Portland, Eugene & Eastern Railway Company

RULES AND REGULATIONS

For the Government of

MOTORMEN, TRAINMEN AND INSPECTORS

In Electric Train Service

Effective January 1, 1914

No. 183

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INSTRUCTION BOOK

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RULES AND REGULATIONS

For the Government of
MOTORMEN, TRAINMEN AND INSPECTORS
In Electric Train Service

Effective January 1, 1914

Every employe whose duties are in any way connected with the operation or maintenance of the air-brake and electric equipment used in electric train service will be required to have a knowledge of the apparatus which he is called upon to operate in the performance of his duties.

TRAINMEN will be required to familiarize themselves with the name, location and purpose of the apparatus in order that they may carry out instructions given them by motormen.

MOTORMEN will be required, in addition to the above, to know in general the principles upon which the operation of the various apparatus depends; the manner in which it should be operated, and the method of procedure in case of train failure.

INSPECTORS will be required, in addition to the above, to familiarize themselves with the construction and details of the apparatus and method of making repairs.

(Signed) F. L. BURCKHALTER,
Superintendent.

APPROVED:

D. W. CAMPBELL,
Assistant General M nager.

W. R. SCOTT,
V. P. and General Manager.

CAUTION.

No repair work or corrections shall be attempted, except by those duly authorized, who will first see that all switches controlling the circuit on which work is to be done are open. Before undertaking any work in connection with the electrical apparatus or car wiring, they should ascertain just what is to be done in order to do it with as little delay as possible, and at the same time use care for protection of the passengers, and of themselves.

In addition to methods prescribed in these instructions for resuming service in cases of electric train failure, employes are cautioned to avoid increasing the usual excitement and confusion of passengers in emergency cases. A quiet and confident manner will do much to restore normal conditions, especially where explosion, smoke and flame from a burn out or blown fuse tend to alarm the passengers.

RULES GOVERNING EMPLOYES IN OTHER THAN TRAIN SERVICE

First: Every employe whose duties are in any way connected with the operation or maintenance of the electric and air brake equipment used on electric cars will be required to have a knowledge of the apparatus with respect to its operation, and safety to himself and others. He will be subject to examination covering same.

Second: Only authorized employes shall work on or about the air brake and electric equipments.

Third: Only authorized employes shall move electric cars.

Fourth: Shop employes, inspectors on the road or at terminals, shall not work on or about the electric apparatus on the electric car or cars until after the pantograph trolley has been lowered and locked.

Fifth: In case of failure of the automatic devices on the pantograph trolley, and it becomes necessary to operate the pantograph, it shall not be done until after the employe has first opened the dynamotor-air compressor switch No. 9 on the panel board. The operator shall pull the pantograph trolley from the wire with the insulated hook provided for this purpose.

Sixth: The trolley wire within the shop building shall be energized for only the period of time required to move cars into or out of the shop building. The shop foreman or other employes instructed by him, shall control the energizing and de-energizing of the trolley wire within the building.

Seventh: When moving cars in and out of the Inspection Shop Bay, it is necessary to energize the overhead lines at 1500 volts potential. In order that one may know at all times the condition of the overhead line, there are installed two indicating lights over each track in the building. The green light is an indication that the line is not energized; the red light indicates that the line is energized and is dangerous. In connection with these indicating lights, there is an alarm whistle located near the center of the building.

When the line is to be energized one blast of the whistle will be given. Upon hearing this signal employes working on or about the cars will stand clear of the cars or overhead line, and will wait for the red signal indicating the trolley wire that is energized. Should the red signal appear over the track on which one is working, he shall not return to work until the line shows to be clear, indicated by the green signal. Employes are forbidden to go on the top of the car until they have ascertained that the overhead wire has been de-energized.

Eighth: Preparatory to working under a car, employes shall first open the main switch.

Ninth: 600 volt potential shall be used exclusively for testing purposes.

Tenth: Employes working on or about electric cars will protect themselves by the use of the blue flag during the day and blue light at night.

Eleventh: Employes engaged in moving cars on the main line in or about yards, will be provided with a copy of the Rules and Regulations of the Transportation Department.

Twelfth: In case of accident to an employe the nearest Company Physician shall be immediately notified and all aid rendered in accordance with Instruction Chart on "First Aid to the Injured." The office of the Superintendent of Equipment must be notified immediately of all accidents.

PART I.

INSTRUCTIONS FOR OPERATING THE AMU BRAKE EQUIPMENT

CHARGING

Before starting the air compressor, *close* the drain cocks in the main, auxiliary and supplementary reservoirs, the centrifugal dirt collector drain cocks, the brake pipe and main reservoir pipe angle cocks at each end of the train, the brake valve cut-out cock in the brake pipe under the brake valves not to be operated, and all whistle cut-out cocks except the one in the motorman's cab. On the car to be operated, the cock in the straight-air application pipe underneath the brake valve to be operated must be *open* when running a single car, but *closed* on both ends of the head car in train operation; on all following cars this cock must be *closed.* Straight air operation is thus cut out in train service to avoid rough and improper handling. See that all the following cocks are *open:* governor cut-out cock, cut-out cock in pipe leading to the dynamotor clutch magnet, main reservoir cut-out cock, cut-out cocks in the branch pipes from the brake pipe and main reservoir pipe to the Universal valve, all brake pipe and main reservoir pipe angle cocks between cars, the brake valve cut-out cock under the brake valve to be operated, and the whistle cut-out cock in the operator's cab.

See that all hand brakes are fully released.

Place a handle on the brake valve to be operated (the cut-out cock underneath it being open) and move it to *Release and Running* position at the extreme left. Then start the compressor by closing the switch No. 9 in the dynamotor-compressor circuit.

Do not attempt to move the train (or car) until the brake pipe gauge hand shows full pressure.

RUNNING

Keep the brake valve handle in *Release and Running* position when not being used.

In event of sudden danger move the brake valve handle quickly to *Emergency* position, at the extreme right, and leave it there until the train stops or the danger is past.

If the brakes apply while running over the road, due to the opening of a conductor's valve or rupture of the brake pipe, move the brake valve handle to *Emergency* position at once to prevent loss of main reservoir pressure. After the train stops the cause of the application should be located and remedied before proceeding.

SERVICE APPLICATION

Straight Air

(a) SINGLE CAR.—To apply the brakes for an ordinary stop move the brake valve handle to *Straight-Air Application* position. When the desired brake cylinder pressure has been obtained, as shown on the single pointer air gauge, the brake valve handle should be returned to *Straight-Air Lap* position where it should remain until it is desired either to release the brakes or to make a heavier application. This cuts off the flow of air through the straight air application and release pipe, double check valve, and the Universal valve to the brake cylinder, thus preventing further increase in brake cylinder pressure.

Automatic

(b) TRAIN.—In train operation (*two or more cars*), the brakes are applied by placing the brake valve handle in *Automatic Service* position.

When the brake pipe gauge hand of the duplex air gauge shows that a sufficient reduction in brake pipe (or equalizing reservoir) pressure has been made to apply the brakes as required by the speed, condition of rail, grade, and kind of stop desired, move the handle back to *Automatic Lap* position, where it should remain

until it is desired either to release the brakes or to apply them with greater force. In the latter case move the handle again to *Automatic Service* position, further reducing the brake pipe pressure until the desired result is obtained, then return it to *Automatic Lap* position. The amount of brake pipe reduction necessary in any given case depends entirely on the conditions as stated above, a knowledge of which is soon acquired by practice. It should be especially borne in mind, however, that the retarding effect of any given reduction is relatively greater at low than at high speeds, other conditions being equal. When making a service application, it is useless to *attempt* a reduction below the "Equalizing Point", at which the equalizing and reduction limiting reservoir pressures become equal, since the brake pipe reduction is automatically limited by the Limiting Valve in the brake valve. Under normal operating conditions this corresponds to a reduction of 20 lbs. from 70 lbs. brake pipe pressure.

The best possible stop will be made when the brakes are applied as hard, *at the very start*, as the conditions of speed, rail and comfort of passengers will permit, and then graduated off as the speed of the train is reduced, so that at the end of the stop little or no pressure remains in the brake cylinders.

Because the retarding effect of any given brake application is greater at low than at high speed, a heavy application at low speeds will result in an abrupt stop, which will cause discomfort to passengers, or sliding of the wheels. At *high* speeds a heavy initial application should be made in order to obtain the most effective retardation possible when the momentum of the train is greatest. If the brake cylinder pressure is very light at first and is increased as the speed of the train diminishes, it not only makes a longer stop but the high cylinder pressure at the end will be liable to produce a rough stop, perhaps slide the wheels and result in loss of time because of the necessity for waiting until this high cylinder pressure can exhaust before the train can proceed.

HOLDING BRAKES APPLIED

Straight Air

(a) SINGLE CAR.—When the desired brake cylinder pressure has been obtained, the brake valve handle should be placed in *Straight-Air Lap* position where it should remain until it is desired either to make a heavier application or to release the brake.

Automatic

(b) TRAIN.—After the reduction of the brake pipe pressure has been made, the brake valve handle should be moved to *Automatic Lap* position and left there until it is desired either to make a further reduction or to release the brakes.

