INTERBOROUGH RAPID TRANSIT COMPANY

NEW YORK CITY

ELECTRICAL

AND

AUTOMATIC AIR BRAKE EQUIPMENT

INSTRUCTIONS

OFFICE OF GENERAL SUPERINTENDENT

JUNE, 1904

Interborough Rapid Transit Company

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Automatic Air Brake Equipment Instructions

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INSTRUCTIONS ON THE AIR BRAKE

FOR

EMPLOYEES OF THE INTERBOROUGH RAPID TRANSIT COMPANY.

Q. 1.—What is the power used to operate an air brake?

A.—Compressed air.

Q. 2.—How is the air compressed for use in the brake system?

A.—By air compressors on the motor cars.

Q. 3.—How does it apply the brake?

A.—By being admitted to a brake cylinder and forcing a piston out, which, by means of its connecting rods and levers, pulls the brake shoes against the wheels.

Q. 4.—How is the brake released?

A.—By allowing the air in the brake cylinder to escape to the atmosphere. A spring in the brake cylinder then shoves the piston back and the brake shoes will leave the wheels.

Q. 5.—What is the form of air brake now generally used?

A.—The quick-action automatic brake.

Q. 6.—Why is it called an automatic brake?

A.—Because if anything, no matter what, causes a reduction of pressure in the train pipe, the brake will apply automatically.

Q. 7.—What parts has the quick-action automatic brake on a motor car?

A.—An air compressor, pump governor, main reservoir, main reservoir pipe, two brake valves, two air gauges, train pipe, auxiliary reservoir, brake cylinder, triple valve, conductor's valve, two angle cocks, one bleed cock, four hose and couplings, two stop cocks and cut-out cock.

Q. 8.—Where are the brake valves and air gauges located?

A.—In the motorman's cab at each end of the car.

Q. 9.—What parts has the quick-action brake on a trailer car?

A.—Auxiliary reservoir, brake cylinder, triple valve, train pipe, conductor's valve, two angle cocks, one bleed cock, cut-out cock, four hose and couplings and main reservoir pipe.

Q. 10.—Is there an essential difference between the reservoir, triple valve and brake cylinder on motor cars and trailer cars?

A.—No. The reservoir and cylinder are separated on motor cars, excepting subway motor cars, which are combined, as well as on trailer cars, but the brake operation of all is identical.

Q. 11.—Where is the pressure that supplies the brake cylinder stored or carried with the automatic system?

A.—In the auxiliary reservoir under each car.

Q. 12.—What has to be done to apply the automatic brake?

A.—Reduce or discharge the train pipe pressure, which reduction causes the triple valve to move and admit the pressure from the auxiliary reservoirs to the brake cylinders.

THE MAIN RESERVOIR.

Q. 13.—From the compressors where does the air pressure go?

A.—To the main reservoirs.

Q. 14.—Where are the main reservoirs located?

A.—Under each motor car.

Q. 15.—Does each main reservoir supply air pressure to that motor car alone?

A.—No. All main reservoirs are connected together with a line of pipe called "main reservoir line" in such a way that the entire main reservoir capacity is used by the motorman for all of the cars.

Q. 16.—With the automatic brake what is the main reservoir pressure used for?

A.—To release the brakes and recharge the auxiliary reservoirs.

Q. 17.—Where does main reservoir pressure commence and where does it end?

A.—It commences at the compressors and ends at the motorman's brake valve that is being operated.

Q. 18.—How much main reservoir pressure should be carried?

A.—Ninety pounds maximum and eighty pounds minimum.

Q. 19.—Is there any other name for main reservoir pressure?

A.—Yes; it is sometimes called excess pressure.

Q. 20.—Should it be understood that main reservoir pressure as a whole is excess pressure?

A.—No. Excess pressure is the **difference** between standard train pipe and main reservoir pressures.

Q. 21.—When is excess pressure obtained?

A.—With the brake valve in running position, on lap or in the application positions.

Q. 22.—Is a very high excess pressure advisable, and why?

A.—No. On account of the liability of overheating the pumps, and also skidding the wheels unless the brake valve is handled with great care.

Q. 23.—Why does a pump heat more readily when working against a high excess pressure?

A.—Because the higher the pressure the greater the degree of heat generated during compression.

Q. 24.—What effect does water have in the main reservoir?

A.—It occupies space that should be filled with air and thereby reduces the air capacity of the reservoir.

Q. 25.—How often should the reservoir be drained?

A.—Daily.

Q. 26.—Where does the water come from?

A.—From the atmosphere. There is always more or less moisture contained in atmospheric air, and the water remaining in the reservoir is the precipitation from all the air that passes through the reservoir.

Q. 27.—From the main reservoir where does the air go?

A.—To the motorman's brake valve and through that into the train pipe.

THE TRIPLE VALVE.

Q. 28.—To what is the train pipe connected under the car?

A.—The triple valve.

Q. 29.—Why is it called the triple valve?

A.—Because of the three distinct operations it performs in response to variations of train-pipe and auxiliary-reservoir pressures; it (1) charges the auxiliary reservoir, and (2) applies and (3) releases the brakes. The various positions of the working parts of the triple valve, in accomplishing these results, are illustrated in Figs. 1, 2, 3 and 4, Plate 17, while Fig. 5 is a perspective view of the slide valve and its seat.

The various parts of the triple valve, as shown on Plate 17, are 2, triple-valve body; 3, slide valve; 4, main piston; 5, piston packing ring; 6, slide-valve spring; 7, graduating valve; 8, emergency piston; 9, emergency-valve seat; 10, emergency valve; 11, emergency-valve rubber seat; 12, check-valve spring; 13, check-valve case; 14, check-valve-case gasket; 15, check valve; 16, strainer; 19, cylinder cap; 20, graduating-stem nut; 21, graduating stem; 22, graduating spring; 23, cylinder-cap gasket; 28, emergency valve nut; and **i** and **k**, the feed grooves.

Strainer 16 is designed to exclude foreign matter from the triple valve. Piston 4 operates, in response to variations of train-pipe and auxiliary-reservoir pressures, to open and close feed groove **i**, and controls the movements of the slide valve and the graduating valve. The latter is secured to the piston stem by a pin, shown in dotted lines.

The graduating valve, moved by the main piston, controls the flow of air from the auxiliary reservoir through service ports **W** and **Z** of the slide valve.

The slide valve, moved by the main piston, controls communication between the brake cylinder and the atmosphere, between the auxiliary reservoir and the brake cylinder, and also between the auxiliary reservoir and the chamber above emergency piston 8.

Charging.

Air from the train pipe enters the triple valve at **A** (Fig. 1) and flows through passages **e**, **f**, **g** and **h**, past the main piston through feed grooves **i** in the bushing and **k** in the piston seat, and thence through chamber **m** to the auxiliary reservoir, as indicated. Air continues to flow from the train pipe to the auxiliary reservoir until the pressures equalize, when the main piston is balanced. The main piston constitutes a movable partition wall, separating train pipe and auxiliary-reservoir pressures, and, in studying the operation of the triple valve under various conditions, the first essential consideration is always as to which face of the main piston is exposed to the greater pressure; this determines the direction in which it will move. Seventy pounds is the usual train-pipe pressure, acting upon both faces of the main piston when the train pipe and auxiliary reservoirs are fully charged.

Service Application.

To apply brakes for a service stop, a gradual reduction of train-pipe pressure is necessary; and, for the purpose of illustration, the first reduction will be assumed to be one of five pounds, thus leaving a pressure of sixty-five pounds to act upon the train-pipe face of the main piston, while the original seventy pounds still operates upon the auxiliary-reservoir face. As a result of this reduction, the greater auxiliary-reservoir pressure forces the main piston to the left (Fig. 2). As the piston moves, it closes feed groove **i**, cutting off communication between the train pipe and the auxiliary reservoir, and unseats graduating valve 7, establishing communication between transverse passage **W** and port **Z** of the slide valve. When the graduating valve has become unseated, the collar at the end of the piston stem engages the slide valve, which is then also drawn to the left in the further movement of the piston, thereby cutting off communication between exhaust cavity **n** in the slide valve and passage **r** leading to the brake cylinder. The movement of the main piston to the left is arrested by contact of its stem **j** with graduating stem 21, held in position by graduating spring 22. In this position, port **Z** in the slide valve registers with port **r**, and auxiliary-reservoir air flows through ports **W** and **Z** of the slide valve and passage **r** to the brake cylinder at **C**. When the auxiliary-reservoir pressure has become, through expansion into the brake cylinder, slightly less than that (sixty-five pounds) upon the train-pipe face of the main piston, the greater train-pipe pressure forces the piston back sufficiently to seat the graduating valve, as shown in Fig. 3. This is known as the "lap" position.

