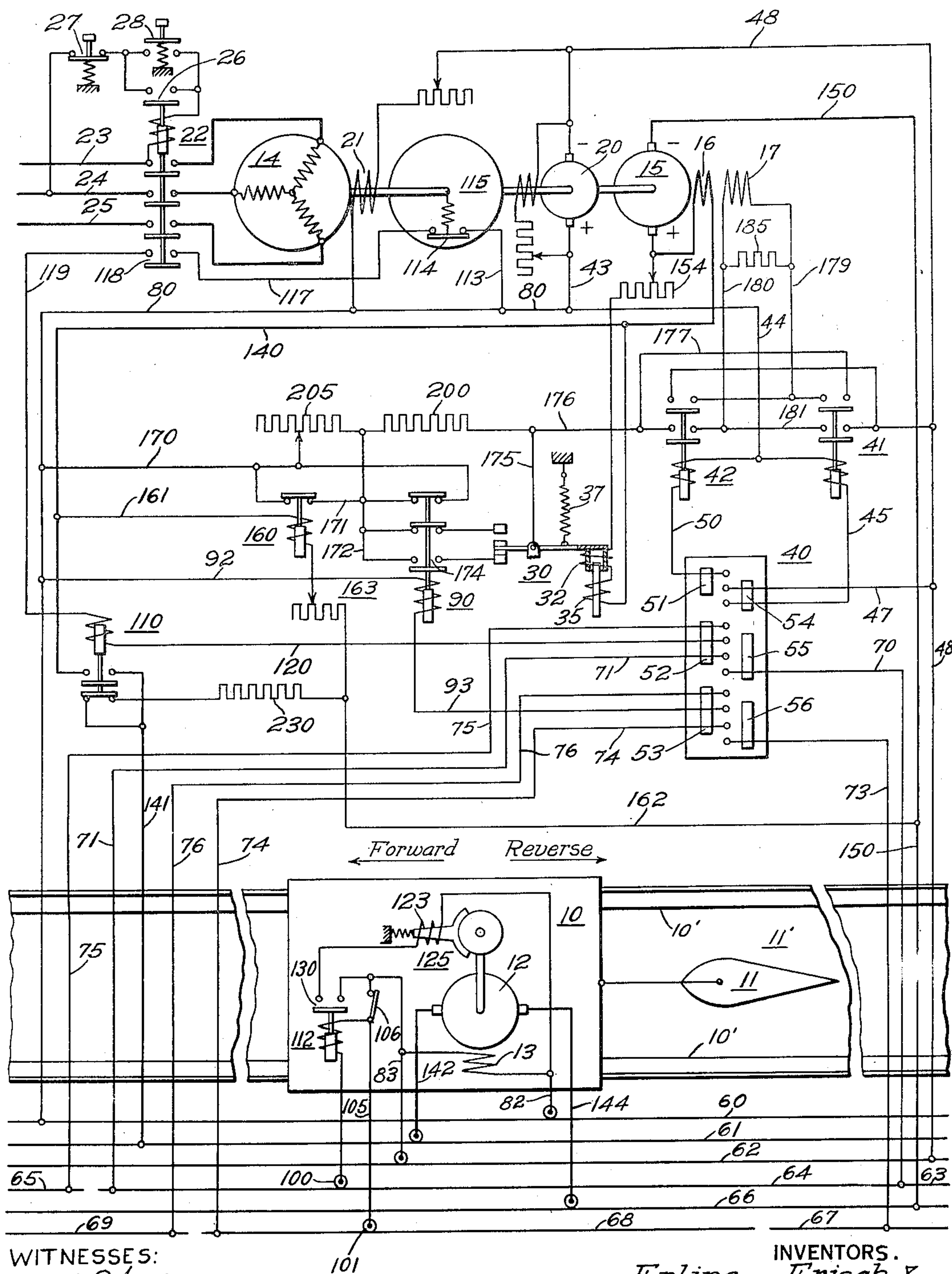


1,940,887

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WITNESSES:

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UNITED STATES PATENT OFFICE

1,940,887

CONTROL SYSTEM

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Serial No. 562,884

10 Claims. (Cl. 104—149)

Our invention relates, generally to control systems and, more particularly, to control systems for propelling a vehicle that may be utilized for towing flying-boat hulls in a channel of water for test purposes.

