

Sept. 7, 1937.

H. S. PARDEE

2,092,014

TRAIN CONTROL

Original Filed Feb. 9, 1931

3 Sheets-Sheet 1

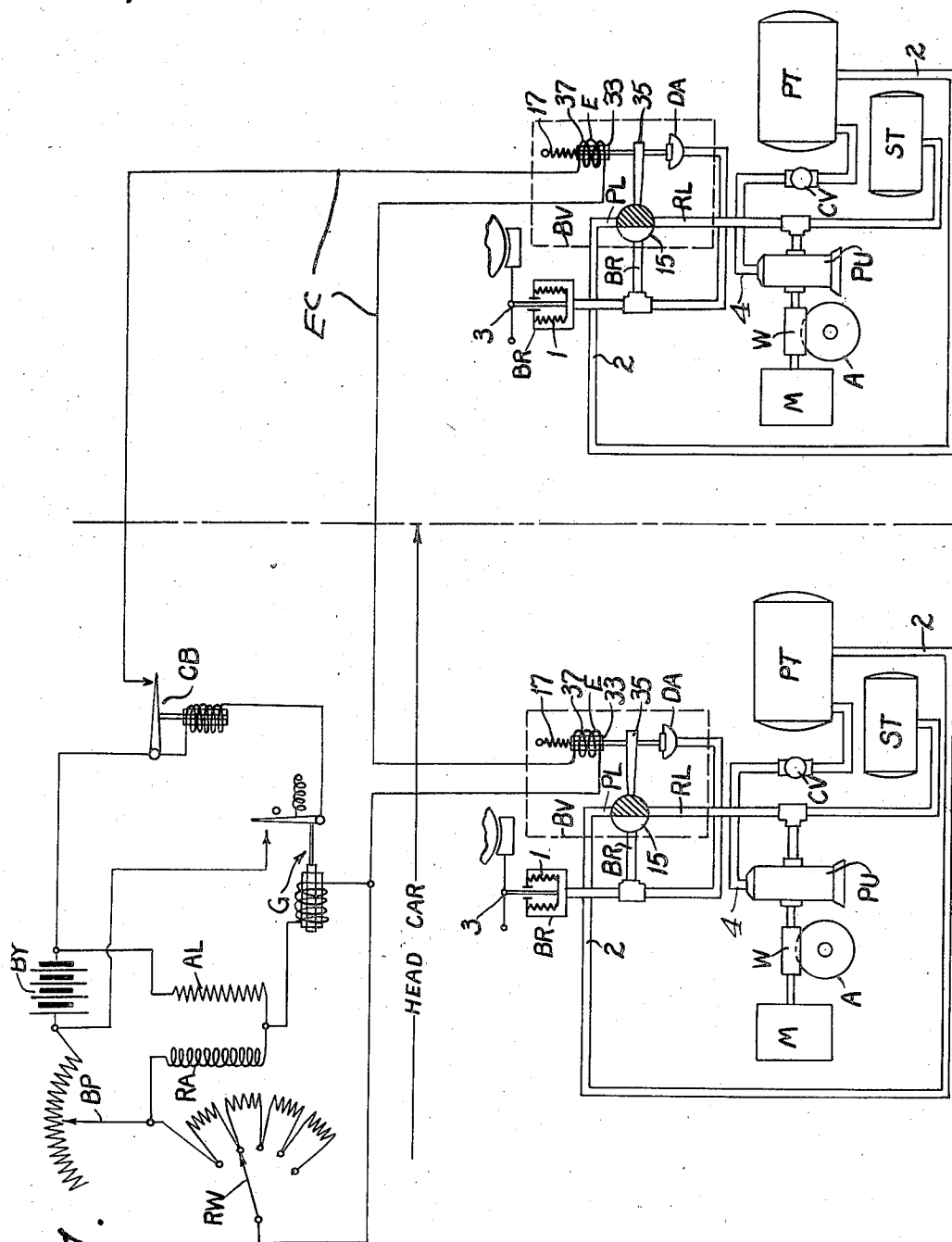


Fig. 1.

