PC CONTROL

Reports of PC equipments in operation have been exceedingly gratifying. The cost of maintenance and the number of failures in service have been very low. To further increase the efficiency of these controllers the designs have been modified where it was found improvements could be made.

The small controllers, notably PC-5, PC-6 and PC-9, in the earlier forms were a little slow turning from the "off" position to the first point. This was remedied by changing the main air engine so that its movement to the first running position is accomplished without bleeding air from the exhaust cylinder, resulting in the same speed turning on as the lager PC controllers.

The accelerating relay was improved by substituting laminated contacts for the older forms of solid copper and silver. The main contacts are protected by a heavy shield to prevent the air gap being accidentally changed.

The Type "QF" reinforced resistor tubes are used throughout. These tubes have a steel reinforcing rod through the center fastened securely at both ends; this feature adds greatly to the strength of the tubes and minimizes breakage due to vibration and shocks.

The most notable improvement in the large controllers is in the type of cable inlets used. Heretofore it has been necessary to thread the conduit, for the car wiring into each inlet of the PC controller. This arrangement required the removal of considerable conduit in the event of a controller being removed from the car. In order to eliminate some of this work and decrease the cost of installation, a split wood block type of cable inlet has been substituted for the conduit type. The split block inlet permits of stopping the conduit several inches from the controller. The ends of the conduit should be provided with suitable protective fittings. The cable is led from the conduit through the split blocks directly to the terminals. With this method of installation a controller can be removed without interfering with the conduit, as it is only necessary to remove the lower half of the split block, disconnect the cables at the terminals in the controller and bend back to the conduit. This lets the controller free to be lowered from position.

The line breaker interlocks have been changed from the front of the line breaker to the back where they are more accessible for inspection and repair and out of the reach of any line breaker arcing.

The magnet valves are contained in a punched steel housing, which has the advantage of permitting a better insulation for the coils and terminal and keeping the valve part free from residual magnetism, thereby eliminating sluggishness in action. The punched steel magnet valves have the additional advantage of permitting the coil terminal to be brought out at any angle in respect to the valve without modifying the housing design. The punched steel magnet valves are of less weight and lower cost than previous designs.

All insulation supports are coated with #880 red insulation paint. This paint gives a smooth, glossy finish from which grease or dirt can be readily wiped off, it also increases the value of the insulation and tends to prevent the absorption of moisture.

Controller	Number of Motors	Rating of Each Motor Neither to be Exceeded Hourly H.P.	Amperes at 75% of Rated Voltage	Full or Tapped Field	Weight in Pounds
		Small controllers 600 Volts, Grounded Circuit			
PC-5	4	70	75	Full	525
PC-6	2	140	135	Full	530
PC-9	2	70	75	Tapped	530
		Large controller 600 Volts, Grounded Circuit			
PC-10	2	250	200	Full or tapped.	1027
PC-12	4	150	140	Full	985
		Large controller 600 Volts, Metallic Circuit			
PC-13	2	250	200	Full	1054
PC-14	4	125	115	Full	1012
		For 1200 & 1500 Volts, Grounded Circuit			
PC-101	4	150	140	Full	1140
PC-103	4	240	220	Full	1050

SPECIAL & SAFETY FEATURES:

The following important features are included in each PC control equipment:

(1) Automatic acceleration with resulting power saving improved passenger comfort, and low maintenance.

(2) Elimination of complicated interlocking.

(3) The master controller has a dead man's release, self-adjusting and non-stubbing fingers. The reverse handle has a safety catch, and is interlocked with the main drum.

(4) Line breaker and contactors have powerful blowout coils, insuring positive arc rupturing, with low maintenance.

(5) The overload relay trips line breaker before excessive currents can harm the equipment.

(6) The reverser is interlocked with the line breaker, so that the former can not be thrown unless the latter is open.

(7) Power can not be applied to the motors unless the reverser is in the position indicated by the reverse handle at the master controller.

(8) Should the power fail, the motor controller returns automatically to the "off" position, and if the master controller handle is retained in an operating position, the car starts automatically without jar when power is restored.