The design of flying-boat hulls demands the best possible combination of aeronautical and naval architecture. Accordingly, the design of practically all of the flying-boat hulls up to the present time, in order to meet both aeronautical and naval requirements, has been based upon empirical design data obtained by tests conducted with models constructed approximately one-fifth the size of the hulls themselves. In this manner, the designer is assured that hulls constructed in accordance with the empirical design data will perform with a fair degree of success in actual service. Thus, hulls of one type may provide a low resistance on the "take-off" or "landing" but at the same time cause an undesirable spray formation which interferes with the propeller of the sea-plane. Hulls of other types may perform perfectly well in landing harbors where the water is smooth but perform very unsatisfactorily in the open sea where the water is rough.

The only available procedure heretofore known for conducting these tests was to utilize a speed boat provided with the necessary testing equipment to tow models of approximately one-fifth the actual size of hulls through the water. This method, however, has many disadvantages that interfere with obtaining accurate design data. One of these disadvantages is the influence of the waves produced by the speed boat upon the testing model, especially when running at relatively high speeds. More important than this, however, is the inability to operate a speed boat at a substantially constant rate of acceleration, or at a substantially constant speed, to prevent jerking while recording the test values.

Also another disadvantage is the inability to obtain test data at relatively high speeds, since a speed boat cannot attain speeds commensurate with the speeds attained by sea-planes during the "take-off" without producing large waves that interfere with the test data.

The equipment to which our invention may be applied provides for overcoming the foregoing difficulties. Briefly, the equipment comprises

a long water channel of suitable width and depth and a motor-operated vehicle disposed to span the width of the channel and run on suitable trackways and provided with the proper testing equipment for towing flying-boat hulls of full size. In this manner, the testing hulls may be towed through the water at the desired speed without encountering waves such as set up by a speed boat or the like. Likewise, it is possible to obtain test data at relatively high speeds, namely, of the order of sixty miles per hour, since the hulls may be towed through the water at speeds commensurate with the speeds attained by sea-planes during the "take-off" and "landing". Moreover, it is possible, with a control system constructed in accordance with our invention, to tow flying-boat hulls of full size through the water without jerking, thereby permitting the obtaining of accurate design data.

It is an object of our invention to provide a control system for the class indicated that shall be simple and reliable in operation and be economically manufactured and installed.

A more specific object of our invention is to provide for accelerating a vehicle at a substantially constant rate until it obtains a predetermined speed and then for maintaining said speed substantially constant for a predetermined distance of travel.

A further object of our invention is to provide for retarding the movements of a vehicle at a substantially constant rate of deceleration for a predetermined length of time and then for further retarding the movements of the vehicle until it comes to rest.

It is also an object of our invention to provide for changing the rate of acceleration and deceleration of a vehicle in order to accommodate any desired operating or testing condition.

A still further object of our invention is to provide for establishing a plurality of predetermined speeds at which a vehicle may be operated.

Another object of our invention is to provide for remotely controlling the movements of a vehicle from a place other than the vehicle itself.

Other objects of the invention will hereinafter become apparent. For a fuller understanding of the nature and the objects of our invention, reference should be had to the accompanying

drawing, in which a control system embodying the features of our invention is shown.

Referring now to the drawing, the reference character 10 designates a vehicle to which our invention may be applied for towing a flying-boat hull, indicated generally by the reference character 11, disposed in a channel of water 11'. The vehicle 10 is shown disposed to travel on suitable trackways 10' provided therefor along each side of the water channel 11'. Since the construction of the channel and the vehicle comprise no part of our invention, it is deemed unnecessary to show the details of construction thereof.

As shown, the vehicle is propelled by a motor 12 having a separately excited field winding 13. Although only one motor is shown, it is apparent that any number of motors may be operated by our control system. In practice, a motor is connected directly to each wheel of the vehicle.

The motor 12 is energized through the illustrated system of trolley conductors, while are connected is circuit with a motor-generator set comprising a synchronous motor 14, having a field winding 21, mechanically coupled to a direct-current generator 15 having a commutating field winding 16 and a separately excited field winding 17. An exciter 20, disposed to provide a substantially constant voltage excitation for the field winding 21 of the synchronous motor 14, the field winding 17 of generator 15, and the field winding 13 of propelling motor 12, is directly coupled to the shaft of the synchronous motor.