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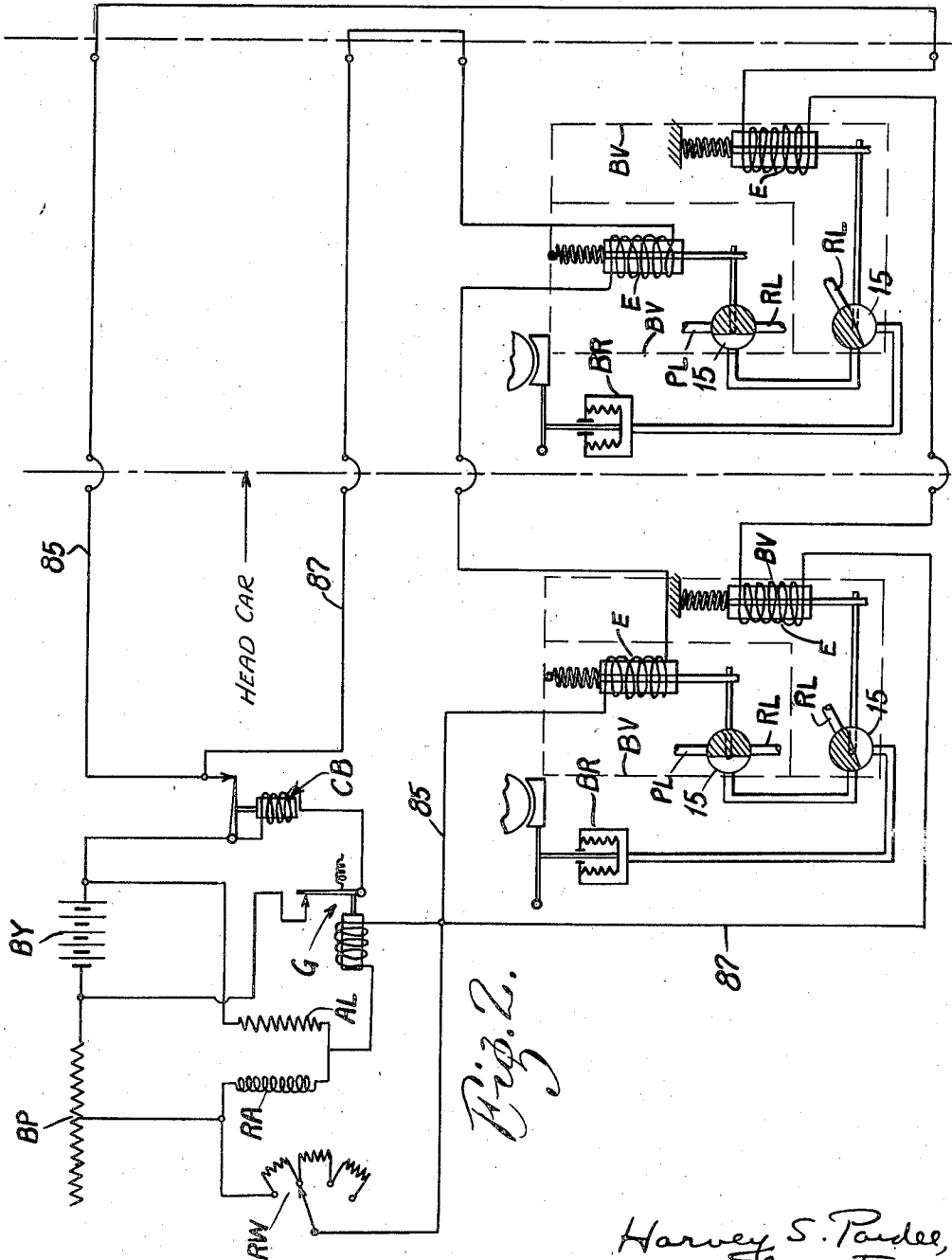


Fig. 2.