Never allow the brake valve handle to remain in Lap position, in either Straight-Air or Automatic operation except while bringing the train to a stop, and in any case it should not be allowed to remain in this position for a sufficient length of time to permit the cylinder leakage to diminish the braking power materially.

RELEASE

To release the brakes fully after any application, move the brake valve handle to *Release and Running* position. The handle must be left in this position at all times when the brakes are not in use, to keep the brake system charged and ready for operation and to insure that the brakes will not be applied by leakage.

Straight Air

(a) SINGLE CAR.—*To graduate, or partially release the brakes,* move the brake valve handle to *Release and Running* position for a moment, then back to *Straight-Air Lap* position; repeat this operation as may be necessary until the train is brought to rest with only enough pressure retained in the brake cylinder to prevent it from starting. With a very little practice the motorman will learn how long the handle should remain in

Release and Running position to produce the desired results. Obviously, this varies with the brake cylinder pressure and the reduction in brake cylinder pressure desired.

Automatic

(b) TRAIN.—To graduate or partially release the brakes when operating automatically, move the brake valve handle momentarily to *Release and Running* position or to *Straight-Air Lap* position, then back to *Automatic Lap* position; repeat this operation as often as necessary until the train is brought to rest with only enough pressure retained in the brake cylinders to prevent it from starting.

With a very little practice the motorman will learn how long the handle should remain in *Release and Running* position or in *Straight-Air Lap* position to produce the desired results. Obviously this varies with the brake cylinder pressure, the amount of reduction in brake cylinder pressure desired and the length of train, etc.

When it is desired to release the brakes but slightly or when handling short trains (two or three cars), if the handle is moved to *Release and Running* position, the resulting increase in brake pipe pressure and corresponding release of brake cylinder pressure is likely to be greater than was intended. For this reason it is usually best in such cases to move the handle from Automatic Lap to Straight-Air Lap instead of to Release and Running position. A few trials will enable the motorman to find out for himself which of the two positions he should use.

EMERGENCY

Should it become imperative to stop in the shortest possible time and distance, to save life or avoid accident, move the handle quickly from whatever position it may be in to *Emergency* position, which is at the extreme right and leave it there until the train has stopped, or the danger is past.

CHANGING ENDS

When changing from one end of the train or car to the other, set the brakes by making a 20 pound brake pipe reduction; close the cut-out cock in the brake pipe underneath the brake valve and the whistle cut-out cock, remove the brake valve handle and, after placing it on the brake valve at the other end and moving it to *Release and Running* position, open the cut-out cock in the brake pipe underneath the brake valve. Always close this cut-out cock before removing a brake valve handle and, in placing a handle on a brake valve, always move it to *Release and Running* position and *then* open the cock. Also open the whistle cut-out cock in the motorman's cab from which train is operated.

AIR BRAKES AND ELECTRO-PNEUMATIC SIGNALS

RULES

A-1. Every employe whose duties are connected with the air brake and air signals must be examined by the Inspector of Air Brakes or other proper authority, as to their practical working and rules governing the same, and is required to visit the air brake instruction car or rooms at every opportunity.

A-2. Shop and Inspector Foremen must see that all drain cocks in all reservoirs are opened and water drained from them each day.

A-3. Air compressors will be oiled and attended to by the shop force at terminals or inspection points at such times as designated by the officer in charge of maintenance of equipment.

A-4. The following air pressures will be carried:

Air Compressor Governor, H. P. Adjustment	100 lbs.
Air Compressor Governor, L. P. Adjustment	85 lbs.
Main Reservoir Safety Valve	110 lbs.
Main Reservoir Pipe Pressure	100-85 lbs.
Brake Pipe Pressure	70 lbs.
Safety Valve on Universal Valve	62 lbs.

A-5. The standard piston travel on all cars is five inches, but between five and seven inches will be permissible.

A-6. Automatic Slack Adjusters should be adjusted for five inches piston travel.

All hand adjustments of brake rigging should be made with these adjusters screwed back to initial position of cylinder lever, close to lug on cylinder head.

To release slack adjuster for application of new shoes, turn fluted end connected to adjuster nut backward until cylinder lever is close to cylinder head lug.

Slack adjusters must be cleaned and oiled each time the brake cylinder receives attention.

A-7. See that there are no leaks in the air pipes or connections, and that air brake apparatus is in good working order generally. All hose must be given soap suds test at each regular inspection.

A-8. Inspectors must see that all brake apparatus including universal valves, brake cylinders, slack adjusters, and centrifugal dirt collectors are cleaned, oiled and tested, according to recommended practice, every three months, date of cleaning, etc., to be stenciled on either brake cylinder or auxiliary reservoir as per standard practice. All old stenciling must be erased when new stencil is applied.

A-9. All air gauges must be tested and corrected every thirty days, and date of test stenciled on face.

A-10. When brake pipe and main reservoir pipe hose are not coupled between cars, or on ends of trains, they must in every case be coupled to the dummy couplings provided for that purpose, to prevent injury to the hose or admission of dirt to the pipes.

A-11. Extra hose for brake and main reservoir pipes must be carried in the baggage compartment of such cars.

A-12. Inspectors must not permit cars to leave terminal or repair stations without air brakes being cut in and operative.

A-13. The shop or general inspection of equipment, cleaning and adjusting of air-brake apparatus, valves,

etc., will be arranged for by the officer in charge of Maintenance of Equipment.

A-14. Motormen must report, on work-book at terminals or repair stations, all defects in air-brake or signal apparatus.

A-15. Air-brakes must not be applied with controller in "on" position.

A-16. Motormen and trainmen must accustom themselves to frequent observations of air-gauges, both when brakes are being used and at other times, noting by varying pressures any irregularity of operation of apparatus as well as the operation of the brakes.

A-17. Employes, when working on brake apparatus on cars, must protect themselves by use of a blue flag by day, and a blue light by night, according to Rules and Regulations of the Transportation Department.

A-18. When a train has been coupled together, all air hose must be connected, and cocks in these pipes opened, except those on front and rear end of train which must be closed.

A-19. On arrival of trains at inspection stations, motormen will apply brakes with a fifteen-pound service reduction. Inspectors will then go over the train, noting cars on which brakes do not apply and other defects, reporting them to the proper authority for such action as may be required under the existing instructions.

A-20. Signals for testing air-brakes will be given as prescribed in Rules of the Transportation Department.

A-21. The terminal inspection of a train will be made as follows: After the entire train is coupled up, apply an inspector's air-gauge to the rear end of train, with connection to brake and main reservoir pipes.

When the train has been charged to standard pressure, the inspector at rear end of train will signal the motorman to apply brakes, which will be done by making a twenty-pound reduction. Inspectors will then go over train, noting the condition of brakes and adjustment, and remedying any defects.

The inspector will then go to rear end of train and signal motorman by four blasts of air-whistle by signal cord, to release brakes. Brakes will be released by motorman, and the air signal answered by two blasts of the alarm whistle. Inspectors will then go over train, noting if all brakes have released.

A-22. If a universal valve should be found defective make repairs if possible; if this cannot be done cut it out by closing the cut-out cocks in the branch pipes, and open the drain cock on the auxiliary and supplementary reservoirs, notifying the proper authority immediately.

A-23. Test of the signal apparatus must be made by inspectors at inspection stations, by trainmen at points where inspectors are not located or are not on duty, and at all other points where the make-up of the train has been changed by the trainmen.

In testing the signal whistle apparatus make test by using signal switch on the rear car, making contact for the length of time it is desired for each blast of the whistle.

A-24. Charging and re-charging of brake-pipe and application of brakes for testing or braking must be done from the head end of train, by the motorman only, except where otherwise provided.

The train will then be ready to go forward and will be so reported to the proper authority by the inspectors.

In case a train is held at an inspection point five minutes after its regular leaving time, through some cause not known to the inspectors, they must have the motorman apply and release brakes just before leaving and see that brakes work throughout the entire train.

A-25. At outlying, or turn-around points, or when cars are picked up or set out, or when motorman changes from one cab to another, the following air-brake test must be made by the trainmen when inspectors are not stationed at such points. After train is made up and charged to standard pressure, the trainmen shall go to the rear of train and signal motorman to apply brakes,

which will be done by making a twenty-pound service reduction, when the trainman at rear of train will notice if the brakes apply by the piston rod moving out of the cylinder and brake shoes applying against the wheels, and if they do, he will signal motorman by four blasts of signal whistle, by the signal switch from the rear car.

The motorman will release brakes as in standard practice and answer signal whistle with two short blasts of alarm whistle. If the brakes do not apply or release, the train must be held and an investigation made to ascertain cause for the failure.

The cause must be remedied before train can proceed.

A-26. When a train has attained a speed of 6 or 8 miles per hour, a running test shall be made after leaving initial or inspection station, or any point where make-up of train has been changed, or hose has been separated, also 1,000 feet before reaching railroad crossings at grade, or drawbridges, and before commencing descent of heavy grade, by motorman making an application of the brakes with sufficient reduction to ascertain if they are working properly. This test should not be made with controller in "on" position.