The synchronous motor 14 may be connected to a supply of three-phase alternating-current power represented by the conductors 23, 24 and 25 by means of a starting contactor 22. As shown, the energizing coil of the starting contactor 22 may be connected across the supply conductors 23 and 24, by means of two manually operable push-button switches 27 and 28, the starting push-button switch 28 being normally biased to the open circuit position by means of a suitable spring, and the stop push-button switch 27, which is utilized for disconnecting the synchronous motor from the supply source, being normally biased to the closed circuit position by means of a suitable spring. The starting contactor 22, when operated by the closing of the contact member of the starting switch 28, establishes a holding circuit through a contact member 26 of the starting contactor for continuously energizing the magnetizing coil thereof until the stop switch 27 is operated.

The sequence of the starting of synchronous motor 14 is as follows: Actuation of push-button switch 28 in a downward direction against the bias of its spring establishes a circuit from conductor 24 through stop switch 27, starting push-button switch 28, the coil of the line contactor, or starting contactor 22 to conductor 23. Operation of line contactor 22 closes contact members 26 thereby establishing an energizing circuit for the coil of the line contactor which is in shunt relation to the starting push-button switch 28. The switch 28 may thus be released and motor 14 continues to run.

During the accelerating and decelerating periods of the vehicle 10, the excitation of field winding 17 of the generator 15 is automatically varied by means of a sensitive and accurate regulator 30 of the vibrating type, to cause the generator to deliver a substantially constant amount of current to the propelling motor 12 of the vehicle. The regulator per se does not constitute part of this invention, however. For a more com-

plete description and showing of the regulator of the type utilized, reference may be had to Patent No. 1,684,151, W. Schaelchlin, issued September 11, 1928, and assigned to the assignee of this invention.

The propelling motor 12 may be started in the forward or reverse direction by means of a manually operable control switch 40 which comprises a plurality of contact terminals disposed to be bridged by a plurality of contact segments 51 to 53, inclusive, when the switch is actuated to the right, and a plurality of contact segments 54 to 56, inclusive, when actuated to the left.

The control switch 40, when actuated to the left, establishes a circuit for energizing a relay 41. This circuit may be traced from the positive side of the exciter 20, through conductors 43 and 44, the magnetizing coil of the relay 41, conductor 45, a pair of contact terminals bridged by a contact segment 54, and conductors 47 and 48 to the negative side of the exciter 20. When the control switch is actuated to the right, a circuit is established for energizing a relay 42. This circuit extends from the positively-energized conductor 44, through the actuating winding of the relay 42, conductor 50, a pair of contact terminals bridged by a contact segment 51 and through conductor 47 to the negatively-energized conductor 48.

Operation of the relay 41 provides for connecting the field winding 17 of the generator 15 to have one polarity for operating the vehicle in a forward direction and, conversely, the operation of the relay 42 provides for connecting the field winding 17 of the generator 15 to have the opposite polarity for operating the vehicle in the reverse direction.

Also, the control switch, when actuated to the left, provides for bridging the gaps between the trolley conductors 63 and 64, and the trolley conductors 67 and 68. The bridging connection for the trolley conductors 63 and 64 extends from the trolley conductor 63 through conductor 70, a pair of contact terminals bridged by the contact segment 55 and to the trolley conductor 64 through a conductor 71. The bridging connection for the trolley conductors 67 and 68 extends from the trolley conductor 67 through conductor 73, a pair of contact terminals bridged by the contact segment 56, and through a conductor 74 to the trolley conductor 68.

When the control switch is actuated to the right, it provides for bridging the gaps between the trolley conductors 64 and 65 and the trolley conductors 68 and 69. The bridging connection for the trolley conductors 64 and 65 extends from the trolley conductor 64, through conductor 71, a pair of contact terminals bridged by the contact segment 52 and through conductor 75 to the trolley conductor 65. The bridging connection for the trolley conductors 68 and 69 extends from the trolley conductor 68, through conductor 74, a pair of contact terminals bridged by the contact segment 53 and through conductor 76 to the trolley conductor 69.

In describing the operation of the control system, it may be assumed that the control switch 40 is actuated to the left, and that the synchronous motor 14 is driving the generator 15 and the exciter 20. The operation of the control system will be described in the following sequence, the accelerating period of the vehicle, the running period, and the deceleration period, including first the regenerating braking period and

finally the dynamic and the mechanical braking period.