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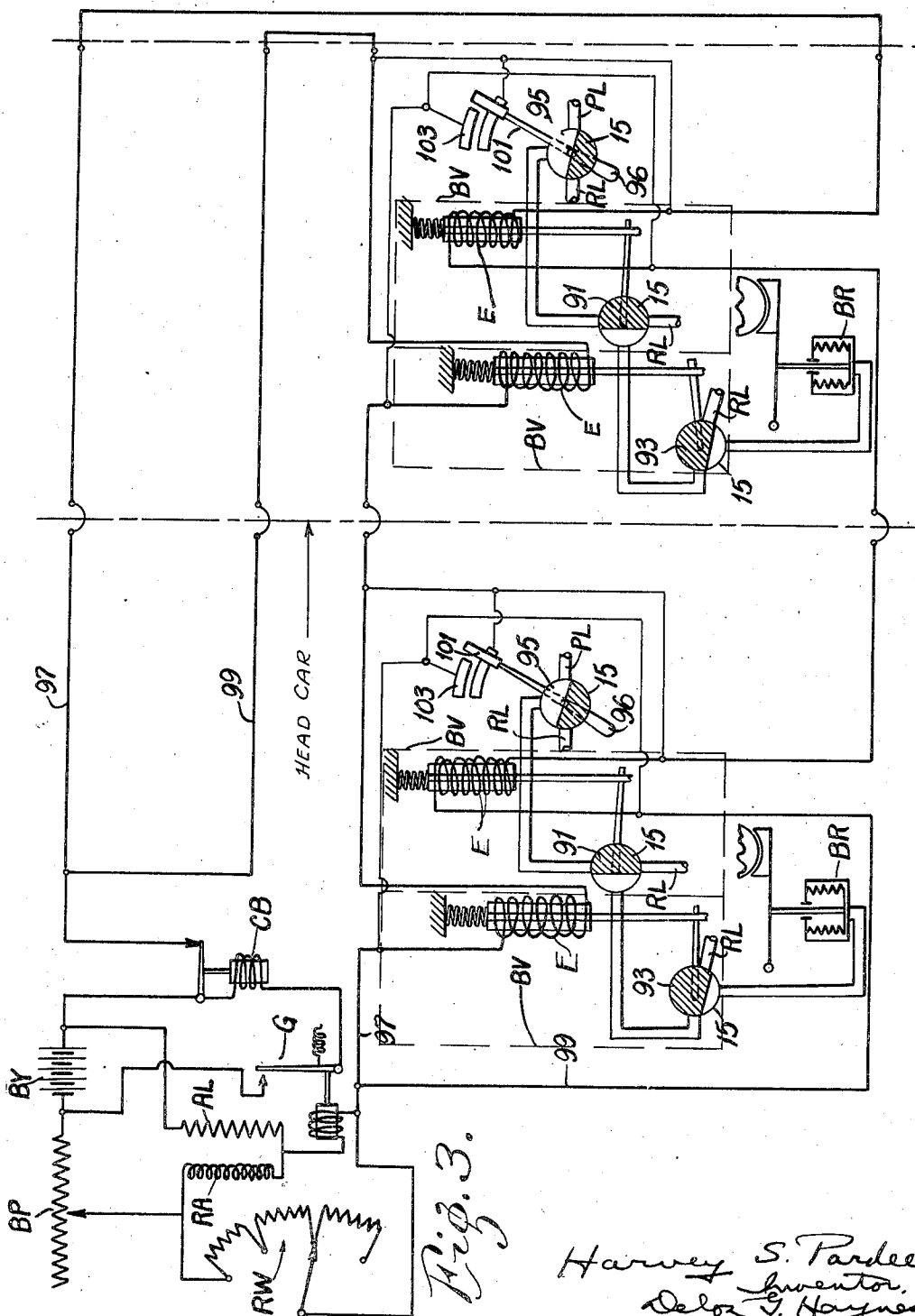
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3 Sheets-Sheet 3



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## UNITED STATES PATENT OFFICE

2,092,014

## TRAIN CONTROL

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mesne assignments, to Hydromatic Corpora-  
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Application February 9, 1931, Serial No. 514,441  
Renewed December 4, 1936

14 Claims. (Cl. 303—20)

This invention relates to control systems, and with regard to certain more specific features, to train control systems.

The invention comprises an improvement upon the control apparatus shown in my Patent 1,784,310 and that shown in the application of myself and Arthur W. Baumgarten, Serial No. 457,005, filed May 29, 1930.