If it be subsequently desired to apply the brake with greater force, a further train-pipe reduction is made, which again leaves auxiliary-reservoir pressure in excess of that in the train pipe, whereby it again forces the main piston to the left and unseats graduating valve 7, the slide valve not moving. A corresponding further reduction may be repeated until the auxiliary-reservoir and brake-cylinder pressures have finally equalized; the brake is then fully applied, and any further train-pipe reduction is but a waste of train-pipe air. A total reduction of from thirteen to fifteen pounds causes the auxiliary-reservoir and brake-cylinder pressures to equalize.

Release.

To release the brake, the motorman admits the excess pressure of the main reservoir into the train pipe, thus

increasing the pressure upon the train-pipe face of the main piston until it becomes greater than that upon the auxiliary-reservoir face and thereby forcing the piston to its position at the extreme right, as shown in Fig. 1. In this position, the air in the brake cylinder is discharged through passage **r**, exhaust cavity **n** in the slide valve, and passage **p** into atmosphere, either directly or through the pressure-retaining valve, where employed. Feed groove **i** being again uncovered in this position of the piston, the auxiliary reservoir becomes re-charged with air from the train pipe.

Emergency Application.

A gradual reduction of the train-pipe pressure causes the main piston to move to the left until stem **j** encounters stem 21, when the tension of the graduating spring prevents further movement; but a sudden train-pipe reduction causes the main piston to move out so quickly that graduating spring 22 cannot withstand the impact of stem **j**, but yields so that the piston moves to the position shown in Fig. 4. In this position of the parts, a diagonal slot in the slide-valve (shown in Fig. 5) uncovers port **t** (indicated by the dotted lines just below the letter **Z**), which admits air from the slide-valve chamber to the chamber above emergency piston 8. Piston 8 is thereby forced downward and unseats emergency valve 10, allowing the pressure in the small chamber **Y** above check-valve 15 to escape into the brake cylinder. Train-pipe pressure instantly raises the check valve, and train-pipe air rushes through chambers **a**, **Y** and **X** into the brake cylinder at **C**. Air from the auxiliary reservoir simultaneously flows through port **S** of the slide valve and passage **r** into the brake cylinder; but, port **S** being very small in comparison with the passageway through chambers **a**, **Y** and **X**, very little auxiliary-reservoir air reaches the brake cylinder before the train-pipe discharge thereto is completed. It thus occurs that, in an emergency application, an increased brake cylinder pressure is secured, through the presence of the air supplied by the train pipe in addition to that from the auxiliary reservoir, which is the only source of air pressure for the brake cylinder in service applications of the brakes.

The rapid discharge of air from the train pipe into the brake cylinder, in the manner just described, causes a sudden reduction of train-pipe pressure, which causes a similar operation of the triple valve upon the next car; the operation of that valve similarly affects the next, and so on, serially, throughout the train.

The release is accomplished in the same manner as that after a service application.

THE BRAKE VALVE.

Q. 30.—From the compressors where does the air go?

A.—To the main reservoir and thence through the main reservoir line of pipe to the brake valve being operated by the motorman.

Q. 31.—From the compressors to the reservoirs through the connecting pipe to the brake valve is all what pressure?

A.—Main reservoir pressure.

Q. 32.—It passes through the brake valve into what?

A.—The train-pipe, and thence through the triple valve to the auxiliary reservoirs.

Q. 33.—In what position of the brake valve is there a direct opening from the main reservoirs to the train pipe?

A.—In full release position.

Q. 34.—In this position how would the main reservoirs and train-pipe pressure stand, comparatively speaking?

A.—Equal.

Q. 35.—What causes a severe blow or leak at the brake valve when brake-valve handle is in full-release position?

A.—A warning port.

Q. 36.—Why is it called a warning port?

A.—Because it attracts the motorman's attention to the improper position the brake-valve handle is in.

Q. 37.—Where does the air come from?

A.—The main reservoirs.

Q. 38.—Is there any other position of the brake valve in which the pressure may pass from the main reservoirs to the train pipe?

A.—Yes; running position.

Q. 39.—In that position has the air a free passage or not?

A.—Yes; so long as the train-line pressure is less than seventy pounds, the pressure to which the slide-valve feed valve should be adjusted.

Q. 40.—What is the excess pressure to be used for?

A.—For re-charging the train pipe quickly so as to insure a prompt and simultaneous release of the brakes.

Q. 41.—What is the next position of the brake valve and what does it signify?

A.—Lap position; all ports closed.

Q. 42.—When is it used?

A.—When holding the brakes or after an application, or when they have been applied by opening a conductor's valve. This position should also be promptly used when train breaks in two; hose become uncoupled or burst; when coupling to air-brake cars or at any time a sudden reduction of train-line pressure takes place when not made by the motorman himself.

Q. 43.—What is the next position and its use?

A.—Service application; should be used for all ordinary stops.

Q. 44.—How is the air discharged from the train pipe in making a service application?

A.—Through a series of restricted openings in the rotary valve. The further the handle is moved in the service-application direction the more rapid the discharge of air.

Q. 45.—Would the blow, or escape, of air from the train pipe be longer with a six-car train than with a three-car train, the same reduction in pounds being made in each case?

A.—Yes; if the brake-valve handle is moved to the same notch in both cases. The capacity of the long train pipe being so much greater, it would require a larger volume of air to escape to make the same reduction in pounds.

Q. 46.—How many service-application notches has the brake valve?

A.—Two.

Q. 47.—When should they be used?

A.—With a six-car train the brake-valve handle can be moved to the second or full-service application opening, but with not more than three or four cars the first-service notch should be used.

Q. 48.—Why not use the second notch with a three or four car train?

A.—Because owing to the comparatively short train pipe, the reduction of train-line pressure would be sufficiently rapid to cause quick action, resulting in a full emergency application of all the brakes when only partial service application was intended.

Q. 49.—What is the next position?

A.—The emergency or quick-action; in this position a large direct opening is made from the train-pipe to the atmosphere.

Q. 50.—When is this position to be used and how?

A.—Only in case of emergency; and then the handle should be moved directly to that position and allowed to remain there until the train stops or the danger is passed.

THE SLIDE-VALVE FEED VALVE.

Q. 51.—How is the train-line pressure automatically regulated?

A.—By the slide-valve feed valve.

Q. 52.—What is meant by the slide-valve feed valve?

A.—It is an attachment to the motorman's brake valve which automatically regulates the maximum train-line pressure when brake-valve handle is in running position.

Q. 53.—What are the essential parts of the slide-valve feed valve?

A.—The slide-valve supply valve (55), a supply-valve piston (54), a regulating valve (59), a diaphragm (57), a regulating spring (67) and a supply-valve piston spring (58).

Plates 10 and 11 illustrate the device. Plate 10 is a central section through the supply-valve case and governing device, and plate 11 is a central section through the regulating valve and spring box and a transverse section through the supply-valve case. Ports f[1] and i register with ports in the brake valve and in Running Position, main reservoir pressure, which is always present on top of the rotary valve, constantly has free access through the feed port of the rotary valve, passages **f** and **f**, to chamber **F**. Chamber **E**, which is separated from chamber **F** by supply-valve piston 54, is connected with passage **i**, and thus with the train pipe, through passage **c**, **c**, port **a** (controlled by regulating valve 59) and chamber **G**, over diaphragm 57. Regulating valve 59 is normally held open by diaphragm 57 and regulating spring 67, the tension of which is adjusted by regulating nut 65. When so open, chamber **E** is in communication with the train pipe and is subject to train-pipe pressure.