Under the foregoing assumed condition, the exciter 20 provides for energizing the field winding of the propelling motor 12, through a circuit that extends from the positive terminal of the exciter through conductors 43 and 80, the trolley conductor 60, conductor 82, the field winding 13 of the propelling motor 12, conductor 83, the trolley conductor 62, and through the conductor 48 to the negative side of the exciter.

Also, the exciter 20 provides for energizing a shunting relay 90 through a circuit that extends from the positively energized conductor 80 through conductor 92, the magnetizing coil of relay 90, conductor 93, the contact terminals of the contact switch 40 bridged by the contact segment 56, at which point the circuit is completed through one of two paths depending upon whether the trolley collector 101 is making contact with the trolley conductor 67 or 68. If the trolley collector 101 is making contact with the trolley conductor 67, as it will be during the initial part of the run, the circuit is completed through the conductor 73, the trolley conductor 67, the trolley collector 101, conductor 105, a safety switch 106 and through conductor 83 to the negatively energized trolley conductor 62. If the trolley collector 101 is making contact with the trolley conductor 68, the circuit is completed through conductor 74, the trolley conductor 68, and collector 101, conductor 105, the safety switch 106 and through conductor 83 to the negatively-energized trolley conductor 62.

The exciter 20, likewise, provides for energizing the relays 110 and 112 through a circuit that may be traced from the positive terminal of the exciter, through conductors 43, 80 and 113, the contact members 114 of a speed-limit switch 115, conductor 117, the contact terminals 118 of the starting switch 22 (when in its closed position), conductor 119, the magnetizing coil of the relay 110, conductor 120, contact terminals of the control switch 40 bridged by the contact segment 55, at which point the circuit is completed through one of two paths depending upon whether the trolley collector 100 is making contact with the trolley conductor 63 or 64. If the trolley collector 100 is making contact with the trolley conductor 63, as it will be during the initial part of the run, the circuit is completed through conductor 70, the trolley conductor 63 and collector 100, the magnetizing coil of the relay 112, the safety switch 106 and through the conductor 83 to the negatively energized trolley conductor 62. If the trolley collector 100 is making contact with the trolley conductor 64, the circuit is completed through conductor 71, the trolley conductor 64, the trolley collector 100, the magnetizing coil of the relay 112, the safety switch 106 and through the conductor 83 to the negatively energized trolley conductor 62.

Operation of the relay 112 energizes the solenoid winding 123 of the mechanical brake 125, thereby retracting the brake shoe from the brake drum against the opposition of a spring which normally biases the shoe against the drum. This circuit extends from the positively energized conductor 82 through the winding 123 of the brake and contact terminals 130 of the relay 112 to the negatively energized conductor 83.

The relay 110, when energized, provides for connecting the armature of the propelling motor 12 in circuit with the armature of the generator 15. This power circuit may be traced from the

positive terminal of the generator 15 through its commutating field 16, conductor 140, the upper contact members of the relay 110, conductor 141, the trolley conductor 61, conductor 142, the armature of the motor 12, conductor 144, the trolley conductor 66 and conductor 150 to the negative terminal of the generator.

In order to provide for regulating the value of the current delivered to the motor 12, the coils 32 and 35 of the regulator 30 are connected in series with an adjustable resistor 154 and across the commutating field 16 of the generator. In this manner, the current traversing the coils of the regulator is proportional to the current delivered by the generator to the motor. It is evident that, by regulating the value of the current traversing the coils of the regulator 30 by means of the adjustable resistor 154, the value of the current delivered by the generator to the motor can be varied.

As shown, the coil of the voltage relay 160 is connected directly across the power conductors 140 and 150 by means of conductors 161 and 162 and an adjustable resistor 163. This voltage relay is designed to operate when the voltage produced by the generator attains a predetermined value, which value may represent a predetermined speed of the vehicle. It is apparent that a plurality of predetermined speeds may be selected by regulating the voltages impressed upon the coil of the relay 160 by means of the adjustable resistor 163.

Since the contact members of the relay 160 are closed during the accelerating period, the circuit for energizing the field winding 17 of the generator 15 extends from the positively energized conductor 80 through conductor 170, the contact members of the relay 160, conductors 171 and 172, the contact members 174 of the relay 90, the lower and the movable contact members of the regulator 30, conductors 175, 176 and 177, the upper contact members of the relay 41, conductor 179, the field winding 17 of the generator, conductors 180 and 181, and lower contact members of the relay 41 to the negatively energized conductor 48.