Among the several objects of the invention may be noted the provision of a control system for operating the brakes, doors and related parts of conveyances such as rail cars, coaches, buses or the like in which an adaptation is made to trains of two or more vehicles.

Another object of the invention is to improvedly control from a single point one or more functions on several vehicles, there being effected a connection between the vehicles and certain automatic operating means whereby difficulties caused by a break in the train are minimized.

Another object of the invention is to effect optimum control of a limited number or any number of cars.

Another object is to provide a system adapted to easily coordinate brake control features with door control and like features.

Other objects will be in part obvious and in part pointed out hereinafter.

It is to be understood that the cars or conveyances or vehicles to which the invention may be applied may be driven by electric or other motors or means and are provided with the usual body constructions suiting them to their particular purposes.

The systems to be described herein refer to cars and trains of cars for street railway operation, electric and steam train operation and other trains of trucks and the like.

The vehicles referred to are provided with brakes, preferably of the friction type contacting with some rotating elements of the vehicles.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structure hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings in which are illustrated several of various possible embodiments of the invention,

Fig. 1 is a diagram illustrating connections to be used in a train of any number of cars;

Fig. 2 is a diagram similar to Fig. 1 but showing duplicate valves and control lines; and,

Fig. 3 is a diagram similar to Fig. 2 but show-

ing a hand control valve in series with the duplicate valves.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

The drive for the vehicle herein described may comprise the spur or worm gear type, with brakes operating in connection with a drive shaft or the wheels. In Fig. 1 such a drive is diagrammatically illustrated as comprising a motor M driving a worm W, the latter meshing with a suitable worm gear A on an axle of the vehicle. As above indicated, the brakes may include shoes which are pressed directly against the wheels.

The braking system herein is represented as comprising a system of brake cylinders BR which force friction brakes against the driving parts of the vehicle. The brake cylinders BR receive fluid pressure in the ordinary manner but, instead of being provided with pistons, they are provided with internal, movable bellows 1 which are positively leak-proof. Each of the bellows 1 is connected on the outside with the brakes, this being done by means of a suitable linkage 3. On the inside, each bellows 1 is exposed to fluid pressure. The movement is enough to set and release the brakes.

It is to be understood that the bellows, wherever referred to herein, are representative of any and all types of substantially movable diaphragms or means adapted to transmit motion but to prevent passage of fluid.

An electromagnetic brake valve BV on each car comprises an electromagnet E, the movable core which is connected to the actuating arm of a three-way valve 15 and to the center of a diaphragm DA subjected on the opposite side to the pressure in the line BR leading to the brake cylinders. A spring 17 acts against the core 33 to move it in the direction of applying fluid pressure to the brakes. As the current in the coil 37 of the magnet E is increased the core acts against the spring and tends to shut off pressure from the pressure line PL to the brake line BR and next to connect the brake line BR to the return line RL, thus relieving the brakes of pressure. The reaction of the diaphragm DA is to oppose both actions and thus to bring about a condition of stable balance for each value of the control current. At zero current the spring overcomes the diaphragm pressure until full braking pressure is admitted. At maximum current the core compresses the spring and turns the valve to release the pressure on the brake line (and under the diaphragm) so that finally the balance

between spring and coil is reached with zero pressure on the diaphragm.

The tank PT comprises a pressure tank designed to withstand the air pressure used and to be air, oil and water tight, for example, the tank pressure may be 100 pounds per square inch.

The sump tank indicated by letters ST, is under atmospheric pressure and preferably placed at the lowest part of the system to receive the drainage from the door engines (if there be such) and brake cylinders. The size of this tank is preferably such that when full it will hold such a quantity that when substantially all of its contents is pumped into tank PT, the pressure in tank PT will be raised from minimum to slightly above maximum providing tank PT is initially filled with air at the minimum operating pressure.

Other details regarding these tanks and their connections may be found in said Patent 1,784,310.