Q. 54.—How does the slide-valve feed valve operate?

A.—When the handle of the Motorman's Brake Valve is placed in Running Position, air pressure from the main reservoir in chamber **F** forces supply-valve piston 54 forward, compressing its spring 58, carrying supply-valve 55 with it and uncovering port **b**, and thereby gains entrance directly into the train pipe through passage **i**, **i**. The resulting increase of pressure in the train pipe (and so on in chamber **G** over diaphragm 57) continues until it becomes sufficient to overcome the tension of regulating spring 67, previously adjusted to yield at seventy pounds. Diaphragm 57 then yields and allows regulating valve 59 to be seated by spring 60, closing port **a** and cutting off all communication between chamber **E** and the train pipe. The pressures in chambers **F** and **E** then become equalized, through leakage past supply-valve piston 54, and supply-valve piston spring 58, previously compressed by the relatively high pressure in chamber **F**, now reacts and forces supply valve 55 to its normal position, closing port **b** and cutting off communication between the main reservoir and the train pipe. A subsequent reduction of train-pipe pressure reduces the pressure in chamber **G** and permits regulating spring 67 to force regulating valve 59 from its seat, thereby causing the accumulated pressure in chamber **E** to discharge into the train pipe. The equilibrium of pressure upon the opposite faces of supply valve piston 54 being thus destroyed, the higher main-reservoir pressure in chamber **F** again forces it, with supply-valve 55, forward, and re-charges the train pipe through port **b**, as before.

Q. 55.—The slide-valve 55 then maintains an open port until maximum train-line pressure is reached?

A.—Yes.

Q. 56.—Will train-pipe pressure be automatically governed with brake valve in any other than the running position?

A.—No.

Q. 57.—What care should be given this feed valve?

A.—The piston and its slide valve should occasionally be taken out, all dirt and gum removed from them and the chambers where they work, being careful to leave no lint and to avoid bruising the parts removed. A very small amount of some light lubricating oil (engine oil will do in the absence of a better) should be applied to the piston, the face of the slide valve and the spring on the latter. In replacing the parts, move them back and forth a few times to insure that they work freely. Next, remove the regulating valve, carefully clean it, its valve seat and the hole through which its stem extends, using no metal to do this so as to avoid scratching, and replace the valve dry.

Q. 58.—Must the main reservoir be drained to do this?

A.—No. Put the handle of the brake valve in emergency position and the parts can be removed.

Q. 59.—When properly regulated, what can cause pressure to feed too high in the train pipe?

A.—The following defects in the motorman's brake valve with which the train is being handled will cause this; a leaky rotary valve or feed-valve case gasket, a leaky slide valve (55), a heavy oil or grease on the feed-valve piston (54), leakage to the atmosphere past the piston-cap nut (53), the diaphragm (57) or dirt under regulating valve (59) holding it from its seat.

Q. 60.—What other cause is there for this too high feed?

A.—It may be caused by any one of the other brake valves on the train which has not been placed on perfect lap or that has a leaky rotary valve.

Q. 61.—Why will grease on the feed-valve piston or a leak to the atmosphere, as mentioned in answer to Question 59, cause too high train-line pressure?

A.—The grease on the piston will, while it remains, act as a packing and prevent a prompt equalization of pressures on its two sides when the regulating valve closes. Leakage from the outside of the piston acts the same way.

Q. 62.—Why will dirt on the seat of the regulating valve cause too high train-line pressure?

A.—With this valve unseated an equalized pressure cannot be obtained on the two sides of the piston and the supply valve is held open until practically main-reservoir pressure is obtained in the train pipe.

Q. 63.—How should brakes be tested in preparing train for service?

A.—With the brake-valve handle in running position, charge the train line and auxiliary reservoirs which can be determined by lapping the brake-valve, and if everything is charged the black hand will not fall. Motorman will then apply brakes by moving handle of brake valve to service-application-position notch until a reduction of ten pounds has been made in the train line. Then after placing handle on lap, remove handle, and carrying same, motorman will proceed throughout the length of train and see that each cylinder piston of every car has moved out such a distance as to indicate that brakes are properly applied on all cars of the train. The brakes are then to be released from the last cab on end of train. Then again remove handle and return to other end of train, examining all cylinder pistons. Be careful to see that they have moved back to full release, thus indicating that all brake shoes hang free.

Q. 64.—In making an application of the brakes for any purpose, except testing brakes or emergency applications, how much pressure should be drawn from the train pipe at the first reduction?

A.—From five to seven pounds.

Q. 65.—Why not less than this amount?

A.—Because the reduction might not be sufficient to force the brake piston past the leakage groove in the cylinder.

Q. 66.—Why not more than seven pounds?

A.—Because it will cause too severe an application of the brake at the first reduction, and is liable to cause shock to the train.

Q. 67.—After the first five to seven pounds reduction, how much pressure should be drawn from the train pipe at any one reduction?

A.—This must be governed entirely by the circumstances; but the best results are obtained by not using more than three or four pounds at any one reduction after the first one.

Q. 68.—What reduction of train-line pressure is necessary to fully apply the brakes on service application?

A.—From thirteen to fifteen pounds.

Q. 69.—Why should the reduction as stated in the last question fully apply the brake?

A.—Because thirteen to fifteen pounds reduction in train-pipe pressure causes an equalization of auxiliary-reservoir and brake-cylinder pressures, thus fully applying the brakes. A further reduction in train line is simply a waste of air.

Q. 70.—What is the possible result of this waste of air?

A.—The brakes are slower in releasing, fail to release

simultaneously, cause a shock to the train upon stopping, and seriously overtax the compressor.

Q. 71.—How many applications should be used in making the ordinary service stop?

A.—As a general rule, two.

Q. 72.—What is meant by one application?

A.—From the time the brakes are applied until they are released, no matter how many reductions, is one application; after the brakes have been released, and are reapplied, is the second application.

Q. 73.—Why are two applications in making a service stop better than one?

A.—It quickly brings the train down from a high to low speed; is a safeguard against skidding of wheels; insures a greater accuracy of stop and permits the train to be brought to a standstill with a light reduction of pressure on the second application.

Q. 74.—In releasing the brakes after the first or subsequent applications in making a service stop, how should the brake valve be handled?

A.—It should be moved to full release and immediately returned to lap position.

Q. 75.—Why is it essential to return the handle to lap position, after releasing, when another application is desired?

A.—To avoid overcharging the train pipe above the auxiliary reservoir pressure.

Q. 76.—Why should the brake-valve handle be moved to full release position instead of the running position in making a release?

A.—By moving the handle to the full release position, a strong wave of air flows through the train pipe, insuring the release of all brakes simultaneously, regardless of the condition of the triple valves, which would at times not be the case if released in the running position.

Q. 77.—What effect does overcharging the train pipe have, if another application is attempted shortly after the release?

A.—In order to apply the brakes the train-pipe pressure must be reduced lower than the auxiliary reservoir pressure; if the two are kept as nearly equal as possible when releasing, the second application can be obtained immediately; but if the train-pipe pressure is much higher than the auxiliary reservoir pressure, then such higher pressure must be exhausted first to get them equal, and a further reduction made to reduce train-pipe below auxiliary pressure, all of which consumes time and results in the train moving to a point beyond the intended stop.

Q. 78.—In making ordinary station stops, when should the brakes be released, and why?

A.—A sufficient time before stopping to avoid the backward lurch, which is accomplished by a partial release of the brakes before the train has come to a standstill.

Q. 79.—Should the brake valve be manipulated as above stated when making the final stop? Why?

A.—Yes. Sometimes in stopping the brakes release slightly too soon and the train continues to drift very slowly, and by moving the brake-valve handle to the lap position the brakes will again respond to a very light reduction, bringing the train to a standstill with little or no shock, even when held on until the train comes to a stop.

Q. 80.—If after bringing the brake valve to lap the train stops as intended, what should motorman do?

A.—Immediately upon the train coming to a standstill move the handle to running position.

Q. 81.—If brakes release after a service application, where should cause be looked for?

A.—Examine brake-valves in train until trouble is located. Either a brake valve has not been fully lapped or has a leaking rotary valve.

Q. 82.—In case of emergency, when it is essential to stop the train in the shortest possible distance, how should the brake valve be handled?

A.—The handle should be thrown to the full emergency position and left there until the train has come to a stop, or the danger is passed.

Q. 83.—Would it not be better to return the handle to lap position after a quick reduction has been made? The object being to save train-pipe pressure to assist in releasing.

A.—No. The first consideration in case of an emergency is to stop and to do that as quickly and surely as possible. The handle should be left in emergency position.

Q. 84.—If the motorman has the brake partially applied with service application and should be suddenly flagged, what should he do?

A.—Put the valve handle in the emergency position and leave it there until stopped, the same as before.

Q. 85.—Would he get quick action under those circumstances?

A.—That depends on the amount of reduction made in service, and the length of the piston travel. With only a light reduction he would get partial quick action, but would not get full quick action brake cylinder pressure.