The resistor 185, that is connected across the field winding 17, is disposed to dissipate the energy stored in the field winding when the field circuit is opened. It is observed, from the field winding circuit just traced, that the field winding is connected directly across the exciter 20 without any resistance in the circuit. Accordingly, the maximum field current traverses the field winding 17, with the result that the generated voltage, and, consequently, the generated current, that is being delivered to the propelling motor 12, rises quickly to a value corresponding to the setting of the regulator 30, as determined by the adjustment of the resistor 154. Instantly the magnetic pull produced by the coils 32 and 35 overcomes the force of the opposing spring 37 and thereby connects the resistor 200 in series with the field winding 17 of the generator just as soon as the lower and the movable contact members are separated.

The insertion of the resistor 200 causes the generated voltage to drop, which in turn causes the magnetic force of the coils 32 and 35 to be less than the force of the spring 37, whereby the lower and the movable contact members of the regulator are reclosed. The resistor 200 is thus shunted from the field circuit. The frequency of the opening and reclosing of the lower and the movable contact members is very high. The

vibration sometimes reaches a frequency in the order of 20 cycles per second, depending upon the amount of shunting required to maintain a substantially constant amount of generated current.

From the foregoing description of the regulator, it is apparent that, since the current delivered by the generator to the armature of the propelling motor is substantially constant, and since the field excitation of the motor is substantially constant, the torque produced by the propelling motor is substantially constant during the acceleration period. The speed of the motor rapidly increases and it requires an ever increasing generated voltage to maintain the accelerating current. As the voltage increases, the speed of the vehicle increases in like proportion, and since the torque is substantially constant, the rate of acceleration is substantially constant. This means that a flying-boat hull may be towed through the water at a predetermined rate of acceleration without jerking. It is apparent that any number of predetermined rates of acceleration may be attained by varying the settings of the resistor 154.

Since the cost of constructing a long water channel is many times more expensive than the control equipment and since the capacity of the propelling motors is limited in order to keep the total weight of the vehicle to a minimum, it is necessary to accelerate the vehicle in the shortest possible distance of travel, especially while conducting high speed tests, by operating the generator and the propelling motors at their maximum rating.

This feature may be accomplished very readily by our invention. It is only necessary for the operator to adjust the value of the resistor 154 whereby the value of the current delivered by the generator 15 to the motor 12 corresponds to the maximum current that the motor and the generator can safely stand without flashing over at the commutators or without pulling the synchronous motor 14 out of step.

When the vehicle attains a predetermined testing speed as determined by the setting of the resistor 163, as previously explained, the relay 160 operates to connect a resistor 205 in circuit with the field winding 17 of the generator. The exciting current for the field winding now flows from the positively energized conductor 30 through conductor 170, the resistor 205, to the energized conductor 172 and thence through the field winding 17, as heretofore explained.

The inclusion of the resistor 205 causes the field current to decrease. This reduction of the field current causes the value of the current which the generator formerly delivered to the motor to drop to a value much lower than the current required to operate the regulator, with the result that the resistor 200 is shunted from the field circuit by means of the closing of the lower and the movable contact members of the regulator 30. This means that during the running period the field excitation of the generator is governed solely by the resistance 205. This gives a constant field excitation.

During the running period, since the field excitation of the generator is constant, the current delivered by the generator to the motor is constant and in consequence, the speed at which the vehicle is operated is maintained constant. Therefore, the operation of the relay 160 provides for discontinuing the accelerating period and for initiating the running period.

In order that the adjusted or set value of the resistor 205 may maintain the speed of the vehicle equal to the speed at which the relay 160 operates, the values of the settings of both of the resistors 163 and 205 are simultaneously calibrated. Likewise, in order to facilitate the settings of the resistors they may be calibrated to represent miles per hour of the vehicle. Therefore, when the resistance settings of the resistors 163 and 205 coincide, the speed during the running period is the same as the speed at which the relay 160 operates.