(9) "By-passing" the current limit provides increased torque when required.

(10) All parts of the motor controller are particularly accessible for inspection and maintenance.

(11) The arc chutes of the contactor blowouts are assembled in group and hinged to swing downwards exposing all contactor parts, making the apparatus extremely accessible.

(12) The simplicity and compactness of the apparatus permits the assembly of the contactor, reverser, line breakers, relays, etc., in one box as a single unit, simplifying installation and reducing the possibility of improper connections.

These features make this the safest, most reliable and lowest maintained control available.

CONTROL VOLTAGE

Equipments can be furnished to operate from 600 volt trolley, low voltage battery or low voltage motor generator set. Unless special operating conditions require low voltage control, 600 volt equipments are furnished to operate the control from line potential.

The General Electric Co., does not recommend using potentials of less than 32 volts for control circuits. This is due to difficulty of maintaining contacts free from dirt.

With 1200 or 1500 volt trolley potential the current for the control, headlights and car lights is furnished from a low voltage source such as a dynamotor, motor generator or battery.

OPERATING WITH OTHER CONTROLS:

The PC control like all other multiple unit controls may be used for operating either single cars or a train of two or more motor cars coupled in any relation to one another.

When the PC control was designed, reliability, simplicity and reduction in cost were our prime considerations and for these reasons no attempt was made to arrange it for operation with other controls. As a matter of fact with practically no change, it is suitable to operate with either the Sprague G-E Type M automatic control or the Westinghouse automatic control. This latter is known as the AB, the AL and the ALM. It will not operate with non-automatic types of control, as the G-E—Types M, MK control and the lightweight M and PCL, and the Westinghouse HL for the following reasons.

In any system of multiple unit control each train wire has a certain definite function. With non-automatic controls such as Types M and HL these functions are to control several independent units, while with the PC control the advancing of the motor controller from step to step is governed by a single magnet valve. This means that to operate a PC controller with either HL or Type M controls some means must be provided to transfer the train wire function so that each type of control may operate successfully. This adds fingers to the PC control drum; also relays, resistors and additional train wires and requires changes in master controllers, the complication of which is very undesirable.

When equipments are required to operate in train with the Westinghouse Type HL control our Type PCL control should be used.

OPERATION OF MOTOR CONTROLLER

The line breaker, reverser and contactors are actuated by air pressure controlled by magnet valves. The line breaker and reverser are provided with individual magnet valves and air cylinders, while an air engine consisting of two cylinders enclosing opposed pistons, with rack, pinion, cam shaft and cams is used for the operation of all the contactors. Air is admitted to, or exhausted from the air engine by means of magnet valves, controlled by the master controller.

The diagrammatic section of the PC controller air engine on Page 42, shows the position of the magnet valves and the pistons when the master and motor controllers are in the "off" position. In this position, the air pressure is applied to the "off" piston through the "off" magnet valve, while the "on" magnet valve allows any air in the "on" cylinder to pass through to atmosphere. When the master controller is turned on, and the reverser throws, the line breaker closes, and then both the "on" and "off" magnet valves are energized. This applies air pressure to the "on" piston and allows air to escape from the "off" cylinder; the rack moves toward the "off" magnet valve, rotating the pinion and cam shaft until the "off" magnet valve is de-energized. When this occurs air pressure is applied to the "off" piston, and, as the "on" magnet valve applies air pressure to the "on" piston, all movement of the rack and pinion ceases with the motor controller in the first operating position. Subsequent positions on the motor controller are obtained by alternately energizing and de-energizing the "off" magnet valve. When the master controller is turned off, the "on" and "off" magnet valves are de-energized and air pressure is applied to the "off" piston and released from the "on" piston. This causes the rack to move toward the "on" magnet valve and rotates the pinion and cam shaft, turning the motor controller to the "off" position.

AUTOMATIC CONTROL

It has long been recognized that automatic control has many advantages over non-automatic control. However, automatic control of the older systems required a considerable complication of electric interlocking and wiring thus out weighing its advantages in all classes of service except subway and elevated. With the PC control, however, automatic type is simpler than any other multiple unit control.