Q. 86.—Could anything be gained by placing the handle in release position for a moment before going to emergency position?

A.—No; it would be dangerous to do so. Such an action would release the brakes when they were most needed, would make them slower to apply by overcharging the train pipe, and when applied they would be even weaker than a full service application would have been at the start.

Q. 87.—If the motorman had the brakes applied with a thirteen to fifteen pound service application, and was flagged, would it be policy for him to put the brake valve in the emergency position?

A.—Yes, if it were a case of emergency. Possibly some of the brakes have partly leaked off, or have long piston travel. The emergency application would set them fully.

Q. 88.—In the case of emergency should a motorman reverse his motors?

A.—Yes. As a last resort to prevent collision or to save life he may reverse his motors. Reverse handle should be thrown into opposite direction and the controller handle moved to the second notch, which notch is usually found to have the greatest retarding effect. Motors may also be reversed in the event of brakes being inoperative, but in ordinary service conditions motormen must never reverse motors.

Q. 89.—In case the brakes are applied suddenly from the train, what should the motorman do?

A.—Place the brake-valve handle on lap position until a signal is given to release the brakes.

Q. 90.—Why is this done?

A.—To maintain the main reservoir pressure and prevent its escape, thereby providing for a prompt release of the brakes.

Q. 91.—How should the conductor's valve be operated when necessary?

A.—It should be pulled wide open and allowed to remain or be held in that position until the train stops, and then before leaving it the valve should be closed.

All cars have a conductor's valve which, when opened, remains in that position until closed by hand.

Q. 92.—Why is it necessary to leave the conductor's valve open until the train has stopped, if it is used?

A.—Because if it is closed and the motorman fails to place the brake valve on lap position, the brakes will release.

Q. 93.—What does this valve do when it is open?

A.—It makes a direct opening from the train-pipe to the atmosphere the same as when the brake valve is placed in the emergency position.

Q. 94.—Can brakes be released with the conductor's valve?

A.—No. It must be remembered that to release brakes it is necessary to either put air into the train pipe or take it out of the auxiliary reservoirs. The conductor's valve will not do either of these.

Q. 95.—Should the brakes apply suddenly, without the aid of the motorman or train crew, what should be done?

A.—Place the brake-valve handle on the lap position as before.

Q. 96.—What would be the probable cause of this?

A.—Either a burst hose, burst train pipe, or train breaking in two.

Q. 97.—In the event of a burst train line hose, what should be done?

A.—Close the train line or flat handled angle cocks each side of the burst hose, then bleed the train to release the brakes. In case the break was in the center of train, would run from the first motor cab, having brake on the cars ahead of the burst hose, and in case it was between the first and second cars, would station a man on the front end of first car and run carefully from the second motor cab.

Q. 98.—In the event of a main reservoir hose bursting, what should be done?

A.—Close the main reservoir or round handled angle cocks under car platforms at each side of the burst hose, bleed the train to release brakes, and as soon as air is pumped up proceed.

Q. 99.—Should the cross-over pipe connecting the train pipe and triple valve be broken, what should be done?

A.—If the break is between the cut-out cock and the triple valve, the cut-out cock should be closed and the release valve opened, under the disabled car. If the pipe is broken between the cut-out cock and the main train pipe, the flat-handled angle cock on the front end of the disabled car should be closed, release valves in all auxiliary reservoirs behind the disabled car, as well as on that car opened, and the brakes operated the same as with the burst hose.

Q. 100.—If the train pipe should be broken or burst, what should be done?

A.—Close the angle cock on the front end of the car and operate brakes as per answer to Question 97.

Q. 101.—In setting off cars, what should be done?

A.—The angle and stop cocks should be closed first and the hose parted by hand and hung up properly.

Q. 102.—Should the hand brake be set before releasing the air brake?

A.—No.

Q. 103.—What is the proper way to release a brake with the release valve?

A.—The release valve should be held open only until the exhaust air commences to escape from the triple valve. It should then be closed, as, if it is held open longer, it results in waste of air and has a tendency to set the other brakes.

Q. 104.—When is it permissible to cut out brakes on cars?

A.—Only when they are in such condition as to render it impossible to operate the brake on such cars.

Q. 105.—Are small leaks sufficient cause for cutting out cars?

A.—No.

AUTOMATIC SLACK ADJUSTER.

Q. 106.—What is the automatic slack adjuster?

A.—A device for automatically taking up slack in the brake rigging, produced by wearing away of the brake shoes.

Q. 107.—Why is it necessary to take up the slack in the brake rigging?

A.—The wearing thinner of the brake shoes causes the cylinder piston to travel further, thereby reducing the brake-cylinder pressure, and the holding power of the brakes

Q. 108.—How is this brake-shoe wear taken care of on cars not equipped with the automatic slack adjuster?

A.—Slack in the rigging is taken up by hand on the dead levers, or on one or more of the connecting rods.

Q. 109.—With such hand adjustment can a uniform piston travel be maintained?

A.—No. Because of the difference that exists between standing and running travel.

Q. 110.—Why this difference between standing and running travel?

A.—When the car is moving the lost motion of the running gear and tilting of the trucks are caught up and the parts pulled closer together by the brake than when the car is standing. This difference between standing and running travel is called "lost travel."

Q. 111.—If the hand brake adjustment on all the cars of the train is the same, will the braking power be uniform when making a stop?

A.—No; the variation in the total leverage as well as in the running gear will cause a greater or less difference in brake power of the cars.

Q. 112.—What other important and bad effect of hand adjustment may be mentioned?

A.—The piston travel would be different from the time of first application of the brakes, increasing from successive applications, a result of wearing away of the brake shoes.

Q. 113.—We understand then that it is impossible to maintain a predetermined piston travel when such adjustment is made by hand?

A.—Yes.

Q. 114.—How does the automatic adjuster do its work?

A.—It adjusts and maintains the piston at its proper running or working travel, regardless of the lost travel, brake-shoe wear or whether the car be high or low leveraged. Thus, if all cars in a train are equipped with automatic slack adjusters, the travel of all pistons will be uniform when brakes are set to slow down or stop the train. The same brake-cylinder pressure will be had on all the cars at each and every application, and the brakes on each car of the train will do uniform work.

Q. 115.—The work of the automatic adjuster is based on running travel; hence, such running travel will be uniform; but would the standing travel be uniform on all cars having the adjuster?

A.—No. The standing travel would differ about the same as did the running travel when adjustment was made by hand; this, however, is unimportant, as at such time the brakes are doing no work. What is wanted is a true running or working travel, which uniformly is attained with the automatic adjustment.

Q. 116.—Is the automatic slack adjuster a complicated device?

A.—No, on the contrary it is quite simple, as the cuts show.

Q. 117.—How does it operate?

A.—The Automatic Slack Adjuster is illustrated on plates 21 and 22. The brake-cylinder piston acts as a valve to control the admission and release of brake-cylinder pressure to and from pipe **b** (plate 21) through port **a** in the cylinder, this port being so located that the piston uncovers it when the predetermined piston travel is exceeded. Whenever the piston so uncovers port **a**, brake-cylinder air flows through pipe **b** into slack-adjuster cylinder 2, where the small piston 19 (plate 22) is forced outward, compressing spring 21. Attached to piston stem 23 is a pawl, extending into casing 24, which engages ratchet wheel 27, mounted within casing 24 upon screw 4 (plate 21). When the brake is released and the brake-cylinder piston returns to its normal position, the air pressure in cylinder 2 escapes to the atmosphere through pipe **b**, port **a** and the non-pressure head of the brake cylinder, thus permitting spring 21 to force the small piston to its normal position. In so doing, the pawl turns the ratchet wheel upon screw 4, and thereby draws 5 slightly in the direction of the slack-adjuster cylinder, thus shortening the brake-cylinder piston travel and forcing the brake shoes nearer the wheels. As the pawl is drawn to its normal position, a lug on the lower side strikes projection **a** (plate 22) on the cylinder, thus raising the outer end of the pawl, disengaging it from the ratchet wheel, and permitting the screw to be turned by hand if desired.

Q. 118.—How much does this shorten the piston travel?

A.—One thirty-second (1-32) of an inch. Four turns of the ratchet wheel, requiring thirty-two operations of the adjuster, shortens the piston travel one inch.