After the vehicle travels a predetermined distance in the forward direction, depending upon the length of the trolley conductors 67 and 68, the relay 90 is deenergized, thereby establishing a circuit for causing the propelling motor 12 to act as a generator to effect regenerative braking. Deenergization of the relay 90 is effected when the trolley collector 101 makes contact with the deenergized trolley conductor 69. Operation of the relay 90 disconnects the resistor 205 from the field winding 17 of the generator and, at the same time, connects the upper contact members of the regulator 30 in circuit with the resistor 200, through the middle contact members of the relay 90, whereby the movable contact member may vibrate with the upper contact member to shunt out the resistor 200. Since the movable contact member is biased away from the upper contact member and since the value of the ohmic resistance of the resistor 200 is considerably larger than the highest possible value of the resistor 205, the field current immediately drops to a predetermined low value, with the result that the induced electro-motive-force of the generator drops below the induced electro-motive-force of the motor. This means that the momentum-driven motor 12 now operates as a generator to deliver current to the generator 15, which now operates as a motor to drive the synchronous motor 14 as a generator and supply energy back into the alternating-current system.

Immediately upon the insertion of the resistor 200 in the field circuit 17 of the generator by the deenergization of the relay 90, the current that is being delivered by the motor 12 to the generator 15 increases to a value corresponding to the operating value of the regulator, and, accordingly, the force of the coils of the regulator overcome the force of the spring 37 and biases the movable contact member of the regulator against the upper contact member. The closing of the upper and movable contact members disconnects the resistor 200 from the field circuit of the generator 15, with the result that the induced voltage of the generator 15 increases to oppose the induced voltage of the motor 12. This causes the current that is being delivered by the motor to the generator to decrease, thereby causing the force of the coils to be less than the force of the spring 37 of the regulator.

The reopening of the upper and movable contact members of the regulator reconnects the resistor 200 in circuit with the field winding of the generator, which causes the induced voltage of the generator to decrease. The reduction in the induced voltage of the generator allows the current delivered by the motor to the generator for effecting the generator braking to increase again. This repeated action causes the upper and movable contact members of the regulator to vibrate, thereby shunting the resistor 200 periodically from the field winding of the generator. The frequency of vibrations of opening

and re-closing of the upper and movable contacts of the regulator 30 is very rapid, depending upon the shunting required to maintain a constant regenerative braking effect, and, as explained hereinbefore, the rate of vibrations sometimes attains a frequency in the order of twenty times a second. Since the spring 37 of the regulator 30 is relatively long, and since the magnetic force of the coils is constant and is independent of the position of the movable coil 32 relative to the stationary coil 35, the current required to vibrate the movable contact member against the upper stationary contact member is substantially the same as the amount of current required to vibrate the movable contact member against the lower contact member. Therefore, the rate of deceleration of the vehicle is substantially the same as the rate of acceleration.

When conducting tests at relatively high speeds, namely of the order of 60 miles per hour, it is necessary to effect the braking in the shortest possible distance of travel, since the length of the test channel is relatively short. Therefore, when conducting these tests, the resistor 154 is so adjusted that the value of the current delivered by the momentum-driven motor to the generator corresponds to the maximum current that the motor and generator can safely stand without flashing over at the commutators.

After the vehicle travels a predetermined distance, depending upon the distance between the gap between the trolley conductors 63 and 69 and the gap between the trolley conductors 64 and 65, in which interval the speed of the vehicle has been reduced considerably, the regenerative braking discontinues and dynamic and mechanical braking are simultaneously effected to bring the vehicle to rest. This action is accomplished by deenergizing the relay 110 when the trolley collector 100 makes contact with the deenergized trolley conductor 65. Operation of the relay 110 establishes a dynamic braking circuit for the motor through a resistor 230. This circuit extends from a terminal of the motor 12, through conductor 142, the trolley conductor 61, conductor 141, the lower contact members of the relay 110, the resistor 230, conductors 162 and 150, the trolley conductor 66 and through the conductor 144 to the opposite terminal of the motor. At the same time the current collector 100 makes contact with the trolley conductor 65, the relay 112 is deenergized, thereby disrupting the circuit that formerly energized the magnetizing coil 123 of the mechanical brake 125. Deenergization of the magnetizing coil of the brake causes the spring to bias the brake shoe against the drum. The action of the mechanical braking in cooperation with the dynamic braking effect a high braking force, which brings the vehicle to rest within a relatively short distance of travel.