When such running test is made the trainman on the rear car shall observe the brake cylinder gauge, and note if brake applies. If it operates properly he will signal motorman to proceed by giving one short blast of the communicating signal, which signal will not be answered.

If the brake does not operate properly, the train must be stopped and cause of failure remedied.

A-27. In making up trains examine all hose couplings to see if tight and ascertain if all brake valve handles are removed, if cutout cocks in brake pipe underneath brake valve, signal whistle and alarm whistle pipes are closed.

Dynamotor compressor switches should be closed, and illuminated gauge switches "off" except in the cab from which the train is to be operated; and the brake valve in this cab should be in release position.

The cut-out cocks in brake, signal whistle and alarm whistle pipes should be open in cab to be operated from.

A-28. At the summit of all heavy grades specified by the Superintendent, train shall stop and trainmen will make air-brake test as prescribed in rule A-25, and if brakes operate properly, train may proceed, but in case brakes do not operate properly, the cause for such failure must be remedied before commencing the descent.

This test may be made at foot of grades or such other points as may be designated by the Superintendent.

A-29. When defects develop on the road between repair stations which cannot be remedied without serious delay, cut out the defective brake and make out defect card covering the defect, which the conductor must hand to the Foreman of Inspectors at repair station.

Brakes on front and rear cars of a train should not be cut out if it is possible to avoid it. If necessary to cut out brakes on such cars, trainmen must remain on these cars until the repair station is reached.

To cut out brakes, proceed as explained in Rule A-22.

A-30. In making a service stop, a heavy initial reduction of brake pipe pressure should be made, which reduction should be sufficiently heavy to stop the train short of the desired point, then as the speed decreases, the brake-cylinder pressure should be reduced by graduated release of the universal valve, which is accomplished by moving the brake valve handle from lap position to running position for a short period of time and then back to lap again, etc.

This graduation of the release can be varied by long or short periods of movement of the brake-valve handle between lap and running position.

The amount of the graduated reduction of cylinder pressure will be shown on the brake cylinder gauge in motorman's cab. The brake cylinder pressure should be graduated off sufficiently to either release the brakes or retain only a small pressure in the cylinders at the stop.

A-31. If it is found that brakes are sticking, ascertain if the required brake-pipe pressure is being carried. If not, the trouble may be on the car from which the brakes are being operated. Make a ten-pound reduction of brake-pipe pressure, and release immediately; if this does not remedy the trouble the feed valve is not carrying the proper pressure and it will be necessary to bleed the auxiliary and supplementary reservoirs until brakes release.

A-32. Two short blasts of the alarm whistle repeated three times is signal for brakes sticking.

A-33. Frequent application and release of brakes, without allowing sufficient time to recharge the auxiliary reservoirs reduces the efficiency of the brakes and should be avoided, but with this equipment the time required for recharging the auxiliary reservoirs is very much less than with the older form of triple valve.

A-34. When cars are picked up, trainmen must see that handbrakes are released and air-brakes cut in and charged to proper pressure before moving train; and that air-brake is operative and that piston travel is between five and seven inches.

A-35. When cars are set out, release the air-brakes and apply hand-brakes.

If hand-brakes are defective, make out defect card and attach it to the car, and block the car wheels securely before leaving it.

A-36. If a hose should burst, conductors must protect train in accordance with Rules and Regulations of the Transportation Department, before attempting to release the brakes; close angle cocks on brake or main reservoir pipe as may be necessary until the hose is replaced.

A-37. When necessary to release brakes by "bleeding", open the drain cock on the auxiliary and supplementary reservoirs until brake is entirely released and then close them.

A-38. When trains are standing on grade where it is necessary to keep the automatic brake applied, the

brake-pipe pressure should not be permitted to leak down more than approximately thirty pounds below standard pressure. Should this happen an emergency application of the brakes will occur.

Therefore, if necessary to stand a long time on grade, a sufficient number of hand-brakes should be set to permit of releasing and re-charging the brake system to standard pressure, so as to be prepared to start promptly and have proper control of train.

If trains are on ascending grade, hand-brakes should be applied on rear end, and, if on descending grade, hand-brakes should be applied on the head end.

A-39. In case of a complete air-brake failure, train must be protected according to Transportation Department Rules, and must not be moved without authority of the Superintendent.

A-40. To apply brakes by means of the conductor's valve pull the cord and hold the valve open until train stops, then close tightly. *Conductor's valves must be used only in emergencies.*

A-41. Trains must not leave initial points, inspection stations, or start down grade, or from any stop on grade, until full brake-pipe pressure has been obtained in both brake-pipe and auxiliary reservoirs.

If from any cause this cannot be obtained in a reasonable time, or maintained after starting, train should be operated at a reduced speed to insure proper control.

DESCRIPTION OF APPARATUS

Dynamotor Driven Air Compressor is a combination machine consisting of the duplex air compressor portion and a direct current, self-contained dynamotor, connected, when the clutch is thrown in, by herring bone gearing, the function of the dynamotor being twofold: 1st, to supply current at 600 volts for the car lighting and control circuits, and, 2nd, to drive the air compressor as required.

Fig. 1 shows a horizontal section, and Fig. 1-A shows an elevation of the compressor portion, the cylinder

cover being sectioned in the elevation to show the valve arrangement. Fig. 2 shows a vertical end section of the compressor. Figs. 3 and 3-A are sectional views of the dynamotor, and Fig. 4 a sectional view of the clutch.

The compressor portion is of the duplex type with pistons moving simultaneously in opposite directions. The cylinders are on an angle to the horizontal, thus permitting minimum valve clearance and consequently resulting in maximum cylinder efficiency.

The air is drawn through the suction strainer (see Figs. 1 and 1-A), into the pipe tapped opening marked "Air Inlet," in cylinder cover 3, into chamber J, thence by raising either one of the two inlet valves 40, through ports C or C′ into cylinder A or B, (depending upon which piston is moving away from the cylinder cover). On the return stroke the air is forced through either of the two exhaust ports (of which one, K, is shown in Fig. 2), past one of the discharge valves 42, then into chamber E, from which it goes into the discharge pipe. Both the inlet and discharge valves are made of pressed steel tubing and are, therefore, light and easily removable. The inlet valves are accessible by removing caps 41; the discharge valve, by removing caps 43.

The crank shaft 24 and its bearings and the cylinders are lubricated from a bath of oil poured into the dust-proof crank case through the special fitting 22, which acts as a gauge of the oil level. The oil splashed onto the crank shaft rear bearing seeps through this bearing into the gear case whence it is carried by the gear up into the clutch and the rear bearing of the dynamotor. The entering of this oil into the rear bearing of the dynamotor cannot cause any flooding of the dynamotor for the reason that any overflow passes directly back into the crank case through an overflow passage. The motor bearing on the end opposite the clutch is lubricated by the well-known method of oil and waste lubrication.

The compressor is thrown in or out of operation by a clutch. When the pressure in the main reservoirs is less than the cutting in point of the master governor,

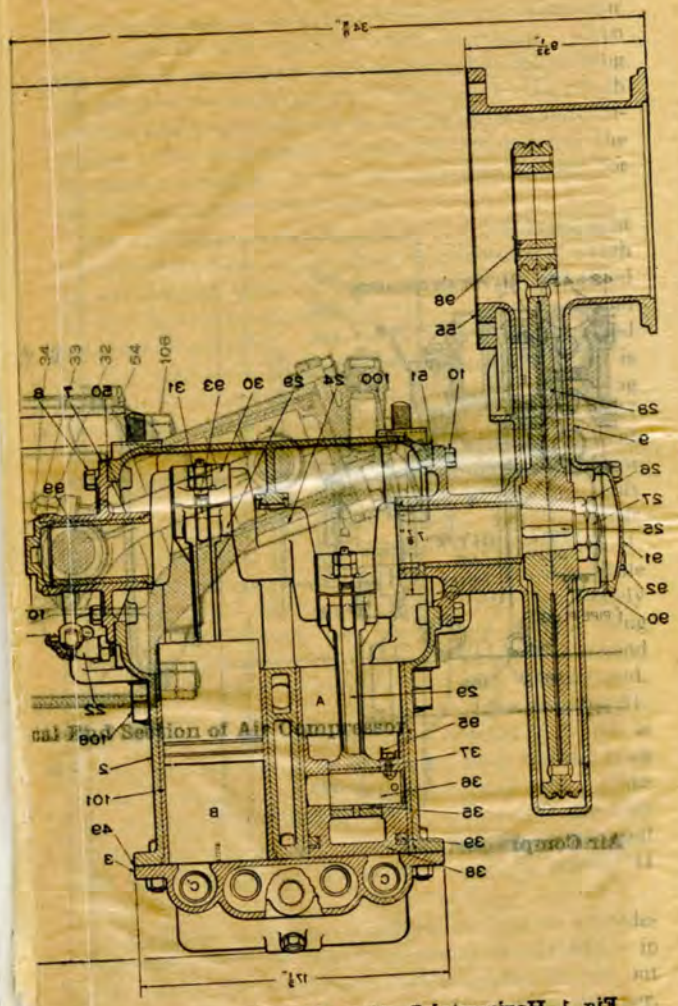


Fig. 1, Horizontal Section of Air Compressor.