Q. 119.—What care does this adjuster require in the way of cleaning and lubricating?

A.—The same as is given the triple valve and brake cylinder. The screw should be kept free from all lubricant so as to prevent its catching dust and dirt.

Q. 120.—How should slack be let out for replacing brake shoes?

A.—By turning the ratchet wheel backward, provision being made for this on the fluted extended portion covering the outer end of the screw.

Q. 121.—What should be done after replacing shoes?

A.—Apply the brake, measure the piston travel and take up on the adjuster screw. The travel is shortened the exact amount the screw is drawn away from the brake-cylinder head.

Q. 122.—Is the adjuster able to wear out a complete set of shoes and at the same time maintain the desired piston travel?

A.—Yes.

Q. 123.—If the piston travel is found to be too short, what should be done?

A.—First, bear in mind that the standing travel is always less than the running travel, and that this and a light brake application may be deceiving. If not, it is due to failure to let out sufficient slack when new shoes were applied, taking up too much by hand afterward on the automatic adjuster or an improper alteration of dead levers or rods.

Q. 124.—How can the automatic slack adjuster be tested?

A.—Turn the ratchet wheel backward sufficiently to permit the brake piston to travel beyond the adjuster port, apply the brake and note whether there is any leakage in the adjuster pipe or cylinder. Next, release the brake, noting if the ratchet wheel turns slightly, as it should do.

Q. 125.—What will be the result if, through improper adjustment of the brake rigging, the adjuster screw is drawn up to its limit?

A.—No more slack will be taken up and, on attempting to back the screw, the ratchet wheel may not turn. When the limit of the screw is reached, the return stroke of the piston cannot be completed, as the pawl does not release the ratchet wheel. Under these conditions should an attempt be made to forcibly turn the ratchet wheel backward, such can only be done by breaking or disabling the slack adjuster. This cannot occur under proper conditions, but provision is made in the adjuster so that by merely backing off a bolt in the adjuster body, the ratchet wheel is given sufficient additional movement to release the pawl.

Q. 126.—Describe the connections and usefulness of the automatic brake valve connected to controller handle.

A.—This valve is on Subway Division motor cars and is connected with the train line operated by the button on top of the controller handle, and is arranged so that when the controller reverse lever is in other than the central position and the button on top of controller handle is up, said automatic valve is open so that the air escapes from the train line and applies the brakes. Therefore, if the controller reverse lever is in either the go-ahead or back-up position, the button on top of controller handle must be held down by the motorman constantly.

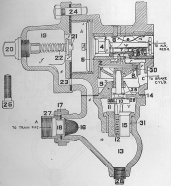


Plate No. 17. Fig. No. 1.

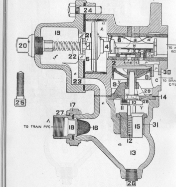


Plate No. 17. Fig. No. 2

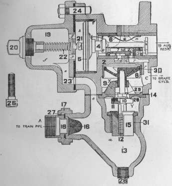


Plate No. 17. Fig. No. 3.

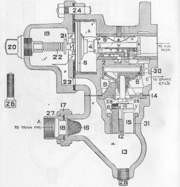


Plate No. 17. Fig. No. 4.

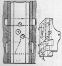


Plate No. 17. Fig. No. 5.

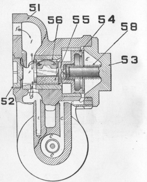


Plate No. 10.

INSTRUCTIONS TO MOTORMEN, SUBWAY AND ELEVATED DIVISIONS, INTERBOROUGH RAPID TRANSIT CO.

The Sprague-General Electric Type "M" control system, as applied to the cars of the Interborough Rapid Transit Co., comprises two distinct sets of controlling apparatus, namely, the main or motor control, and the master control. (See Plate No. 1 Subway Division and Plate No. 2 Man. Div.)

Each motor car is equipped with a set of motor control apparatus which serves to carry current from third rail through the motors to ground, forming different combinations of motors and cutting out resistances in starting that particular car. Each motor circuit is local, being confined to its respective car.

Every car in the train is equipped with master control apparatus, the office of which is to operate the motor control. The important feature of the master control is the train line, a cable comprising a number of small wires running the entire length of the train. On the Subway Division this cable comprises 10 wires, and on the Elevated Division contains 9 wires. On every motor car, a connection is made from this cable to the motor control apparatus on that car. At every cab, connection is made from the train line to a master controller. Consequently, any master controller can energize the entire train line, and therefore all motor control apparatus connected to the train line.

The MOTOR CONTROL on each motor car of the Subway Division comprises 16 contactors, a reverser, 8 rheostats, a switch, a fuse, a circuit breaker, 4 third rail shoes and the necessary cable for connecting this apparatus to the third rail and to the motors. (As shown on Plate No. 1.) On the Elevated Division there are but 13 contactors,

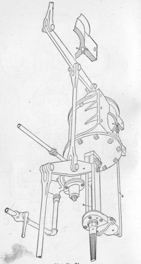


Plate No. 21.

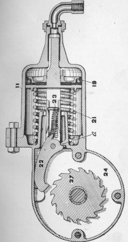


Plate No. 22.

5 rheostats, and there is no circuit breaker. (As shown on Plate No. 2.) The Bus line, air compressor and governor, together with coupler sockets, jumpers, junction boxes, and wiring are also shown on plates Nos. 1 and 2, although not a part of the motor control apparatus.

The Contactor (Plates Nos. 3–A and 3–B) is a switch having heavy main contacts, actuated by an electro magnet which receives energy from the master controller through the train line. It is provided with a magnetic blowout, is capable of opening very heavy current, and is used for making and breaking connections in the motor control.

The Reverser (Plate No. 4) is a switch, the movable part of which is a rocker arm operated by two electro-magnets working in opposition. These coils receive their energy from the master control circuit, and the connections are such that only one can be energized at a time. Wires from the motor armatures and fields are connected to the fingers of the reverser, and by means of copper bars on the rocker arm the proper relations of armatures and fields are established for obtaining forward or backward motion of the car. In order to insure protection from brake-shoe dust and other foreign material, contactors and reversers are installed in sheet iron boxes on the Subway cars, but on the Elevated Division this is not necessary.

A Motor Control Rheostat (Plate No. 6) is made up of 18 cast iron grids mounted in, and insulated from, an iron frame. These rheostats are used to graduate or cut down the supply of current for the motors while the car is going up to speed.

The Main, or Motor Circuit, Switch (Plate No. 7) is a knife blade quick break switch, located on the panel, and is used to cut off the supply of current through the contactors to motors. This switch should not be opened while the motors are taking current, except in emergency. On the Subway Division circuit breakers are provided which can be opened from the motorman's cab, and should these fail to work, in emergencies, such as burning insulation beneath car, the main switch should be opened.

On the Elevated Division, no circuit breakers are used, and should the main fuse fail to blow in case of a partial short-circuit in the car wiring, the main switch should be opened, and if this fails, bus line jumpers should be pulled and wooden slippers inserted between contact shoes and rail.

The Circuit Breaker (Plate No. 8) is similar in construction to a contactor, except that it is designed to carry and break full current taken by a car. It is held closed against a spring by a toggle locked by an electro-magnet known as the retaining coil. When current is shut off from the retaining coil, the circuit-breaker opens. This is also done automatically when excessive current flows because of motor trouble, and it is ordinarily opened from the cab by moving the handle of the *combined master controller and circuit breaker tripping switch.* (See Plate No. 15.)

The Main Fuse (Plate No. 9) is a copper ribbon contained in a box. This fuse will melt and open the motor control circuit under excessive current in a period of time slightly greater than is necessary to open the circuit breaker. Thus the circuit breaker is supposed to open in all cases of excessive current (*which means improper handling* of motor or motor trouble), the fuse operating only when circuit breaker fails to work.

As a further protection, the entire equipment on a motor car is protected by an enclosed fuse at each third rail shoe.

Master Control Apparatus comprises 2 controllers, one at each end of every car, cutout switch, connection boxes, coupler sockets, master control rheostat, switches and fuses and train line with 10 wire cable for connecting above apparatus to the train line. (As shown on Plate No. 1.) On the cars of the Elevated Division 9 wire cable is used throughout, and consequently in all master control apparatus there is one connection less than on that of the Subway cars. (Plate No. 2.)

The Master Controller (Plates Nos. 10–A and 10–B) contains movable contact cylinder and stationary fingers, and is used to supply current in proper sequence to the different wires of the train line for the purpose of actuating or moving the contactors on all the cars of a train.