Upon the completion of a test in one direction, the flying boat hull may be attached to the other end of the vehicle and a test may be conducted in the reverse direction by actuating the control switch 40 to the right. The control switch 40, when actuated to the right, provides for bridging the trolley conductors 64 and 65 and the trolley conductors 68 and 69, and for disconnecting the trolley conductors 63 and 64 and the trolley conductors 67 and 68. Therefore, the operation of the vehicle in the reverse direction is the same as that heretofore explained for the operation in the forward direction. In the reverse direction, regenerative braking is initiated when the current collector 101 makes contact

with the deenergized trolley conductor 67, and dynamic and mechanical braking are initiated when the current collector 100 makes contact with the deenergized trolley conductor 63.

In the interest of safety, a speed limit switch 115 is provided to initiate dynamic and mechanical braking in the event of a failure of the alternating-current supply source represented by the conductors 23, 24 and 25. In such event, the current delivered by the momentum-driven motor 12 to the generator 15 would cause the generator to drive the synchronous motor at extremely high speed since the synchronous motor can deliver no power back to the supply system. When the synchronous motor attains a predetermined speed, the centrifugal force of the bridging members 114 of the speed-limit switch overcomes the pull of the illustrated spring and thereby interrupts the circuit that energizes the relay 110. Therefore, the speed limit switch 115 provides for immediately effecting dynamic and mechanical braking upon the failure of the alternating-current supply source.

Also, as an additional safety feature, means are provided for initiating mechanical braking and dynamic braking independently of the control system by opening the manually operated switch 106. The opening of the switch 106 deenergizes the relays 110 and 112 and thereby establishes dynamic and mechanical braking to retard the movements of the vehicle.

We have thus described a control system that provides for accelerating a vehicle at a substantially constant rate until it attains a predetermined speed and then for maintaining said speed substantially constant for a predetermined distance of travel. Also, we have described a control system for retarding the movements of a vehicle at a substantially constant rate of deceleration during the regenerative braking period, the rate of deceleration being substantially the same as the rate of acceleration. Furthermore, we have described a control system for regulating the value of current delivered by the generator to the motor during the accelerating period and the current delivered by the motor to the generator during the regenerative braking period so that it corresponds to the maximum current that the motor and generator can safely stand without flashing over at the commutators.

Since certain changes in our invention may be made without departing from the spirit and scope thereof, it is intended that matters contained in the foregoing description and shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

We claim as our invention:

1. A control system for vehicles utilized for towing boat hulls and the like for test purposes comprising, in combination, a source of electrical energy, a motor energized by the said source for propelling a vehicle, means for accelerating the vehicle at a substantially constant rate of change of velocity until it attains a predetermined speed, means for maintaining said speed substantially constant for a predetermined distance of travel, means for retarding the movements of the vehicle at a substantial constant rate of change of velocity for a predetermined distance of travel, and means for further retarding the movements of the vehicle until it comes to rest.

2. A control system for vehicles utilized for towing boat hulls and the like for test purposes comprising, in combination, a source of electrical energy, a motor energized by the said

hource for propelling a vehicle, means for accelerating the vehicle at a substantially constant rate of change of velocity until it attains a predetermined speed, means for maintaining said speed substantially constant for a predetermined distance of travel, means for preselecting the rate of change of velocity at which the vehicle is accelerated, means for providing a plurality of predetermined speeds, means for retarding the movements of the vehicle at a substantially constant rate of change of velocity for a predetermined distance of travel, means for preselecting the said rate of change of velocity at which the vehicle is decelerated, and means for further retarding the movements of the vehicle until it comes to rest.

3. A control system for vehicles utilized to tow boat hulls and the like for test purposes comprising, in combination, a generator, means for driving the generator, a motor connected in circuit with the generator for propelling a vehicle, means for delivering a substantially constant predetermined amount of current to the motor, thereby producing a substantially constant torque, means responsive to a predetermined speed for decreasing the amount of current delivered to the motor to a predetermined value, means for maintaining the decreased value of the current substantially constant, means effective after a predetermined distance of travel for delivering a substantially constant predetermined amount of current to the generator, thereby retarding the movement of the vehicle by a substantially constant torque, and means effective after a second predetermined distance of travel for effecting dynamic and mechanical braking until the vehicle comes to rest.