The hydraulic pump PU is preferably of the rotary positive type, and connected directly to a moving axle or propeller shaft of the vehicle. It thus starts and stops with the motion of the car or engine. It should be arranged with a minimum amount of initial slip so that when the pump starts the pressure on the delivery side will build up quickly. This pump need have but a small pumping capacity because the demands for liquid quantity are relatively small when non-expansive fluid is used instead of an expansible gas. By-passes and other auxiliary pump equipment are not here shown inasmuch as they have been disclosed in said Patent 1,784,310, enough having been herein disclosed to make clear the improvements.

Although it is possible to apply the present invention to a pneumatic system, and the claims cover such, it is preferable that a hydraulic system be used. The hydraulic fluid to be used in the present system comprises preferably a liquid relatively non-expansive and non-compressible as compared with gases such as air. It should be selected with a viscosity reasonably constant at the various operating temperatures; it should not corrode metal and should have a low enough vapor tension so as not to create an appreciable vapor pressure at the operating temperatures. It should not deteriorate with time or use. It will be seen from the above that fluids such as are now known for hydraulic braking systems may be used, or oil or the like.

#### *Train control (Fig. 1)*

Fig. 1 shows the first application of the invention. The operation of the pump PU, pressure tank PT and sump tank ST has been made clear in Patent 1,784,310, but broadly speaking, the sump tank ST carries a charge of liquid. The pressure tanks PT carry a charge of air. The pump PU pumps liquid from the sump tank ST into the pressure tank PT to build up the pressure therein to a point where said pressure is useful through the liquid as a compression link, to apply or release the brakes, depending upon whether the brakes are to be directly set or spring set. Excessive pressures are avoided by suitable pump by-passes and/or slip as stated in said patent.

The cars are each provided with a hydraulic system. The only connections between cars is an electric control line EC.

Thus the operating valves on each car are controlled from the head car by electric lines. These lines may be hydraulic.

Referring to Fig. 1, PT indicates the pressure

tank, one of which is installed on each car. BV is an electromagnetically controlled brake valve on each car, BP a rheostatic hand-controlled lever in the head car, BY is the operating source of E. M. F. and RL the fluid return line. All of the brake valves BV operate simultaneously by control of the rheostat BP. Liquid pressure is thus admitted from the respective pressure tanks PT to the respective brake cylinders on the respective car, thus causing the brakes to be set or released, depending upon whether springs are used to apply the brakes or direct fluid pressure. The direct fluid pressure method is shown in the brake linkages of Fig. 1. When the fluid is released it flows to the return line and to the sump tank ST on each car where it is pumped to the pressure tank PT as set forth in said Patent 1,784,310.

Between the line 4 from each pump PU and each storage tank PS is a check valve CV which prevents the storage tank from discharging back into the line in the event of a break in the line. But each tank PT delivers to the proper valve BV by way of line 2.

The brake valves BV are arranged so that a continuous current is required to hold the valves in release positions. As this current is diminished the brakes are applied, reaching full application when the current approaches zero. Full application consequently also occurs when the electric train control line is broken for any reason.

The electric train control line is also subject to accidental short-circuits which might act to set the brakes on only part of the train. Therefore, for protection against any change in the resistance of the line due to open circuit or short circuit, partial or complete, there is used the Wheatstone bridge arrangement of resistances AL, RA, RW and the electromagnetic valves BV, with a relay G connected across the bridge between resistances AL and RA on one hand, and RW and BV on the other hand. AL and RA are relatively high resistances; and AL is preferably arranged with sufficient self-inductance so that its time constant is substantially the same as the control line containing the electromagnetic valves. This keeps the bridge in balance during momentary changes in current flow.

The relay G which is connected across the bridge, as shown, is balanced in open position during normal operation, but any substantial change in the resistance of the line, greater or less than normal will close the contact on said relay G and close the operating coil of a circuit-breaker CB to open the train line control circuit. This acts through the electromagnetic valves BV to set the brakes on all cars at once.

As more or fewer cars are used in the line the resistance RW is adjusted so that the relay G is in balance and this balance is maintained regardless of the current used to operate the valves. Control of the system is entirely through the rheostatic controller BP which carries the current in the line to the valves BV. This variation may also be obtained by taking variable taps from the battery instead of using a rheostat.

It will be noted in connection with Fig. 1 that the solenoids of the brake valves BV are connected in series.