On all standard PC controllers, except those used in service such as, elevated and subway (where cars are normally operated in train and rarely have to start on a grade) a bypass feature is included as a part of the accelerating relay. This by pass feature adapts it to all emergency conditions arising in service, such as starting a car on a steep grade or hauling a dead motor car.

A small lever called an 'advance lever' is provided on the top of the master controller by means of which in the above emergency conditions the motorman can advance the motor controller one notch at a time regardless of the value of the motor current. Also by holding this advance lever in the closed position the progress of the motor controller can be stopped, thus giving practically all the advantages of an automatic control with the flexibility of a non-automatic control. The particular advantages of automatic operation are:

1st The elimination of the abuse of the equipment due to notching up too fast with the non-automatic controller.

2nd Power consumption for the car is decreased due to the resistors being cut out of the motor circuits as rapidly as possible.

3rd A smooth and comfortable acceleration is obtained.

4th Increased safety due to the motorman not being required to devote any time or thought to the acceleration of the car.

5th Fewer train wires used and smaller and lighter coupler plugs and jumpers to handle.

NOMENCLATURE

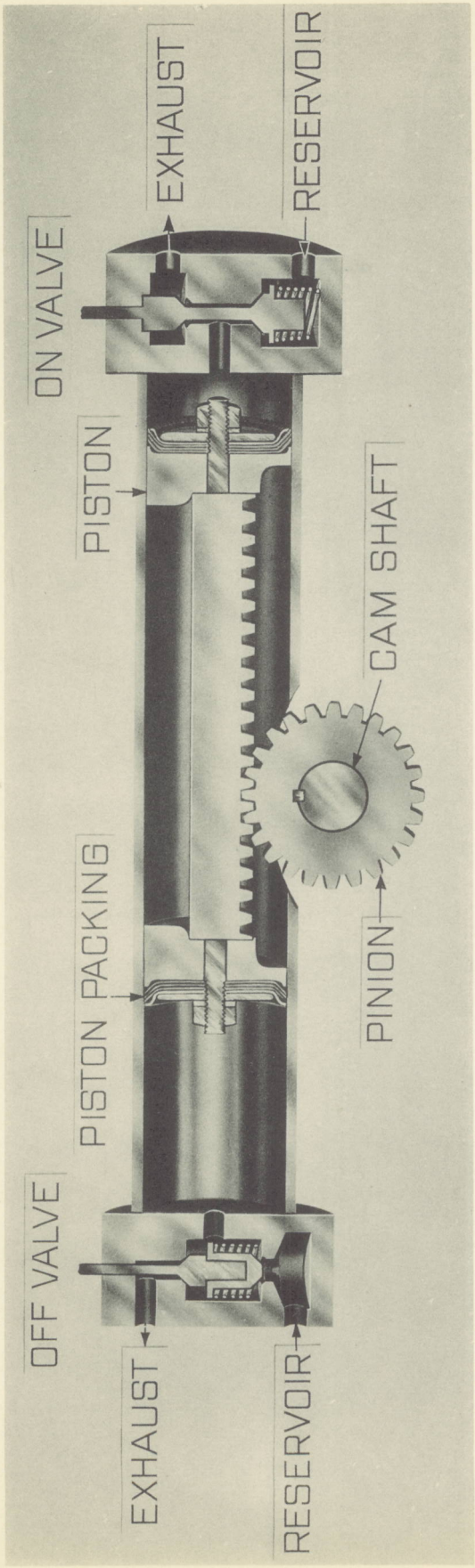
The letters "PC" indicate the type of control. These are followed by a number representing the general construction of the apparatus such as large or small size, two or four motors, 600 or 1200 volts. This number is followed by a letter indicating minor mechanical details and this letter in turn by a number denoting electrical details. From this is seen that the complete title of a motor controller would be PC-5-K-4.

MASTER CONTROLLER

The master controller provided with the standard PC equipment includes a "deadman's release feature," namely, the power will be cut off when the motorman removes his hand from the controller handle. It does not include the "emergency air brake feature," namely, applying the air brakes in the event that the motorman releases the controller handle. This latter feature can be furnished only at a considerable increase in price.