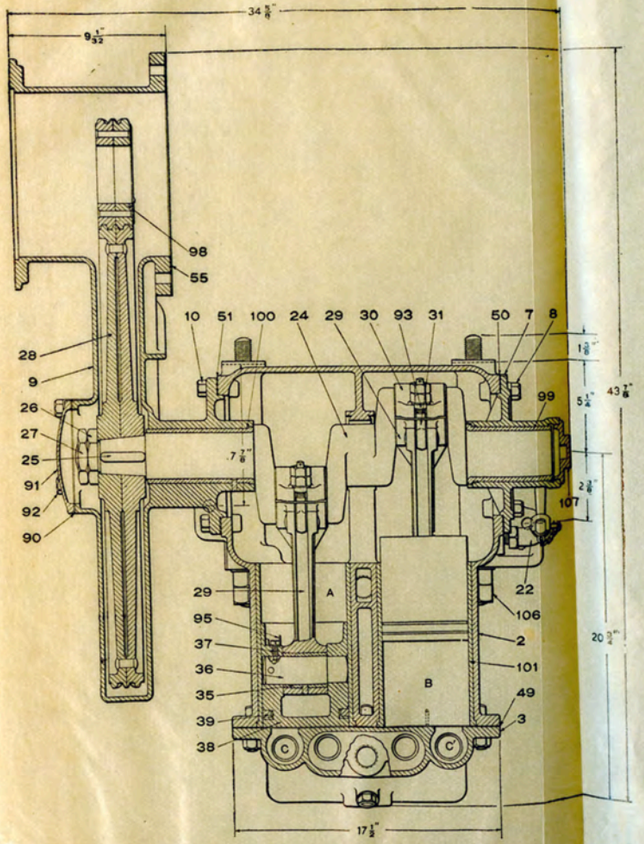


Fig. 1, Horizontal Section of Air Compressor.

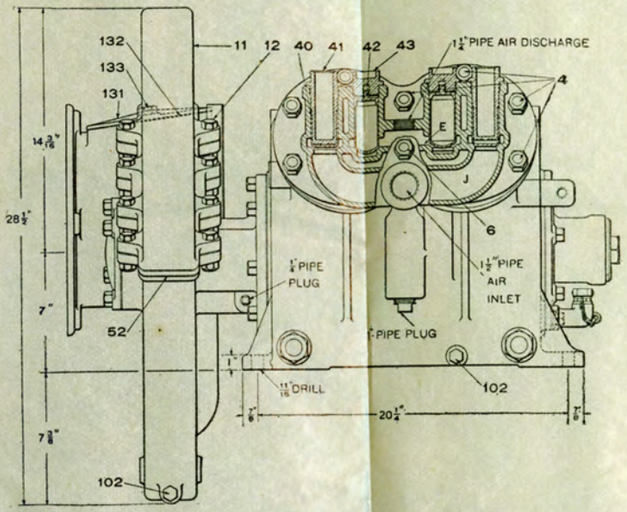


Fig. 1-A, Elevation of Air Compressor.

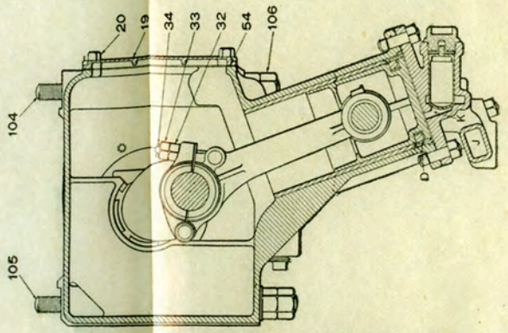
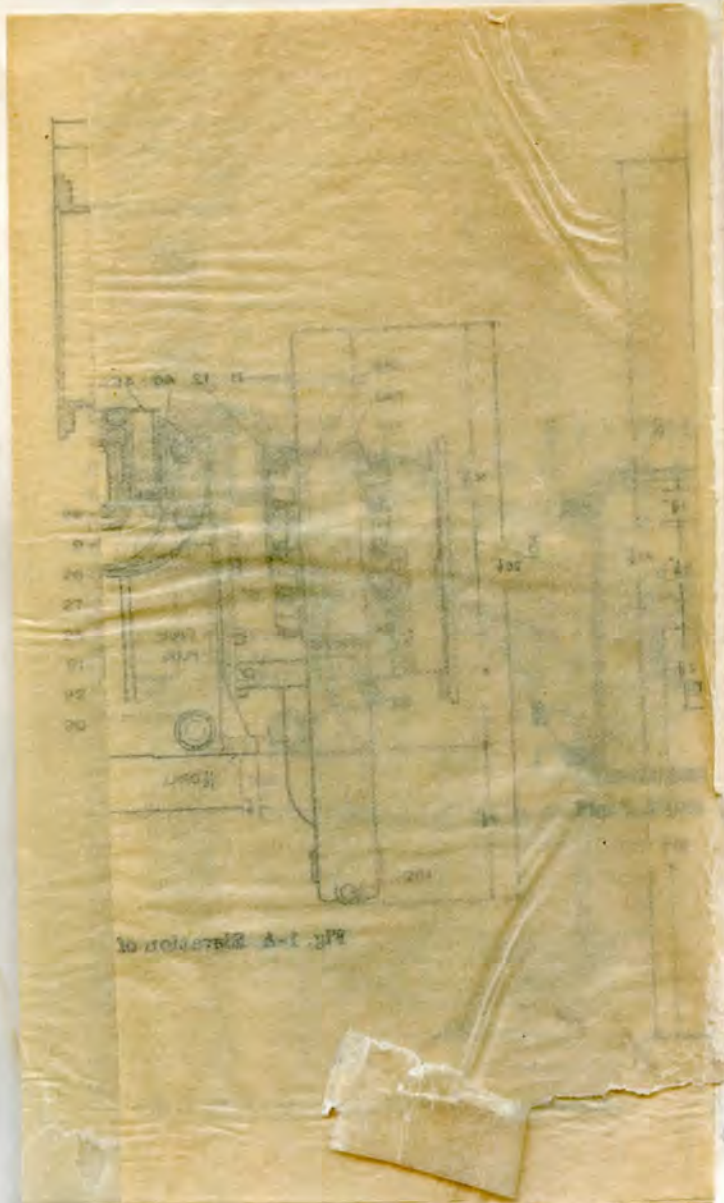


Fig. 2, Vertical End Section of Air Compressor.



the clutch connects the compressor to the dynamotor shaft and thereby operates the compressor. When the pressure in the main reservoirs reaches the cutting out point of the governor, air is admitted to the clutch cylinder which opens the clutch and disconnects the compressor. The compressor then stops running but the dynamotor continues to run for supplying current for the lighting and control circuits.

Fig. 4 shows the clutch in cut-out position, being held there by main reservoir pressure, the admission of which to and exhaust from the piston chamber is controlled by the combined operation of the clutch magnet and compressor governor. The piston arm 23 is connected by the yoke rods 19 to the yoke 15 against which is pressed, by spring 13, the spring follower 16, the spring being compressed between the follower and cotter 17 which passes through spring ferrule 14. Pinion bracket extension 12 fits loosely over the end of the dynamotor shaft while driving bracket 11 is fastened to the shaft and therefore revolves with it. The right and left hand discs 9 and 10 fit loosely over the bracket 11, the cutout portion of these discs being circular while the bracket is hexagonal in shape; disc 8 also loosely fits over the bracket, but, the cut-out portion being hexagonal, revolves with it. The right and left hand discs are arranged alternately with disc 8 interposed. Clutch plate 7 also fits loosely over the bracket 11. The pinion is placed upon pinion bracket 2, which is free to revolve about the dynamotor shaft bearing bush when the clutch is cut out, the pinion being held in place by the pins shown and by nut 34. Therefore the only moving parts when the dynamotor is in operation and the clutch is out are the dynamotor shaft, bracket 11 and discs 8.

As soon as main reservoir pressure falls to a predetermined point, the master governor cuts in which in turn causes the dynamotor clutch magnet to cut out and thereby exhaust the air from the piston chamber. This permits spring 13, acting on spring follower 16, to

return piston arm 23 to its inmost position. As the spring follower moves inward it bears down upon the clutch lever 3 (of which there are three), which is free to move on a pin 4 attached to pinion bracket 2. This pressure transmitted to pin 6 (of which there are three), presses plate 7 against the discs, causing them to be compressed. This results in the transmission of motion of the dynamotor shaft through driving bracket 11, discs 8, 9, and 10, and the pinion bracket 2 to the pinion.

THE MASTER GOVERNOR is a device for maintaining the pressure in the main reservoir within certain limits, in this case 85 and 100 lbs.

Referring to Fig. 5 it will be seen that the governor consists of two distinct portions; a switch portion, having a removable cover, and a pneumatic regulating portion. The electric circuit from the trolley to the clutch magnet and synchronizing wire is made or broken by the switch portion of the governor, which consists, essentially, of a switch spider 43, rigidly attached to the switch piston and rod 16 and forming the connection between the finger contacts 5 when the governor is in "cut-in" position.