The CUTOUT SWITCH (Plate No. 11) is a 9 point switch having two sets of 9 fingers, and is for the purpose of cutting out the contactors. One set connects to the train line, the other to the operating coils of the contactors and reversers on the same car. In the "off" position there is no connection between the two sets of fingers, but when the handle is turned to the "on" position a set of metal strips bridge between corresponding fingers, thus connecting the operating coils of the motor control apparatus or contactors, to the train line. The Subway Division equipment has one more point in cutout switch, and is shown on Plate No. 18.

CONNECTION BOX (Plate No. 12). All connections from master controller to train line are made at connection box, which contains 10 studs, insulated from each other, on which wires to be connected to each other are clamped. The individual wires in the 10 wire train cable used for train line and for connecting with the master control apparatus have different colored braiding as an outside cover, and this distinguishes any wire, throughout the train. Wires of the same color are always interconnected, except at one connection box on each car, where the two wires which operate the reversers are crossed in order to obtain direction of movement in accordance with position of reverser handle in either controller. Elevated Division equipment is similar, except that there are 9 studs instead of 10.

JUMPERS (Plates Nos. 13-A, B and C). Train line connections between cars are made with 10 wire jumpers supplied with a coupler plug at each end. These plugs fit into a coupler socket on each of two adjacent cars. The socket has 10 small split studs which fit into corresponding metal pockets in the jumper plug, and the studs connect to the local section of train line in either car. The

construction of Elevated equipment is similar except that there are 9 points instead of 10.

Jumper plugs are so constructed that they can only be inserted in one position. They are held in the sockets by springs, but will readily pull out if the train should break apart.

On cars of the Subway Division, there is in addition to master control train line, another composed of seven wires, one large and six small, the method of connecting between cars being the same as in the master control train line. (See Plate No. 1.) The connection boxes are also of the same type except that they have only 7 studs. The large wire connects to all the third rail shoes, being fused between cars so that excessive current cannot be carried over this wire. This insures continuous light and heat, contactor and motor current throughout the train in crossing gaps in third rail, since these connect to this large bus on all cars of the train. All circuit breaker retaining coils, and the small contacts in the master controller switches connect to one of the small wires, so that all coils may be energized and circuit breakers held closed from any of these switches.

The CONTROL CIRCUIT RHEOSTAT (Plate No. 14) consists of 12 tubes wound with resistance wire, contained in an iron frame, and is used to cut down the current in the operating coils of contactors. On the Subway Division equipment this rheostat is contained in the end of the Rectangular Box. (Plate No. 1).

The MASTER CONTROLLER SWITCH (Plate No. 15) is used to admit current to the master controller at the operating end of the train and to energize the retaining coils on all the circuit breakers. This switch is provided with a removable handle, and *but one handle should be used on a train.* Any master controller switch will hold all the circuit breakers in on the train when closed, and it follows that all of these switches must be open in order to open the circuit breakers. *It is therefore important that only one switch should be closed at any time, and that the* *one in the cab with the motorman.* This does not affect the automatic opening of a circuit breaker when motor troubles occur, since this is done by an overload coil attached to the circuit breaker.

The master controller switch on Elevated Division performs a similar office, except that it does not operate a circuit breaker and that the handle is not removable.

The CIRCUIT BREAKER SETTING SWITCH (Plate No. 16) is used to energize the closing coils of the circuit breakers and works in conjunction with the *master controller switch, which must be closed first.* The circuit breaker setting switch should be held closed only momentarily, and it is designed to open automatically as soon as the hand is removed.

The SWITCH PANEL (Plate No. 18), besides containing main motor circuit cutout switch and train line 10 point cutout switch and fuses, also contains the light, heat, air compressor, and platform light transfer switches and fuses.

TRAIN OPERATION.

Before starting a Subway Division train, the motorman should close the air compressor switches located on the switch panel (Plate No. 18) and wait until his train line and reservoirs are properly charged, following air brake instructions relative to testing his brakes, and should see that *all main switches are closed* and that *all master controller switches are open.* He should then close the master controller switch in the operating cab, thus energizing the retaining coils of all the circuit breakers. Next move the handle of the *circuit breaker setting switch to the right as far as it will go, holding for about two seconds,* and then release it. This closes all the circuit breakers. To start, press down the button in the controller handle and throw the reverse handle to forward position. Then swing the controller handle to the left as far as it will go and hold it there, *always holding down the button in the handle.* This winds up a coiled spring which drives the controller cylinder

on through a set of gears. The controller cylinder is provided with a governor to limit the speed (or regulate the acceleration of a train). The cylinder immediately starts and revolves until a set of segments makes contact with the controller fingers. Current then passes from the third rail shoes up to the cab, through the master controller switch, controller and connection box to the train line and thence through cutout switches to the reverser operating coils on each motor car. If the reversers are set in the wrong direction they immediately throw to the proper position. As soon as this is accomplished, the current flows on through certain of the contactor coils and back through the train line to master controller to ground. This closes a set of contactors on each car, the action being simultaneous and similar in every way. Motor current then flows from the third rail shoes through the main switch and back through the circuit breaker and fuse to the contactors, then through a set of resistances (or cast iron grids) and reverser to No. 1 motor; through the motor, back to the contactors; through another set of resistances and the reverser to No. 2 motor and thence to ground. The motors are now in "SERIES" and the car starts. The motor current meanwhile has passed through the operating coil of a Relay (See Plates Nos. 4 and 5) attached to the reverser. This closes the relay which allows another or a very small master control circuit to pass through what is known as the lock coil of the controller (Plate No. 10–B). This coil works in conjunction with the *Controller Governor* (No. 3, Plate No. 10–B) and when energized, pulls the governor shoes firmly against the shell stopping the motion of the controller cylinder. As the speed of the car increases the motors automatically cut down the current, and when this reaches a predetermined value, the relay opens, cutting off current from the lock coil, thus releasing the governor and allowing the controller cylinder to move on to the next point, and energize another wire of the train line. This closes another set of contactors thereby cutting out part of the resistance from motor circuit, increasing the current and duplicating the previous locking process. This is repeated until the resistance is all out and the motors are then in "FULL SERIES" or on 6th point. As the controller cylinder moves on from this point, the control circuit is opened and all contactors drop, to close again in another combination on the next point. Motor current now goes over the same path as before to the contactors, but there it divides, one half going through a set of rheostats and No. 1 motor to ground, the remainder going through another set of rheostats and No. 2 motor to ground.

The motors are now in "PARALLEL." The locking and unlocking process is repeated until all resistance is cut out and the running position is reached. This action is simultaneous on all motor cars, so that at any moment the condition is the same on every car.

Current is cut off from the motors by swinging controller handle back to "off" position. This cuts off current from train line, allowing the contactors to drop and open the motor circuit completely. *If for any reason the controller handle can not be turned off, the motorman should release the button on top of the controller handle.* Holding this button down holds closed an auxiliary switch (No. 4, Plate No. 10–B) and an air valve in the controller. Both of these are closed against spring pressure, so that when the button is released, the switch opens, cutting off current from the controller and opening all the contactors. If this should fail, open the Master Controller switch which opens each circuit breaker on each car.

The EMERGENCY BRAKE ATTACHMENT for master controller consists of a main valve outside the controller (Plates Nos. 17 and 10-B, No. 17) and a pilot valve inside. The main valve contains a chamber "A" divided into two parts by a piston "B" connected to a valve "C" exhausting to atmosphere. The lower part of the chamber "A" connects directly to the train line. The upper part "A" connects to the pilot valve "F" and pressure in both parts is equalized by a small hole in the piston "B."

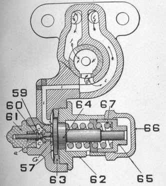


Plate No. 11.

When the pilot valve is opened, pressure in upper part of main valve is reduced and the piston lifts, allowing train line to exhaust through a hole drilled in a plug to atmosphere in the bottom of the main valve. The pilot valve is opened by a cam in the controller, which presses against the stem of the valve whenever the button in the controller handle is released, except when the reverse handle of the controller is in the *"off" position. The button on the controller handle should always be held down, except when the reverse handle is in the "mid" position. Releasing it at any time cuts off current from train line and motors and applies brakes throughout the train.*

Train operation on Elevated Division is similar, except that the controller is not automatic but must be notched up from point to point.