ACCELERATING RELAY

The accompanying diagram Page 44, shows the simplified control connections of the DB-850 accelerating relay with bypass feature.



319626 DIAGRAMMATIC SECTION OF P. C. CONTROLLER MAIN ENGINE AND MAGNET VALVES.
INDEX E-353.7 7 22 18

NORMAL OPERATION

Assume the master controller is advanced to the third or full parallel position, connecting wires #1, #2, #3 and #4 to their source of energy. This causes the line breaker in the PC controller to close which closes the interlocks 'LB' in the 'on' and 'off' magnet valve circuit, and the PC controller is advanced to the first position. If the current through the motors and the series coil of the relay exceeds a predetermined value causing the series coil armature to be attracted, holding contacts "A" open, then the 'off' magnet valve will not be energized until current through the motors decreases to such a value that this relay armature is released allowing contact "A" to close. The circuit will then be through wires 1, 1A, 1B, 1C, as indicated by the full heavy line, causing current to flow through the 'off' magnet valve coil, advancing the PC controller toward the second point. As wire 1A leaves the segment, wire 2C makes contact with its segment energizing the holding and lifting coils. The latter aids the series coil in attracting its armature. This circuit, indicated by the full light line, insures that the PC controller will advance to the next point even through the rise of current in the series coil between points cause contacts "A" to open.

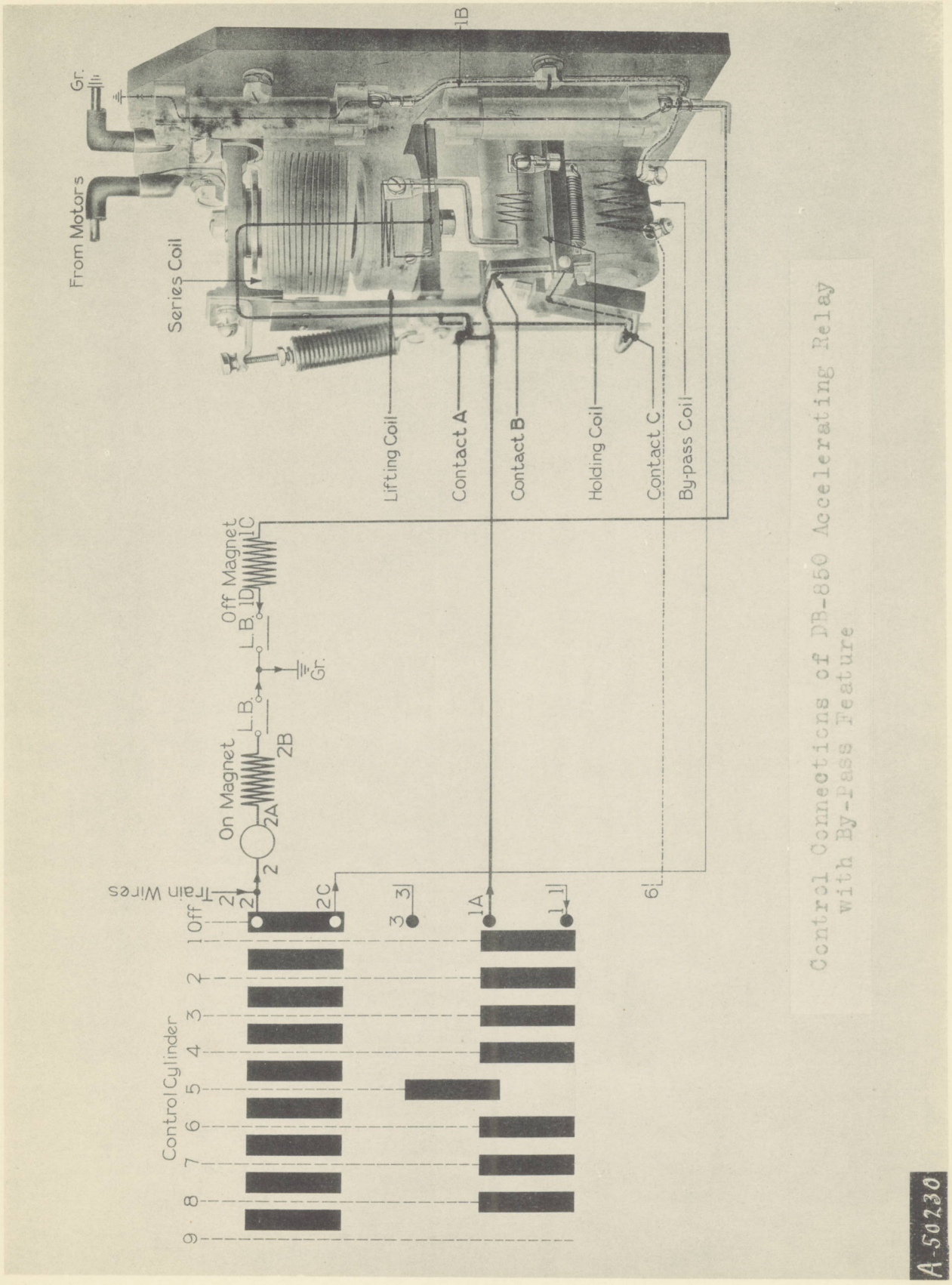
This sequence of operation continues until the full series, or 5th point on diagram Page 44 is reached when the 1A wire is energized by the segment making contact with the #3 wire. This allows the PC controller to advance to the parallel position after the current through the motors drops to the proper value. The sequence of operation then continues as in the series positions.