The electric portion of this device is confined entirely to one end and is insulated thoroughly from the parts with which it comes in contact. It is covered with a thin iron casing which can be quickly and readily removed after loosening the thumb nuts 13. The terminal blocks and screws are all readily accessible when the cover is removed and are entirely protected when it is in place.

The admission of air to and exhaust of air from the air cylinder W is controlled by the regulating portion of the governor and takes place through port *g* shown by dotted lines, which, when the governor is in "cut-in" position, is connected by cavity *h* in the slide valve 76 with the exhaust port *f* which leads to the atmosphere. Referring to Fig. 5, (which, it should be clearly understood is not a true section of the governor, but is drawn diagrammatically so as to show clearly the different parts of the device and their connections), air from the main

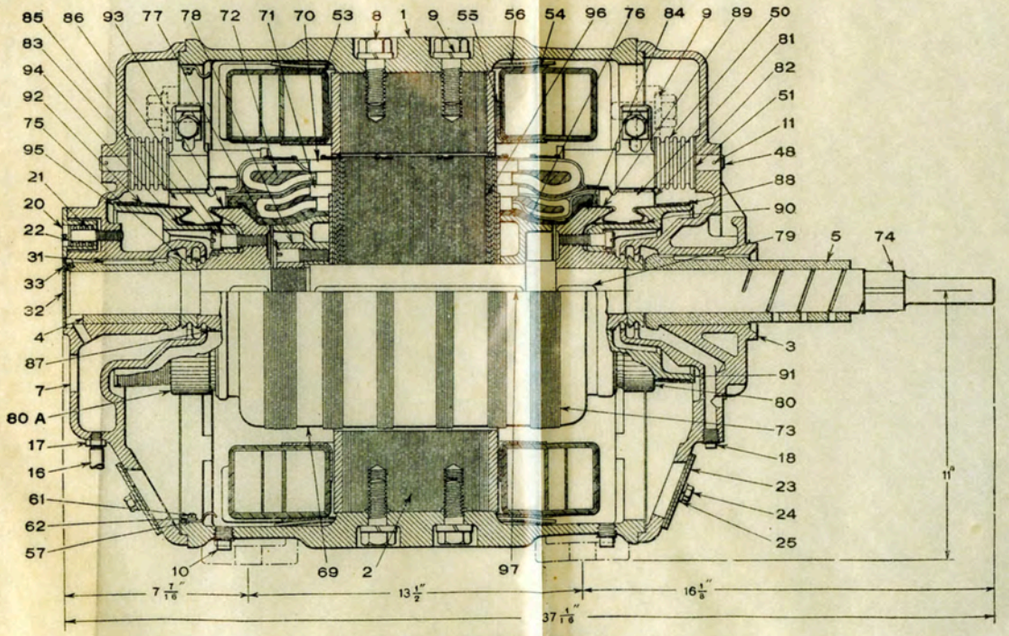


Fig. 3, Cross Section of Dynamotor

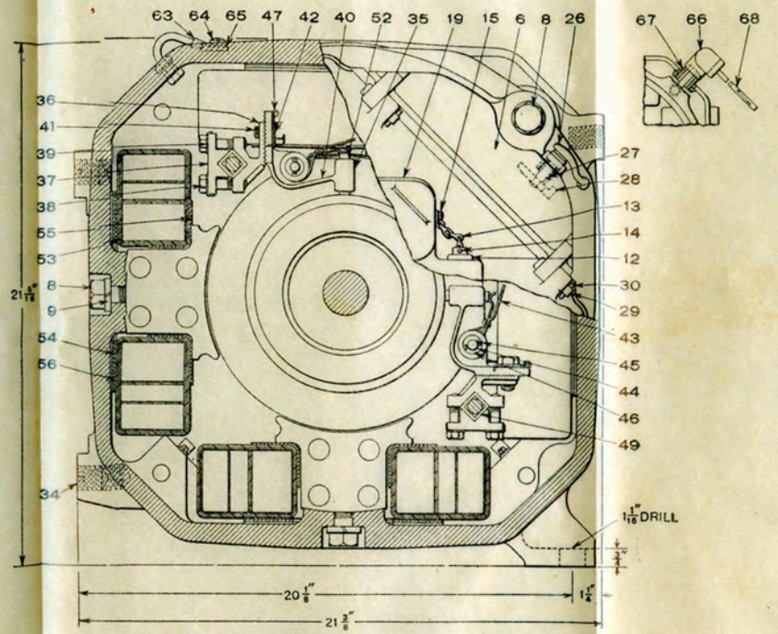


Fig. 3-A, End Section of Dynamotor

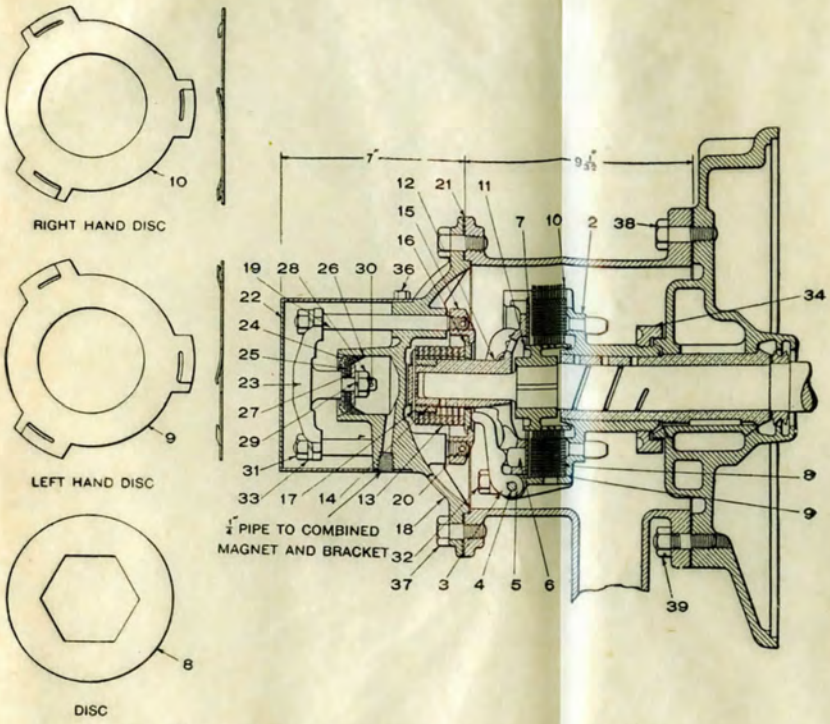


Fig. 4, Cross Section of Dynamotor Clutch

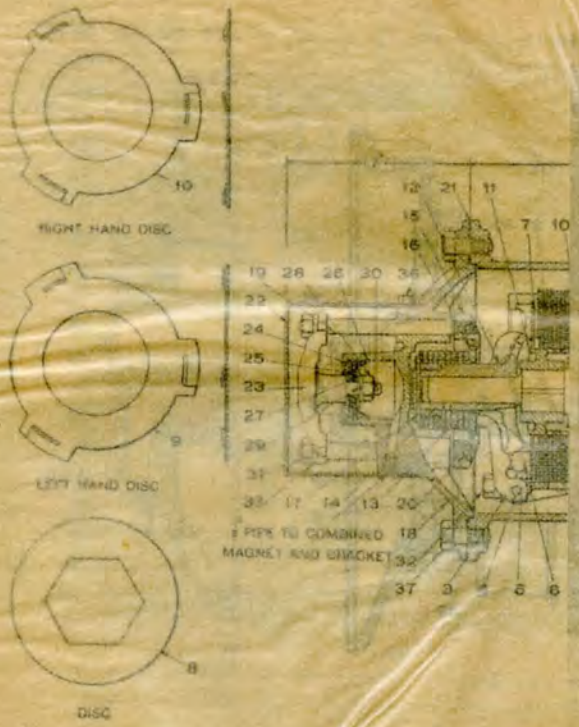


Fig. 4. Cross Section of Dynamot

reservoir enters the governor at the pipe connection marked "To Main Reservoir," and flows through passage *a* to the space B between the double pistons 25. The pressure in chamber B is therefore always that of the main reservoir. Air from chamber B flows through port *e* and *j* to the space K on the face of the diaphragm 60, on the opposite side of which is a spindle 61 held against the diaphragm by the regulating spring 62. The stem of the spindle 61 projects through the regulating nut 63 to the end of the "cutting-out" regulating valve 28, which is held firmly against the end of the spindle or its seat, as the case may be, by the regulating valve spring 27. So long as the main reservoir pressure is less than that for which regulating spring 62 is adjusted the latter holds the spindle 61 over so that the "cutting-out" regulating valve 28 remains seated. When, however, the main reservoir pressure is increased so that its pressure on diaphragm 60 is able to overcome the pressure of the regulating spring 62 on its opposite side, the spindle 61 is forced back toward regulating valve 28, which it lifts slightly, thus permitting the air in chamber C to flow through port *l* and space M past the regulating valve to the atmosphere. As the pressures on the smaller end of the double piston are balanced at this time and the pressure in chamber B on the right-hand side of the larger end of the double piston is now much higher than that in chamber C, the pistons and attached slide valve are moved to the left to "cut-out" position as shown in detail at the right, Fig. 5. It will be seen that the first movement of the slide valve 76 opens port *b* to chamber B, permitting air at main reservoir pressure to flow through port *b* to the piston "seal" 21. The area of port *b*, however, is so small that the main reservoir pressure acting therein is not able to overcome the pressure of spring 17, which holds the switch piston to its seat. But a further travel of the slide valve opens port *g*, which allows air at main reservoir pressure to flow to the air cylinder W, thus breaking the "seal" of the piston, and main reservoir

pressure then acts on the entire area of the piston, causing it to move outward very rapidly and break the circuit. By having port *b* open before port *g*, a free flow of high-pressure air to the space W below the switch piston is insured and a "quick break" obtained, which eliminates any tendency to cut out slowly. During this movement the air above the switch piston is compressed, and forced through ports *y* and *z* in the hollow rod to the atmosphere. The ports *z* are so placed that they pass the ends of the contact fingers just at the moment when the circuit is broken and the quick movement of the piston causes the air in chamber X to be expelled with such force as to make a most effective and complete pneumatic blow-out.

