference and actuating motors, a gear train may fix the two parts with respect to one another, in which case the frequency of the flux-sensor-derived signal that corresponds to the standard frequency may not be equal to the standard frequency.

In another frequency differential-accumulator of the invention, 100, illustrated in FIG. 5, the bodies 101 and 102 of reference and actuating synchronous motors, 103 and 104, respectively, are fixed with respect to one another by fixing them both to the automobile body 105. The shafts 106 and 107 of the motors 103 and 104 are connected by a differential gear train that includes bevel gears 108 and 109 carried on the shafts 106 and 107, respectively, which both mesh with a third bevel gear 110. The gear 110 is rotatably supported on a lever 111 that is pivotably attached to a yoke 112 by a pin 113. A link 114 connects the free end of the lever 111 to the carburetor throttle valve. When a difference in the rate of rotation of the shafts 106 and 107 occurs as a result of a difference between the frequencies of the flux-sensor-derived signal and the standard signal, the gear 110 is caused to advance in an arc about the pin 113. The resulting movement of the lever or output member 111, through the link 114, opens or closes the carburetor throttle valve.

Arrangements other than a physical connection are contemplated for coupling the frequency differential-accumulator to the carburetor throttle and valve. For example, the lever 44 of the embodiment shown in FIG. 4 or the lever 111 of the embodiment shown in FIG. 5 can operate the valve of a vacuum actuator, which in turn moves the carburetor throttle valve; such an arrangement requires less power from the synchronous motors and amplifiers.

FIG. 6 shows a diagram of the electric circuitry that may be used with the frequency differential-accumulator illustrated in FIG. 4. As shown in the diagram, the two flux-sensors 26 and 27 mounted on the auto 25 are each connected to amplifiers 51 and 52, respectively. The amplified signals travel to a mixing amplifier 53 where they are combined and further amplified and then conducted to the actuating synchronous motor 35 of the frequency differential 33. The signals also travel to threshold relays 54 and 55, respectively, and if the signals are high enough in magnitude, they operate the threshold relays to the condition shown in FIG. 6.

Thus, when an automobile 25 travels on highway 10 in adequately close proximity to the stripe to obtain control signals of useable amplitude, the flux sensors 26 and 27 develop a signal that actuates the threshold relays. In all likelihood, when an automobile begins travel on a controlled highway, the lever 44 will be resting against one of the stops 47 and switch 48. The driver has been advised of the speed required to travel on the highway by reading signs or maps, and he accelerates or slows his car to that speed. As the car reaches and slightly passes the control speed, (exceeds or becomes slower than, depending on whether the car was originally traveling slower or faster, respectively, than the control speed) the discrepancy in frequency between the flux-sensor-derived signal and the standard signal causes the lever 44 to lift off the stop 47 and actuate the switch 48, whereupon a range light 57, mounted on the dashboard of the automobile and electrically connected from the threshold relay 55 through the switches 48 to ground, is illuminated. (In an alternative arrangement, the driver may, through operation of a switch or button mounted on the dashboard, actuate a mechanism to center the lever 44 between the stops 47.)

Illumination of the light 57 indicates to the driver of the automobile that he may switch on his automatic guidance system. He does so by pushing the button 58, which is also mounted on the dashboard. Closing the pushbutton 58 completes a circuit from the automobile battery to ground through line 59 and switches 60 and 62, and then through various parts of the automobile guidance system: the coil 64 of a solenoid-based magnetic coupling 65 that connects the lever 44 of the frequency differential-accumulator to the throttle valve of the carburetor; two external lamps 67 and 68 which reveal to other drivers that the automobile 25 is being controlled by an automatic guidance system; and the coil 71 of a solenoid that holds the button 58 in closed position. With the system thus energized, signals developed in the flux-sensors 26 and 27 are compared to a standard frequency by means of the frequency differential-accumulator 33 to operate the lever 44 and control the speed of the automobile.

The vehicle 25 may be taken out of the control of the automatic guidance system by several alternative ways. If the operator of the vehicle either presses the brake pedal or the accelerator pedal, he opens one of the switches 60 and 62, respectively. Thereupon, the magnetic coupling 65 between the frequency differential 33 and the throttle valve 46 is disconnected (whereupon, if the driver is not pressing the accelerator pedal, a return spring 72 tends to return the throttle valve to the idle position).

The operator may remove the automobile at his own volition or he may be warned to do so. For example, if the system is malfunctioning in some way so that the second synchronous motor 35 gets too far behind the first, the lever 44 will strike one of the switches 48 and switch it from its position in FIG. 6. Thereupon, the dashboard light 57 will darken and a circuit to ground will be completed through a thermal flasher 73, the tail light 74 of the automobile 25, a "take-control" light 75 mounted on the dashboard, and a warning buzzer 76. The driver will then assume control of the car and steer it out of the controlled lane. The warning devices are also actuated when the automobile deviates sufficiently from the regular course that the amplitude of signal developed in either flux-sensor 26 or 27 is too low to hold its threshold relay 54 or 55, respectively, in the condition shown in FIG. 6.