EMERGENCY OPERATION

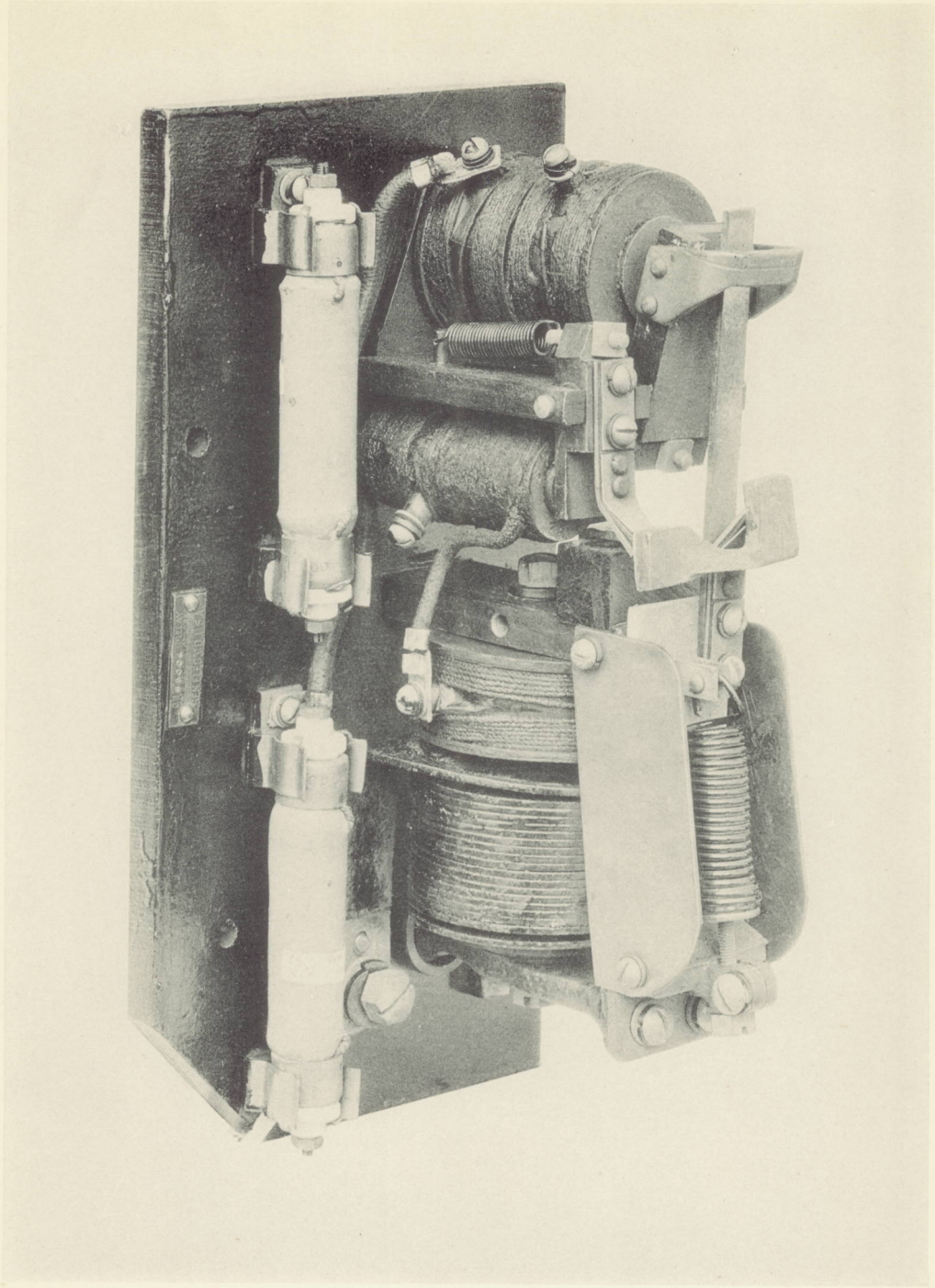
If the PC controller is on some point where the current through the series coil is too great to release its armature although not enough to start the car an additional point on the PC controller can be obtained by energizing wire #6 with the advance lever on the master controller, thus energizing the bypass coil, attracting its armature and closing contact "C." The current will then flow through wire 1A, through contacts B, C, etc. as indicated by the heavy dotted line, thereby bypassing contacts "A", thus energizing the 'off' magnet and advancing the PC controller even though these contacts "A" remain open.