In this position of the slide valve 76 it will also be seen that cavity *h* connects port *e* to the exhaust port *f* and atmosphere, thus relieving diaphragm 60 of pressure and permitting the regulating valve 28 to seat. Air from chamber C can then no longer escape to the atmosphere and it rapidly becomes equal in pressure to that in chamber B, (due to flow of air through the small leakage port shown in the large double piston). Both ends of the double piston are then balanced and the parts remain in "cut-out" position until the governor is "cut-in" as follows:

A branch from port *a* permits air at main reservoir pressure to flow through port *q* to *p* and the space O on the face of diaphragm 71, on the opposite side of which is a spindle 67 held against the diaphragm by the "cutting-in" regulating spring 70. The stem of the spindle 67 projects through the regulating nut 68, and the "cutting-in" regulating valve 65 is held against the end of the stem by the regulating valve spring 66. So long, therefore, as the main reservoir pressure on the face of the diaphragm 71 is greater than the pressure of the regulating spring 70 on its opposite side, the regulating valve 65 will be held to its seat by the stem of spindle 67, and the port *n* is then closed.

After the governor has been "cut-out" as explained above and the main reservoir pressure falls to such a point that the air pressure on diaphragm 71 is no longer able to overcome the pressure of the regulating spring 70 on its opposite side, the latter moves the spindle over so as to permit the regulating valve spring 66 to raise the regulating valve 65 slightly from its seat. This permits the air in chamber D, back of the smaller end of the double piston to escape through port *n* and past the regulating valve 65 to the atmosphere. The larger end of the double piston is balanced at this time and the pressure in chamber B therefore forces the smaller piston, carrying with it the large piston and slide valve, back to the position shown in Fig. 5, exhausting the air from the air cylinder W through ports *g*, *h* and exhaust port *f*, to the atmosphere and allowing the piston spring 17 to force the piston 16 and the circuit closer 43 back to "cut-in" position. It will be seen from the cut that when the double piston moves to "cut-in" position, as explained, a projecting boss on the outside face of the small piston closes the connection between chamber D and port *n* so that the pressure in D has no escape when the governor is cut in. Chamber D is very small and as the small piston and its packing ring when fitted as tight as is practicable, are still not absolutely air tight, the slight leakage past the small piston soon equalizes the pressures in D and B and, as the pressures in C and B are also equal, both double pistons are again balanced and the parts remain in "cut-in" position until the governor is "cut-out" as already explained.

It will be noted that the regulation of the cutting-in and cutting-out pressures is entirely independent, there being a diaphragm and spring for each. In adjusting the governor, the *cutting-out* pressure should be regulated *first* and the cutting-in pressure *afterwards*, the difference between the two to be decided by the requirements of service in each individual case. The regulation of the cutting-out feature of the device should always be for a *higher* pressure than the cutting-in;

in other words, the regulating nut 63 should be screwed in farther than the regulating nut 68.

It is important that this should be thoroughly understood because if the cutting-in regulation is higher than the cutting-out, the compressor when once stopped will continue to cut in and out in rapid succession without giving the desired regulation.

The method for regulating the governor is as follows: Slack off completely both nuts 63, (cut-out regulating nut), and 68, (cut-in regulating nut), so that both the regulating springs exert no pressure; valve 65 is then open and valve 28 closed; consequently chamber D is open to the atmosphere while chamber C is not. Under such conditions when the compressor starts and accumulates any pressure, the effect of such against the diaphragms will close valve 65 and open valve 28; the governor will then move to the cut-out position and stop the compressor. Then put considerable compression on spring 62 by screwing in nut 63 and thereby closing valve 28; next screw in nut 68 slowly until the compressor starts; watch the air gauge and note the pressure at which the governor cuts out. If too low, increase the pressure on spring 62 by screwing in regulating nut 63; if too high, decrease the pressure on the spring 62; then start the compressor again by "bleeding" the main reservoir or increasing the pressure on the cutting-in regulating spring 70, *always taking care to have the main reservoir pressure at or below the desired cutting-in point before increasing the pressure on spring 70.* This is necessary to make sure that the cutting-in point is not made equal to or greater than the cutting-out point. As the compressor raises the main reservoir pressure, again note the pressure at which the governor cuts out and make what further adjustment of regulating nut 63 is necessary to obtain the cutting-out pressure desired.

When the cutting-out adjustment is made, "bleed" the main reservoir slowly so as to reduce its pressure gradually, until the governor cuts in. If the cutting-in

pressure is not that desired, increase or decrease the pressure on spring 70 and repeat the operation until the desired adjustment is reached.

After the proper adjustment has been made the regulating check nuts 64 and 69 should be tightened so as to lock the regulating nuts 63 and 68 and the governor adjustment then tested to make sure that no change in adjustment was accidentally made when tightening up the check nuts.

At each general inspection the governor should be cleaned and oiled. The small valves 28 and 65 should be thoroughly cleaned with kerosene and wiped dry; a *few* drops of good oil should be placed on the slide valve seat and on the surfaces passed over by the pistons. *Avoid too much oil.*

BRAKE VALVE

The brake valve, Figs. 6 and 6A, located in each motorman's cab, is of the rotary type, with removable handle. The operating parts are mounted on a bracket to which all the pipe connections are made so that the valve may be removed for examination and repairs without disconnecting the pipe joints.

Seven pipe connections are made to the bracket as follows: main reservoir pipe, brake pipe, straight air application pipe, straight air release pipe, equalizing reservoir, reduction limiting reservoir, and brake valve exhaust. Raised letters are cast on the bottom of the pipe bracket, Fig. 6-B, as follows: MR, for main reservoir pipe; BP, for brake pipe; S. A. AP, for straight air application pipe; S. A. REL, for straight air release pipe; ER, for equalizing reservoir; RLR, for reduction limiting reservoir; and EX, for brake valve exhaust pipe.

The Brake Valve embodies the following important features:

(1) An Equalizing Piston and Valve, which govern the rate of brake pipe reduction, according to the length of train, to a degree which would be

impossible if the flow of air from the brake pipe to the atmosphere were direct and act to prevent a surge of air to the head end of the brake pipe which, if the opening were closed quickly, as would be the case with only the direct exhaust, might cause some of the head brakes to release. A direct exhaust is used in combination with the equalizing piston exhaust, the direct exhaust insuring an immediate reduction in brake pipe pressure and eliminating the time element in the lifting of the equalizing piston.

(2) The *equalizing piston being of the "collapsible" type* also prevents the equalizing reservoir from being charged to a higher pressure than the brake pipe when releasing and recharging. As a result, an absolute equality of brake pipe and equalizing reservoir pressures is assured and it is possible at any time during the release of the brakes to move the brake valve handle to application position and secure an immediate response of the brakes.

(3) REDUCTION LIMITING FEATURE, which restricts the amount of brake pipe reduction so that the brake pipe pressure cannot be reduced below the equalizing pressure of the equalizing and reduction limiting reservoirs. This insures against an over-reduction in brake pipe pressure and, in consequence, excessive compressor duty.