Cutout Cock is inserted in the feed pipe to controller valve and is held open by a seal. If controller valve at any time leaks, seal on cutout valve should be broken and controller valve cut out and report of same promptly made as per instructions governing train operation.

In case of control or motor trouble on any car, this car should be made inoperative by throwing the *10 point cutout switch to the "off" position and opening the main switch on that particular car. (If this is not effective, jumpers between cars affected should be removed).* The cutout switch disconnects the operating parts of contactors, reverser and circuit breaker on the car from the train line, but does not affect the operation of the rest of the train, although it may be the car from which the train is being operated.

The arrangement of apparatus is such that the train may be operated in either direction from any master controller in the train. In case the train breaks apart, the coupler jumpers will pull out, cutting off current from the train line on the section of train behind the break. This drops all contactors and circuit breakers on this section, while the front section continues under control of the motorman.

The reverser is so arranged that unless it is set in the proper position current is cut off from the contactors and consequently the motors on that car receive no current. When in the proper position, it is electrically locked while the motors are taking current. The contactors are also interlocked to insure either proper combination or, in case of trouble, none at all.

The master controller contains mechanical interlocks which prevent the controller from being operated when the reverse handle is in the "off" position, and since the reverse handle can only be moved at the "off" position, the controller cannot be operated without a *reverse handle*. Furthermore, the reverse handle can not be thrown except when the controller handle is in the "off" position.

The wires of the master control circuit are all protected from damage due to excessive current, by means of fuses. A fuse in the master controller switch automatically cuts off current from the entire train line, and connections in case any wire of the train line is accidentally grounded. All the return circuits on the individual cars are protected by fuses which will open the circuit should one of the wires come in contact with any of the motor control conductors. These fuses are all located on the panels of their respective cars. (See Plates Nos. 18 and 19.)

INSTRUCTIONS TO DETECT CAUSES FOR FAILURE OF TRAIN MOVEMENT.

Q. 1.—If train fails to move after instructions under *Train Operation* have been followed, what should be done?

A.—Light circuit switches should be cut in to ascertain if there is power in the contact rail, or motorman should note if trains in neighborhood are moved by power.

Q. 2.—If it is found that there is current in operating car, what should be done?

A.—Master controller handle should be moved to first point, then master controller switch opened to ascertain if the master control circuits are closed, which will be indicated by arcing at master controller switch. Master controller handle should then be moved to "off" position.

Q. 3.—What would cause the failure of train line circuits?

A.—First: Imperfect master controller fuse. Second: Grounded train line. Third: Imperfect auxiliary contact in master controller. Fourth: Loose coupler jumper.

Q. 4.—What should be done to detect imperfect fuse?

A.—Insert new fuse, and if this fails it is evident that the trouble is elsewhere.

Q. 5.—What should be done when a grounded train line occurs?

A.—The master controller fuse should be replaced and the controller moved to the "on" position to determine if fault lies in construction of the fuse. If this fails, an attempt should then be made to locate the ground in the train line. The first thing to do is to throw the *CUT-OUT SWITCH* (Plate No. 11) on the operating car to "off" position. If this proves ineffective, this operation should be repeated back through the train, cutting out, however, the train line jumper between car tested and one to be tested.

Q. 6.—What should be done to detect imperfect auxiliary contact in master controller?

A.—Motorman should remove cover from controller and note the movement of contact fingers nearest to the top of controller. The action of the train is dependent upon the contact of these fingers, and if it is found that the contact is imperfect he should endeavor to readjust the contacts, and if he fails in this it is then necessary to operate the train from the next car.

Q. 7.—What should be done to detect a loose jumper?

A.—Motorman should lose no time in going back through his train to determine if the coupler plugs are properly inserted in the sockets, and, if not, he should insert them properly.

Q. 8.—What mechanical trouble can occur in the master controller that will affect train operation?

A.—A controller finger may stub or catch on the cylinder contact plate, thereby preventing movement of cylinder.

Q. 9.—What is the remedy for this?

A.—The controller finger should be bent back to clear the cylinder contact plates, and the train operated in the usual manner. If this fails train should be operated from the next motor car.

Q. 10.—What are the other causes that would prevent the operation of a train or reduce the speed?

A.—First: The blowing of trolley rail contact device enclosed fuses. Second: The blowing of main motor circuit fuses on Manhattan Division. Third: The blowing of circuit breakers or main fuses on Subway Division. Fourth: An imperfectly acting triple valve causing brakes to remain set on one or more cars in train. Fifth: An imperfect or slow acting control governor.

Q. 11.—How can enclosed fuse that has blown be detected?

A.—If an enclosed fuse has blown, there is a deposit or collection of a grayish powder at the ends of the box.

Q. 12.—What should be done in the event of an enclosed trolley contact fuse blowing?

A.—This enclosed fuse will blow only when there is a short circuit on the car equipment, and fuse should not be replaced but train continued in the regular manner, and report promptly made to the train despatcher or person in charge of nearest terminal.

Q. 13.—What should be done on the Manhattan Division when the main motor circuit fuses have blown?

A.—If all the fuses have blown and the train is a considerable distance from the point of inspection, motorman should re-fuse at least two cars, but be sure that the main or motor circuit switch on car to be fused has been cut out and all contactors have been knocked down. He should then notify the point at which an inspector can be obtained and proceed to that point where the inspector will complete re-fusing the train. If fuses of a train have blown at or near a terminal or point of inspection, the motorman may have the following train push his train to terminal or inspection point, but this is only permitted when in the judgment of the motorman the detention to train service can be reduced.

Q. 14.—If a circuit breaker acts or blows on the Subway Division, what should be done?

A.—The Circuit Breaker Setting Switch should be moved to the "on" position, and if the circuit breaker fails to respond it is because some of the contactors have stuck up, and if there is sufficient power in the train motorman should proceed to point where an inspector can be obtained and secure his assistance.

Q. 15.—What should be done when a triple valve acts imperfectly?

A.—Air Brake Instructions should be followed, *i.e.*, valves should be cut out and auxiliary reservoir cock opened to release brakes.

Q. 16.—What should be done when the controller governor acts slowly?

A.—Controller cover should be removed and BUTTON ON TOP OF THE DRUM (No. 1, Plate No. 10-B) should be pressed down and fastened by turning to the right, which cuts out the main spring. In addition there is directly under the gear above the main cylinder a small latch (No. 2, Plate No. 10-B), which should be raised and moved to left as far as it will go. This cuts the governor out of action and enables the motorman to accelerate his train at any desired speed by turning on and notching up the same as with the master controller on the Elevated Division.

Q. 17.—What should be done if controller governor acts too rapidly?

A.—Automatic feature should be cut out as described under Q. 16.

Q. 18.—If a train is standing on cross-over and current cannot be obtained on the operating car, although the other cars of the train and trains in the neighborhood have current, what does this indicate?

A.—This indicates that the bus line fuses between the operating and adjacent cars have blown, or that bus jumper is loose or disconnected.

Q. 19.—What should be done to continue operation of train?

A.—Motorman should go back to the first motor car where current can be obtained, and move train through cross-over, then go back to the first car again and proceed in the usual manner, until a point of inspection can be reached and inspector notified.

Q. 20.—If a fire occurs in any car in the train, what should the motorman do?

A.—On the Subway Division equipment open all circuit breakers by moving the master controller switch (Plate No. 15) to the "off" position, and if this fails he should then open the main or motor circuit switch (Plate No. 9) and the main cut out switch (Plate No. 11) on the car on which the trouble occurs. On the Elevated Division equipment this same operation should be gone through with the exception of the circuit breakers.

Q. 21.—If the above operation fails to stop arcing, or if a car is derailed and truck or any part of car is sufficiently

close to the contact rail to permit the current arcing from rail to car truck, what should motorman do?

A.—Motormen on the Subway Division should immediately cut out the nearest Contact Rail Cutout Switch (Plate No. 24.) (Location shown on Plate No. 25), and on the Manhattan Division he should telephone the nearest substation and request that current be cut off that particular section. But in an instance of this kind Motorman is required to use his best judgment, for when contact rail cutout switch has been opened or current cut off section train operation is suspended on that particular section until cause of trouble has been removed. It is important therefore, that the Motormen follow all instructions pertaining to stopping fires on cars before cutting off or ordering off the power from contact rail.

Q. 22.—If smoke or fire is observed by the train men in any of the light or heater circuits within the car, what should be done?

A.—The train man should immediately cut out the light or heater switches, whichever the case may be, and the trouble reported to the Despatcher in charge of nearest terminal.