In the operation of trains using hydraulic systems, the control circuit may be opened or grounded due to minor, accidental causes less than breaking in two of the train. This will result in safe stopping of the train but means should be provided to prevent any delaying of

the train on the track while repairs are made, or normal conditions restored.

The desired result is effected by providing duplicate control system as shown in Fig. 2. This method provides duplicate control lines 85 and 87 and duplicate valves 15 in the electro-magnet valves BV, the valves 15 of the valves BV, being connected in series as shown.

In Fig. 2 the lines 85 and 87 and the electro-magnet valves BV are shown partially energized to effect neutral positions of the valves 15. If now the position of either one of the valves 15 is changed to brake applying position, nothing happens, inasmuch as no through connection has been made between PL and BR. If, however, the other valve 15 is then changed to brake applying position by the deenergizing of its magnet E, communication is established between PL and BR and the cylinder BR is operated. Either valve 15 may now close the connection and thus control the brake cylinder BR.

Both of the duplicate lines 85 and 87 are normally energized and are operated together. Both lines, however, must be de-energized to apply the brakes, and if both of the lines 85 and 87 are de-energized, that is, not carrying current, either or both may be energized to apply the brakes. Thus, although either of the lines 85 or 87 may be rendered inoperable by breakage or by short circuiting or the like, the remaining line is still capable of controlling the operation of the brake cylinders and the pressure lines.

Referring now more particularly to Fig. 3, there is shown another method of providing emergency control. Of three three-way valves 15 which are shown in series in a brake line of a single car, valves 91 and 93 are controlled by electromagnets E and are normally operable to apply the brakes from the electrical control system, being arranged, as described in Fig. 2, so that both must be de-energized to apply the brakes, but either may be energized to release the brakes. The three-way hand valve 95, also in series with the valves 91 and 93, is adapted to control the pressure to the brake cylinders BR when both of the valves 91 and 93 are set in braking position, as when the control lines 97 and 99 are disconnected, on single cars in the yards, or portions of a disabled train. Thus the hand valve 95 may be used to keep the brakes released while the car is being switched or moved in other than regular long train operation.

Each valve handle 95 is provided with a contact arm 101 adapted to contact with sector 103 when in release position. The arms 101 and the sector 103 short circuit the coils of the magnet valves 91 and 93 when the hand valve 95 is used to release the brake, as for instance, when the car is being switched about. This prevents the control of the brakes by the control line during switching or the like. If the hand valve 95 is left in released position after the car has been incorporated in the train, this fact becomes evident to the operator because in order to obtain a balance of the Wheatstone bridge arrangement the setting of this resistance RW will not correspond to the number of cars in the train. He may then locate the car with the valve 95 in released position and change it to normal. An advantage of this method of control is the ease with which cars may be switched about in the yards without connecting or disconnecting the electrical control system.

An advantage offered by the emergency control method is the fact that the failure of one of the

control systems will not stop the train, which may still safely proceed with full braking capacity made available by the duplicate control line. Further, the attention of the operator is called to the fact that one of the control lines has become inoperative by means of the change in resistance required in setting RW, or by the change in position of the relay G.

In the hydraulic systems shown above the energy storage was obtained by means of compressed air (or other gas) trapped in the top of the pressure tanks (see Patent 1,784,310). Most gases are absorbed to a greater or less extent by the liquid used necessitating a make-up system such as for example, as is described in the patent application of myself and Arthur W. Baumgarten, Serial Number 457,005 filed May 29, 1930. The need for such a system may be minimized by the use of a gas which is not as readily absorbed as air is and for this I find it advantageous to use helium gas. Other gases with similar characteristics may be used in place of air if desired.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in carrying out the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A train control system comprising fluid-operated braking means for a train of cars, valved means in each car adapted in conjunction with said braking means to set the brakes, an electrical circuit running the length of said train of cars, means for energizing said circuit, means in said circuit and associated with each of said valved brake controlling means operable to be set to predetermined braking and release positions at predetermined current values in said circuit, the arrangement being such that substantially zero current value in said circuit corresponds to a setting of said valved means causing operation of the brakes, resistances in said circuit arranged with the valve operating portions thereof as a Wheatstone bridge, and a circuit breaker controlled from said bridge adapted to open the circuit when the same is substantially unbalanced as to resistances, whereby local, short, or open circuits effect braking operation.