The different positions of the brake valve handle in order from the left (See Fig. 6-A) are:

(1) RELEASE AND RUNNING position, in which air that has been supplied from the main reservoir and has been reduced to 70 lbs. by the feed valve attached to the pipe bracket of the brake valve (which air always has access to the top of the rotary valve through a port in the body casting) is permitted to flow directly to the brake pipe, charging it to feed valve pressure, and also the auxiliary and supplementary reservoirs and the equalizing chamber (hereinafter called "equalizing reser-

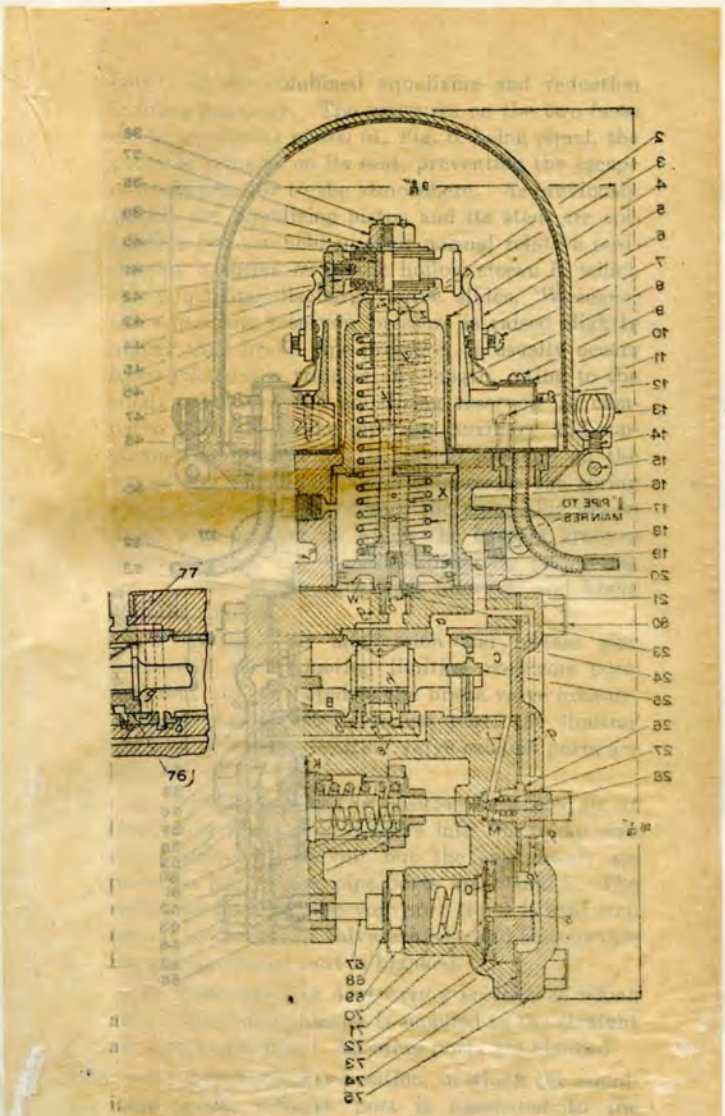


Fig. 6, Master

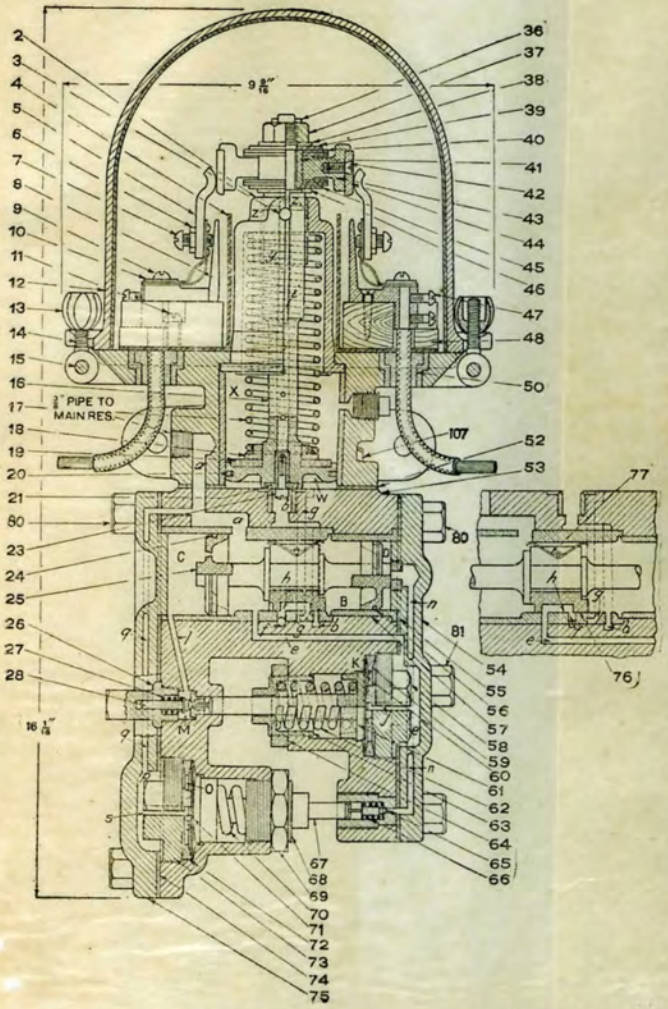


Fig. 5, Master Governor

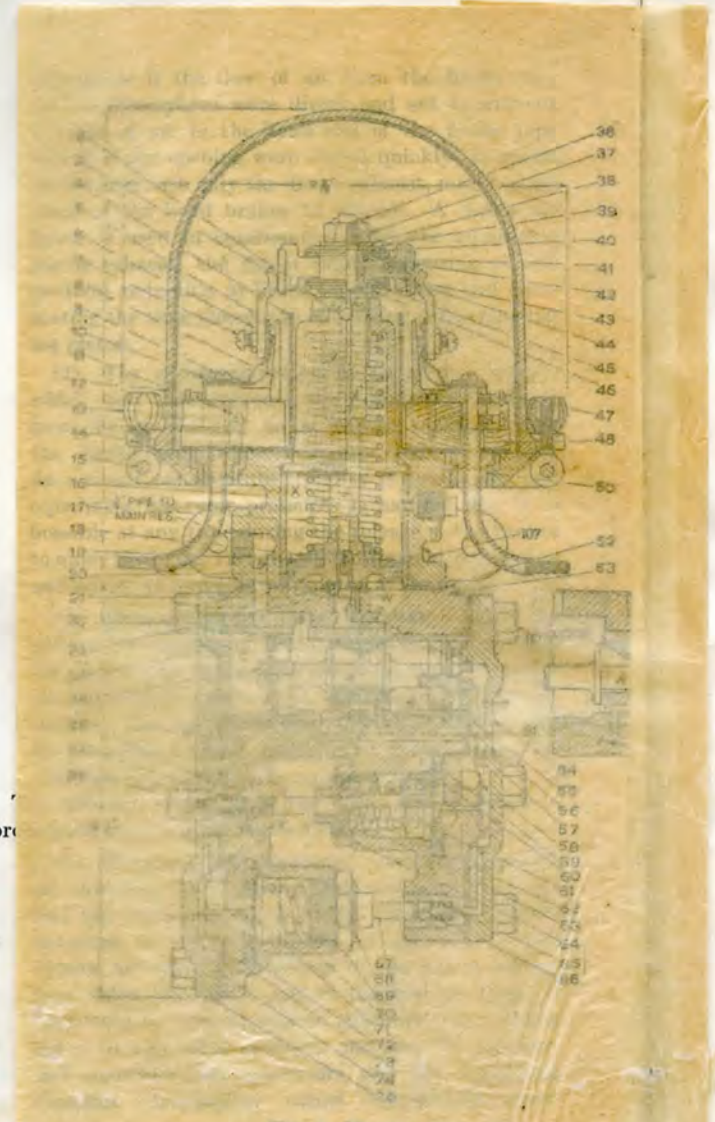


Fig. 5, Master Governor

voir'') of the combined equalizing and reduction limiting reservoir. The pressures on the two faces of the equalizing piston 51, Fig. 6, being equal, the valve 53 remains on its seat, preventing the escape of brake pipe air to the atmosphere. As previously stated, the equalizing piston and its stem are collapsible but are held in their normal relative position by a spring 56 in the hollow sleeve in which the equalizing discharge valve slides. Whenever the equalizing reservoir pressure is raised slightly higher than brake pipe pressure, as usually occurs when releasing a train of any length, owing to the small volume of the equalizing reservoir as compared with the brake pipe and auxiliary and supplementary reservoirs, the excess pressure on the top of the equalizing piston compresses the spring above referred to and forces the equalizing piston down to a position in which the by-pass grooves in its bushing are uncovered, thereby permitting the pressure in the equalizing reservoir and brake pipe to equalize.

The straight air application and release pipe ports and the reduction limiting reservoir port, Fig. 6-C, are connected to the brake valve exhaust. The equalizing piston exhaust port, the limiting valve port and the limiting valve exhaust ports are blanked.

(2) Straight Air Lap position in which air at feed valve pressure still flows into the brake pipe and equalizing reservoir but the straight-air application and release pipe ports are blanked. The reduction limiting reservoir port No. 1 is still connected to the brake valve exhaust, and the equalizing piston exhaust port is blanked.

(3) Straight Air Application position in which air at feed valve pressure is supplied to the straight air application pipe. All other ports are blanked.

(4) Automatic Lap position, in which the equalizing piston exhaust port is connected to the

brake valve exhaust, all other ports being blanked.