Frequency differential-accumulators of the invention have other uses than in automobile speed-controlling devices. For example, they may be used to control the frequency of the current generated in a gasoline-engine power plant. In such a control system, the windings of the reference motor are supplied a standard signal such as from a reference oscillator and the windings of the actuating motor are supplied a portion of

the current generated in the power plant. If the frequency of the generated current varies, the speed of the gasoline engine is changed to correct the frequency of the generated signal; if left uncorrected, the variation in frequency would prevent the satisfactory operation of devices on the system driven by synchronous motors, such as clocks, etc.

I claim:

1. A frequency differential-accumulator for comparing as to frequency a standard electric signal and an electric signal derived in magnetic-flux-sensors on an automobile passing through a patterned sequence of magnetic fields along a highway, comprising (1) a reference synchronous electric motor and an actuating synchronous electric motor that each comprise a stator, an armature rotatively mounted within the stator, and electrically conductive windings carried on at least one of the stator and armature that may be supplied an electric current to cause rotation of the armature relative to the stator, the windings of the reference motor being connected to a source of current having a standard frequency and the windings of the actuating motor being supplied by the flux-sensor-derived signal whereby the rate of said rotation for the reference motor corresponds with the rate of said rotation for actuating motor when the frequencies of the derived and standard signals correspond; (2) connection means physically connecting the reference and actuating motors so that one of the stator and armature of the actuating motor is fixed with respect to one of the stator and armature of the reference motor, and so that the rate of rotation of the other of the stator and armature of the actuating motor differs from the rate of rotation of the other of the stator and armature of the reference motor in proportion to any lack of correspondence between the frequencies of the standard and derived signals; and (3) an output member drivingly connected to the other of the stator and armature of the actuating motor so as to be moved in proportion to any lack of correspondence between the frequencies of the derived and standard signals.

2. A frequency differential-accumulator of claim 1 in which (a) the connection means includes a rigid couple attaching said one of the stator and armature of the reference motor to said one of the stator and armature of the actuating motor, (b) the other of the stator and armature of the reference motor is adapted to be fixed with respect to the automobile body, and (c) the output member is attached to the other of the stator and armature of the actuating motor.

3. A frequency differential-accumulator of claim 1 in which (a) the connection means includes means adapted to attach said one of the stator and armature of the actuating motor and said one of the stator and armature of the reference motor to the automobile body, (b) differential gear means are connected between the other of the stator and armature of the actuating motor and the other of the stator and armature of the reference motor, and (c) the output member is connected to a portion of the differential gear means that moves in response to any difference in the rates of rotation of said others of the stator and armature of the actuating and reference motors.

4. In combination, (A) an automobile, (B) magnetic-flux-sensors positioned on the automobile to travel through a patterned sequence of magnetic fields along a highway, (C) a frequency differential-accumulator for comparing as to frequency a standard electric signal and the electric signal derived in the flux-sensors, comprising (1) a reference synchronous motor and an actuating synchronous motor that each comprise a stator an armature rotatively mounted within the stator, and electrically conductive windings carried on at least one of the stator and armature that may be supplied an electric current to cause rotation of the armature relative to the stator, the windings of the reference motor being connected to a source of current having a standard frequency and the windings of the actuating motor being supplied by the flux-sensor-derived signal whereby the rate of said rotation for the reference motor corresponds with the rate of said rotation for the actuating motor when the frequencies of the derived and standard signals correspond; (2) connection means physically connecting the reference and actuating motors so that one of the stator and armature of the actuating motor is fixed with respect to one of the stator and armature of the reference motor, and so that the rate of rotation of the other of the stator and armature of the actuating motor differs from the rate of rotation of the other of the stator and armature of the reference motor in proportion to any lack of correspondence between the frequencies of the standard and derived signals; and (3) an output member drivingly connected to the other of the stator and armature of the actuating motor so as to be moved in proportion to any lack of correspondence between the frequencies of the standard and derived signals, and (D) linkage means linking the output member to a throttle of the automobile so that movement of the output member adjusts the speed of the automobile.

5. A combination of claim 4 in which, in the frequency differential-accumulator, (a) the connection means includes a rigid couple attaching said one of the stator and armature of the reference motor to said one of the stator and armature of the actuating motor, (b) the other of the stator and armature of the reference motor is fixed with respect to the automobile body, and (c) the output member is attached to the other of the stator and armature of the actuating motor.

6. A combination of claim 4 in which, in the frequency differential-accumulator, (a) the connection means includes means attaching said one of the stator and armature of the actuating motor and said one of the stator and armature of the reference motor to the automobile body, (b) differential gear means are connected between the other of the stator and armature of the actuating motor and the other of the stator and armature of the reference motor, and (c) the output member is connected to a portion of the differential gear means that moves in response to any difference in the rates of rotation of said others of the stator and armature of the actuating and reference motors.