2. An electrical train control circuit comprising brake valves, a circuit, separate brake valve operating means in said circuit, means for energizing the circuit, control means for regulating the amount of energization, said brake control means being adapted to affect the brake valves according to the positioning of said control means and means for inserting compensating resistance into said circuit for accommodating a change in the number of brake valves to be controlled, auxiliary resistances in said circuit, a circuit breaker therein and a relay adapted to cause operation of the circuit breaker, the brake valve operating means and said compensating resistances being arranged as a Wheatstone bridge with said relay, whereby an open or short circuit will cause operation of at least one of said brake valves.

3. A train control comprising brake valves, a circuit, brake valve operating means in said circuit, means for energizing the circuit, variable means for controlling the degree of energization whereby said brake valve operating means may be variably controlled, conditions tending toward

open circuit characteristics effecting the brake valve operating means toward brake setting positions, a circuit breaker in said circuit, means for operating the circuit breaker and a Wheatstone bridge arrangement in the circuit, said means for operating the circuit breaker being bridged thereover, whereby brake setting positions of said brake valve operating means are approached upon short circuit or upon an increase in resistance tending toward open circuit positions.

4. A train control comprising brake valves, a circuit, brake valve operating means in said circuit arranged in series therein, means for energizing the circuit, variable means for controlling the degree of energization whereby said brake valve operating means may be variably controlled, conditions tending toward open circuit characteristics effecting the brake valve operating means toward brake setting positions, a circuit breaker in said circuit, means for operating the circuit breaker and a Wheatstone bridge arrangement in the circuit, said means for operating the circuit breaker being bridged thereover, whereby brake setting positions of said brake valve operating means are approached upon short circuit or upon an increase in resistance tending toward open circuit positions.

5. A train control apparatus comprising a closed hydraulic pressure system having fluid lines in successive cars, a brake on each car, separate means including at least two valves in series on each car for operating said brake from said fluid lines, a control line running the length of said cars, a duplicate control line in each of said cars, means in said lines for operating said valves whereby both of said control lines must be deenergized to set said brake but either may be energized to release said brake and means for controlling said control line from one of said cars.

6. A train control, comprising a closed system of fluid lines in successive cars, fluid operated brake setting means in respective cars, a valve for delivering fluid to and from said brake operating means without loss of fluid from the system, a through electrical circuit running the length of said cars, means for controlling said electrical circuit in each of said successive cars adapted to be connected in parallel with said through circuit, the duplicate circuit in any car being adapted to be cut in when through circuit in that car is inoperable.

7. A train control, comprising a closed system of fluid lines in successive cars, fluid operated brake setting means in respective cars, at least two fluid valves in series in respective cars adapted to deliver fluid to and from said brake operating means without loss of fluid from the system, a through electrical circuit running the length of said cars, means for controlling said circuit from one of said cars, a duplicate electrical circuit in each of said successive cars connected in parallel with said through circuit and means in said circuits for controlling said respective fluid valves whereby said brake setting means is set only when both circuits are deenergized and is released by either circuit being energized.

8. A train control apparatus comprising a closed hydraulic pressure system having fluid lines in successive cars, a brake on each car, separate means including at least two valves in series on each car for operating said brake from said lines, a through electrical control circuit for operating one of the respective valves in each

car, a duplicate circuit for operating the other of said valves whereby said brake is applied by the deenergizing of both of said circuits, but is released by the energizing of either of said circuits, and means for controlling said circuits in one of said cars.

9. A train control apparatus comprising a closed hydraulic pressure system having fluid lines in successive cars, a brake on each car, separate means including at least two valves in series on each car for operating said brake from said lines, a through electrical control circuit for operating one of the respective valves in each car and a duplicate circuit in parallel with said through circuit for operating the other of said valves, means for controlling said circuits in one of said cars whereby said brake is applied by the deenergizing of both of said circuits and is released by the energizing of either of said circuits, and a manually operable valve in each car in series with said first-named valves for releasing said brake when said first-named valves are in brake setting position.