The magnetic circuits of the bypass and holding coils are so arranged that with the bypass coil energized the flux leakage from the coil will hold the contacts "B" open after they have been opened by the holding coil being energized. By energizing wire #6 the PC controller can be advanced but a single point as wire 2C is energized during the advance, between points, causing the holding coil to attract its armature opening contacts "B" breaking the circuit through the 'off' magnet coil. This causes the PC controller to pause on each point until the advance lever is again released allowing contacts "B" to close preparing the circuit for the next bypass around contacts "A."

When the relay is used on equipments the control of which operates from a low voltage source resistor tubes are omitted.



Control Connections of DB-850 Accelerating Relay with By-Pass Feature



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DB 850 C 4 RELAY

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USE OF THE BYPASS FEATURE FOR TESTING THE CONTROL

By inserting a piece of mica or other insulation between contacts "A" the advance lever can also be used in testing the control, when there is no current in the series coil, to see that it advances properly from step to step. When the PC controller is on any point except the last and the bypass coil is energized contacts "C" are closed completing the circuit through the 1 and 1A wire and contacts "B" and "C" through the 'off' magnet coil, as indicated by the heavy dotted line, causing the PC controller to start to advance to the next step. When advancing between points wire 2C is energized and the circuit closed through the 'off' magnet coils which insure that the PC controller advances one step. The holding coil being energized attracts its armature causing contacts "B" to open, thus making it necessary to release the advance lever, opening the circuit in the bypass coil, before contacts "B" will again close.

SIZE OF AUXILIARY RESERVOIR FOR PC CONTROLLER

The following sizes of auxiliary air reservoirs are furnished with standard PC car equipments.

With equipments using small PC controller 12" x 33" Reservoir
" " " large " " 16" x 48" "

These reservoirs are provided in order to obtain a supply of dry air for the controller and to have a reserve supply of air in case of the failure of the compressor. This reserve supply will give air for 10 or 15 operations of the PC controller before the pressure is reduced below the point at which the controller will work. On subway and elevated service where it is unsafe to run without air for brakes this auxiliary reservoir is cut down to 10" x 15" size. This may also be done on city or interurban cars operating in train where the reserve supply of air for the control is not required.