Q. 23.—If an unusual noise is observed in the movement of train, what should be done?

A.—To prevent delay, the motorman should have the conductor stand beside the train to locate the noise while he moves train, after which, if the trouble is with the brake rigging, same should be tied up.

Q. 24.—If the noise is located within the motors, what should be done?

A.—Motormen should cut out the cutout switch (Plate No. 11) on the car affected, and proceed after reporting trouble to Despatcher in charge of terminal.

Q. 25.—If a trolley rail contact device is broken, what should be done?

A.—Motorman should first pull the bus line jumpers, both ends of the car, insert wooden insulating slippers between the contact shoe and rail and then proceed to detach or tie up remnants of device, exercising extreme care that the contact device is kept clear of the truck frame, contact rail, structure, or any grounded parts to prevent injury to himself.

Q. 26.—If an unusual jerking is noticeable in a train, what is the cause of same?

A.—An unusual jerking of a train is due either to irregularly formed circuits causing control apparatus on the affected car to operate at a higher speed than the other cars in train, or some mechanical failure in control apparatus causing the same result.

Q. 27.—What should be done to prevent this?

A.—Motorman should call up his conductor and request that he make an inspection to note the movement of the various cars in the train during the period of acceleration until the affected car is discovered, after which the cutout switch (Plate No. 11) should be cut out on car affected, and the trouble reported to the inspector or despatcher at the terminal.

Note.—If one or two cars of a train have been rendered inoperative due to failure of apparatus, Motorman must use his judgment as to whether it is advisable to attempt to locate trouble or continue train operation until a point of inspection can be reached. If trouble occurs a considerable distance from a terminal or point of inspection, and the delay, in the judgment of Motorman, will be greater than that caused by his endeavor to locate and correct trouble, he should then follow instruction given hereinbefore.

DIVISION.

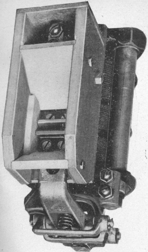


Plate No. 3-A. 1/2 Size.
CONTACTOR, SUBWAY DIV.

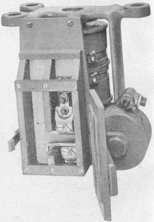


Plate No. 3-B. 1/4 Size.
CONTACTOR, MANHATTAN RY. DIV

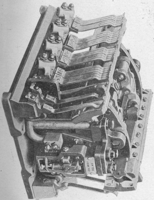


Plate No. 4. 1/6 Size.
REVERSER, SUBWAY DIV.

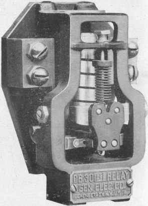


Plate No. 5. ⅝ Size,
REVERSER RELAY, SUBWAY DIV.

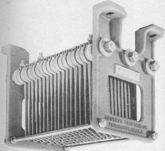


Plate No. 6. ⅓ Size.
MOTOR CONTROL RHEOSTAT,

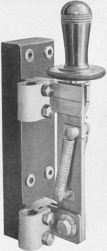


Plate No. 7. $^2/_3$ Size.
MAIN SWITCH.

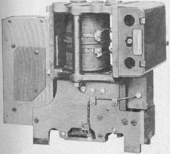


Plate No. 8. $^1/_6$ Size.
CIRCUIT BREAKER, SUBWAY DIV.

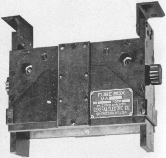


Plate No. 9. 1/5 Size.
MAIN FUSE.

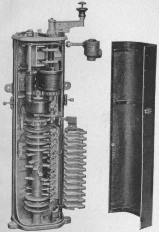


Plate No. 10-A. 1/12 Size.
MASTER CONTROLLER.

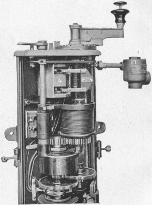


Plate No. 10-B. 1/7 Size.

MASTER CONTROLLER WITH EMERGENCY VALVE, SUBWAY DIV.

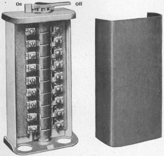


Plate No. 11. 1/4 Size.

CUT OUT SWITCH, MANHATTAN RY. DIV.

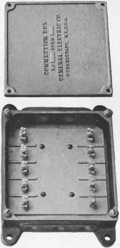


Plate No. 12. 1/3 Size.
CONNECTION BOX

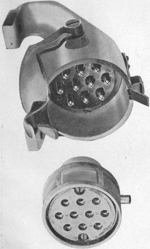


Plate No. 13-A. 1/3 Size.
TRAIN LINE JUMPER PLUG AND SOCKET, SUBWAY DIV.

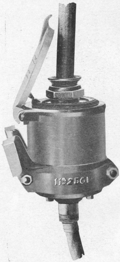


Plate No. 13-B. $^1/_4$ Size.

BUSS LINE JUMPER.

Plate No. 13-C. $^1/_2$ Size.

LIGHT AND HEAT JUMPER PLUGS AND SOCKETS, MANHATTAN RY. DIV

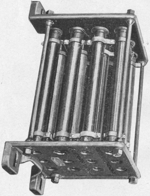


Plate No. 14. $^1/_5$ Size.
CONTROL CIRCUIT RHEOSTAT.

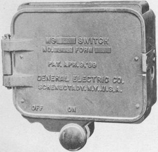


Plate No. 15. $^2/_5$ Size.
COMBINED MASTER CONTROLLER AND CIRCUIT BREAKER TRIPPING SWITCH, SUBWAY DIV.

Plate No. 16. 1/2 Size.
CIRCUIT BREAKER SETTING SWITCH, SUBWAY DIV.

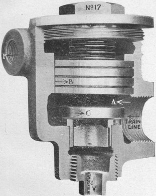


Plate No. 17. 4/5 Size.
CONTROLLER EMERGENCY VALVE, SUBWAY DIV.

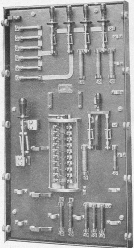


Plate No. 18. 1/6 Size.
SWITCH PANEL, SUBWAY DIV.

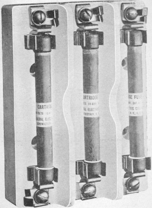


Plate No. 19. 3/5 Size.
CONTROLLER FUSES.

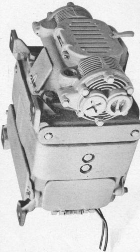


Plate No. 20. 1/7 Size.
AIR COMPRESSOR, MANHATTAN RY DIV

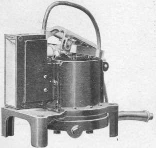


Plate No. 21. 1/4 Size.
AIR COMPRESSOR GOVERNOR, MANHATTAN RY. DIV.

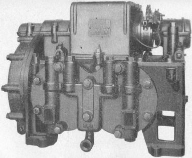


Plate No. 22. 1/7 Size.
AIR COMPRESSOR, SUBWAY DIV.

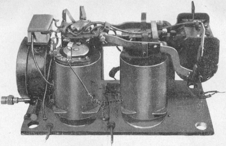
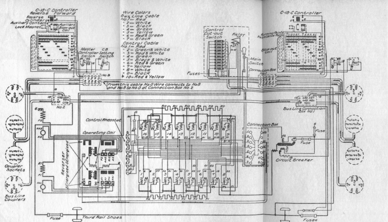
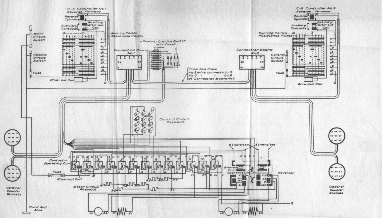


Plate No. 23. 1/5 Size.
AIR COMPRESSOR GOVERNOR, SUBWAY DIV.



WIRING DIAGRAM, SUBWAY DIVISION.



WIRING DIAGRAM, MANHATTAN RAILWAY DIVISION.

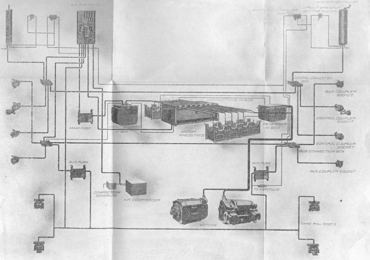


Plate No. 1.

ARRANGEMENT OF CONTROL APPARATUS AND MOTORS, SUBWAY DIVISION.