10. A train control apparatus comprising a closed hydraulic pressure system having fluid lines in successive cars, a brake on each car, separate means including at least two valves in series on each car for operating said brake from said lines, a through electrical control circuit for operating one of the respective valves in each car and a duplicate circuit for operating the other of said valves, means for controlling said circuits in one of said cars whereby said brake is applied by the deenergizing of both of said circuits and is released by the energizing of either of said circuits, and a manually operable valve in each car in series with said first-named valves for releasing said brake when said first-named valves are in brake setting position, said last-named valve also being adapted to shunt said circuits.

11. A train control system comprising fluid-operated braking means for a train of cars, a plurality of valve means in each car, said valve means being arranged in series with respect to pressure flow therethrough and each having a separate release outlet and said valves being adapted in conjunction with said braking means to set the brakes, an electrical circuit comprising two lines running the length of said train of cars, means for energizing said circuit, means in said circuit and associated with each of said valved brake-controlling means adapted to be set to predetermined braking and release positions at predetermined current values, the respective lines controlling different valves of the pluralities of valves in the respective cars, the arrangement being such that substantially zero current value in either of said lines corresponds to the setting of the valves controlled thereby to position for operation of the brakes, but the line having the highest current value setting its respective valves to release, and means for controlling the current in either and both lines.

12. A train control system comprising fluid-operated braking means for a train of cars, a plurality of valve means in each car, said valve means being arranged in series with respect to pressure flow therethrough and each having a separate release outlet and said valves being adapted in conjunction with said braking means to set the brakes, an electrical circuit comprising two lines running the length of said train of cars, means for energizing said circuit, means in said circuit and associated with each of said

valved brake-controlling means adapted to be set to predetermined braking and release positions at predetermined current values, the respective lines controlling different valves of the pluralities of valves in the respective cars, the arrangement being such that substantially zero current value in either of said lines corresponds to the setting of the valves controlled thereby to position for operation of the brakes, but the line having the highest current value setting its respective valves to release, means for controlling the current in either and both lines, and resistances in said circuit arranged with the valve operating portions in both lines as a Wheatstone bridge, and means controlled from said bridge adapted to open the circuit when the same is potentially unbalanced as to resistances, whereby local, short or open circuits effect braking operation.

13. A train control system comprising fluid-operated braking means for a train of cars, a plurality of valve means in each car, said valve means being arranged in series with respect to pressure flow therethrough and each having a separate release outlet and said valves being adapted in conjunction with said braking means to set the brakes, an electrical circuit comprising two lines running the length of said train of cars, means for energizing said circuit, means in said circuit and associated with each of said valved brake-controlling means adapted to be set to predetermined braking and release positions at predetermined current values, the respective lines controlling different valves of the pluralities of valves in the respective cars, the arrangement being such that substantially zero current value in either of said lines corresponds to the setting of the valves controlled thereby to position for operation of the brakes, but the line having the highest current value setting its re-

spective valves to release, means for controlling the current in either and both lines, resistances in said circuit arranged with the valve operating portions in both lines as a Wheatstone bridge, means controlled from said bridge adapted to open the circuit when the same is potentially unbalanced as to resistances, whereby local, short or open circuits effect braking operation, and an adjustable resistance for maintaining a potential balance for various numbers of cars in the train.

14. A train control system comprising fluid-operated braking means for a train of cars, a plurality of valve means in each car arranged in series and adapted in conjunction with said braking means to set the brakes, an electrical circuit comprising two lines running the length of said train of cars, means for energizing said circuit, means in said circuit and associated with each of said valved brake-controlling means adapted to be set to predetermined braking and release positions at predetermined current values in said circuit, the respective lines serially controlling different valves of the pluralities of valves in the respective cars, the arrangement being such that substantially zero current value in either of said lines corresponds to the setting of the valves controlled thereby to position for operation of the brakes, but the line having the highest current value effecting brake release, means for controlling the current in either and both lines, and manually controllable valves in the respective cars arranged in series with said plurality of valves therein, switch means associated with said manually controllable valves adapted upon setting the respective valves to release positions to shunt the electrical valve control means in the respective car.

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