4. A control system for vehicles utilized to tow boat hulls and the like for test purposes comprising, in combination, a source of electrical energy, a propelling motor disposed to be driven by the momentum of the vehicle, means including a plurality of trolley conductors for connecting the motor in circuit with the said source, means for accelerating the vehicle, means for effecting regenerative braking of the motor, and a relay of the vibrating type for so controlling the amount of current delivered to the motor during the accelerating period and for so controlling the amount of current delivered to the said source during the regenerative braking period that the rate of change of velocity of the vehicle during the accelerating and the decelerating periods is substantially constant, thereby avoiding any jerking of the boat hulls.

5. A control system for vehicles utilized to tow boat hulls and the like for test purposes comprising in combination, a source of electrical energy, a motor connected in circuit with the said source, means for accelerating the motor, means for effecting regenerative braking thereof, and a relay of the vibrating type for maintaining the amount of current delivered to the motor during the accelerating period substantially the same as the amount of current delivered to the said source during the regenerative braking period.

6. A control system for vehicles utilized to tow boat hulls and the like for test purposes comprising, in combination, a source of electrical energy, a motor connected in circuit with the said source, means for accelerating the motor, means for effecting regenerative braking thereof, and a relay of the vibrating type for maintaining the amount of current delivered to the motor during

the accelerating period substantially the same as the amount of current delivered to the said source during the regenerative braking period, and means for preselecting the amount of current delivered to the motor and the amount of current delivered to the said source, thereby preselecting the rate of change of velocity at which the motor is accelerated and decelerated.

7. A control system for vehicles utilized to tow boat hulls and the like for test purposes, comprising, in combination, a source of electrical energy, a motor connected in circuit with the said source, means for accelerating the motor, means for retarding the motor, and means including a relay of the vibrating type for maintaining the rate of change of velocity during both the accelerating and the decelerating periods substantially the same.

8. A control system for vehicles utilized to tow boat hulls and the like for test purposes comprising, in combination, a power generator having a field winding, an auxiliary generator, means for driving the two generators, a motor, having a field winding, to propel the vehicle, circuit connections including sectionalized trolley conductors to interconnect the armature and the field winding of the motor in circuit with the power generator and the auxiliary generator, respectively, means for establishing a circuit connection to accelerate the vehicle, means operable after the vehicle has accelerated to a predetermined selective velocity, for establishing a circuit connection to cause the vehicle to run at the said predetermined selected velocity, means for establishing a circuit connection to decelerate the vehicle after the vehicle has traveled a predetermined distance, means for interconnecting the field winding of the power generator in circuit with the auxiliary generator, and means for so regulating the field excitation of the power generator that the rate of change of velocity of the vehicle during the accelerating and decelerating periods and the velocity during the running period is substantially constant.

9. A control system for vehicles utilized to tow boat hulls and the like for test purposes comprising, in combination, a power generator having a field winding, an auxiliary generator, means for driving the two generators, a motor having a field winding to propel the vehicle, circuit connections including sectionalized trolley conductors to interconnect the armature and the field winding of the motor in circuit with the power generator and the auxiliary generator, respectively, means for establishing a circuit connection to accelerate the vehicle, means operable after the vehicle has accelerated to a predetermined selected velocity for establishing a circuit connection to cause the vehicle to run at the said predetermined selected velocity, means operable after the vehicle has traveled a predetermined distance for establishing a circuit connection to decelerate the vehicle, means for interconnecting the field winding of the power generator in circuit with the auxiliary generator, and a vibrating relay that is responsive to the current flowing through the power generator for so regulating the field excitation of the power generator that the rate of change of velocity of the vehicle during the accelerating and the decelerating periods is substantially constant.

10. A control system for vehicles utilized to tow boat hulls and the like for test purposes comprising, in combination, a power generator having a field winding, an auxiliary generator,

means for driving the two generators, a motor having a field winding to propel the vehicle, circuit connections including sectionalized trolley conductors to interconnect the armature and the field winding of the motor in circuit with the power generator and the auxiliary generator, respectively, means for establishing a circuit connection to accelerate the vehicle, means operable after the vehicle has accelerated to a predetermined selected velocity for establishing a circuit connection to cause the vehicle to run at the said predetermined selected velocity, means operable after the vehicle has traveled a predetermined distance for establishing a circuit connection to decelerate the vehicle, means for interconnecting the field winding of the power generator in circuit with the auxiliary generator, and means for preselecting the velocity during the running period and the rate of change of velocity during the accelerating and decelerating period.

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