(5) AUTOMATIC SERVICE position, in which the reduction limiting valve piston 81, being normally sealed against the lower gasket 86, permits brake pipe air to exhaust directly to the atmosphere through the limiting valve exhaust port and slide valve 83. This feature eliminates the lag between the movement of the brake valve handle and the beginning of brake pipe reduction incident to the use of the equalizing piston and insures a prompt response of the brakes. When the air in the chamber above the equalizing piston, which is always in communication with the equalizing reservoir, has been reduced sufficiently by the flow of air from the equalizing reservoir to the atmosphere through the limiting valve exhaust port, the equalizing piston will be raised by the greater brake pipe pressure beneath, permitting brake pipe air to escape to the atmosphere through the equalizing piston exhaust port and the brake valve exhaust.

The back of the limiting valve piston and slide valve chamber is always connected to the equalizing reservoir. The face of the piston is always connected to the reduction limiting reservoir. Normally this reservoir is connected to the atmosphere, but in Service position, while the equalizing reservoir is being reduced through the preliminary exhaust (limiting valve exhaust) port, the reduction limiting reservoir is being charged by feed valve pressure above the rotary valve through the limiting valve port. When the pressure on the face of the piston slightly exceeds that on the back of the piston, the piston and slide valve will be moved up, cutting off communication between the equalizing reservoir and the atmosphere, and the brake pipe and the atmosphere; this movement also cuts off communication between the rotary valve chamber, feed valve pressure and the reduction limiting reservoir. No further reduction can

therefore occur through the limiting valve portion, and, consequently when the brake pipe pressure on the lower face of the equalizing piston has blown down through the equalizing piston exhaust equal to the equalizing reservoir pressure on the upper face of the equalizing piston, the equalizing piston will fall and prevent further reduction. The straight air application and release pipe ports are blanked.

(6) HANDLE OFF position, in which the handle may be removed. The straight air release pipe port is connected to the brake valve exhaust, all other ports being blanked.

(7) EMERGENCY position, in which the brake pipe is connected direct to the atmosphere, causing a rapid fall in brake pipe pressure and hence a quick application of the brakes. The straight air release pipe is also open to feed valve pressure through a large port in the rotary valve, thus allowing feed valve air to *maintain* cylinder leakage and also insuring a brake application even though the cut-out cocks in the brake pipe and straight air application pipe under the brake valve are closed.

UNIVERSAL VALVE

THE UNIVERSAL VALVE consists of the following portions:

(a) TWO-FACE ANGLE BRACKET, designated "Type B," Figures 10 and 11, to which are bolted the quick-action, equalizing and double check valve portions, the latter being inserted between the equalizing portion and the angle bracket face. The bracket is bolted to the underframing of the car, all pipe connections being made permanently to this bracket, so that no pipe connections need to be disturbed in the removal or replacement of any one of the operating portions of the universal valve.

(b) THE EQUALIZING PORTION, which is similar in a general way to the old style plain triple valve.

Fig. 7, Equalizing Portion, Universal Valve

It is this portion which is directly affected by variations in brake pipe pressure and it controls (either directly or indirectly, through the medium of the other portions of the Universal Valve) the desired charging of the reservoirs, the application of the brake, whether in service or emergency, and the release of the brakes.

(c) THE DOUBLE CHECK VALVE PORTION which operates according to the application made (straight air or automatic) to admit air to the brake cylinder in service applications and to exhaust it from the brake cylinder in both service and emergency applications.

Fig. 8, Quick Action Portion, Universal Valve

Fig. 10, Two-Face Angle Bracket, Universal Valve

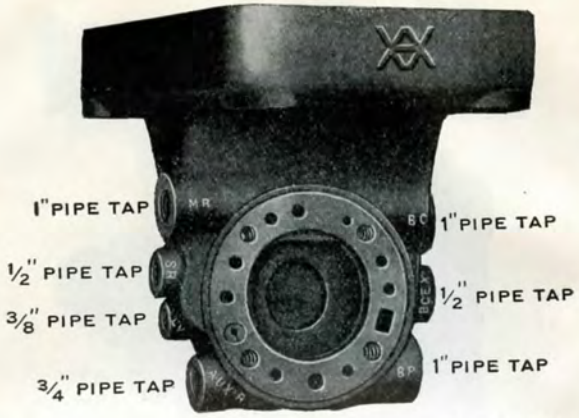


Fig. 11, Two-Face Angle Bracket, Universal Valve

(d) The Quick Action Portion which includes the various parts controlling the quick action and high pressure functions.

Figure 12 shows in a purely diagrammatic way the Universal Valve. The actual proportions and the mechanical construction have been entirely disregarded in order to make the connections and operation more easily understood.

CHARGING

Air from the brake pipe enters the Universal Valve at the connection marked "Brake Pipe" and flows in two directions—to the equalizing portion and to the quick-action portion.

Charging the Equalizing Portion: Air from the brake pipe passage *a* flows through passage *b* to chamber F and the face of equalizing piston 4, forcing the piston with slide valve 3 and graduating valve 7 to *Full Release* position, as shown (if it is not already there). Brake pipe air can flow from chamber F in two directions:

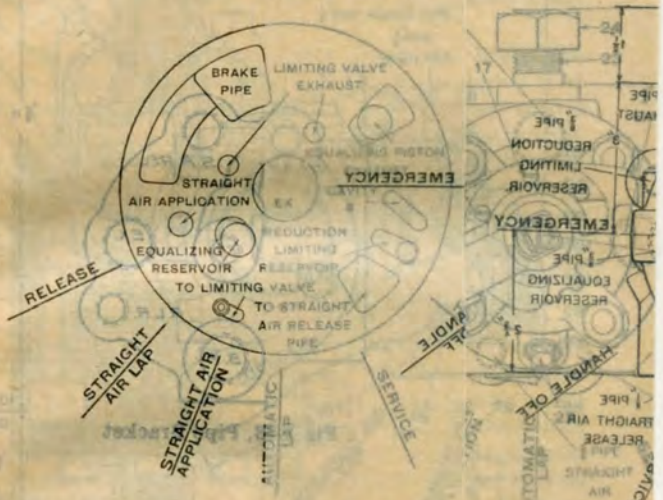


Fig. 6-C, Rotary Valve Seat

Brake Valve

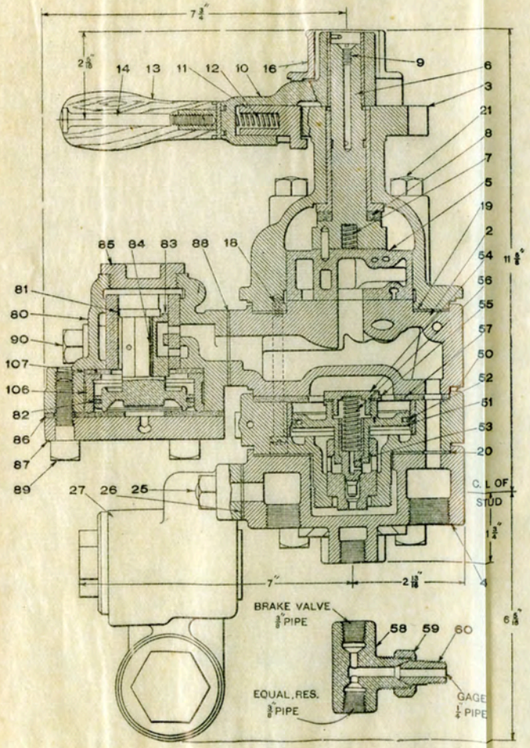


Fig. 6, Section Through Brake Valve

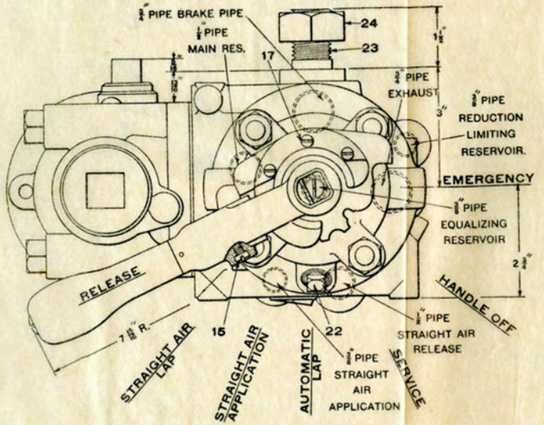


Fig. 6-A, Brake Valve

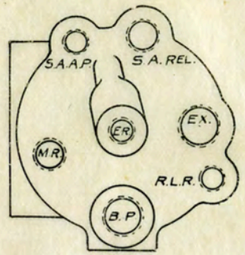


Fig. 6-B, Pipe Bracket

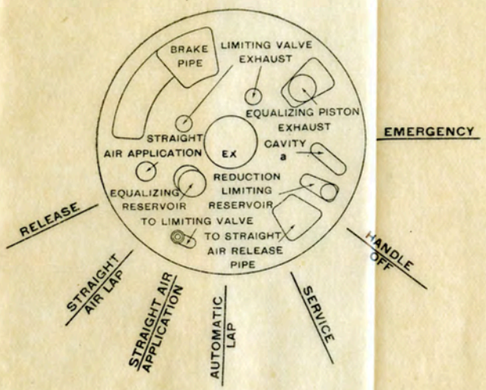


Fig. 6-C, Rotary Valve Seat

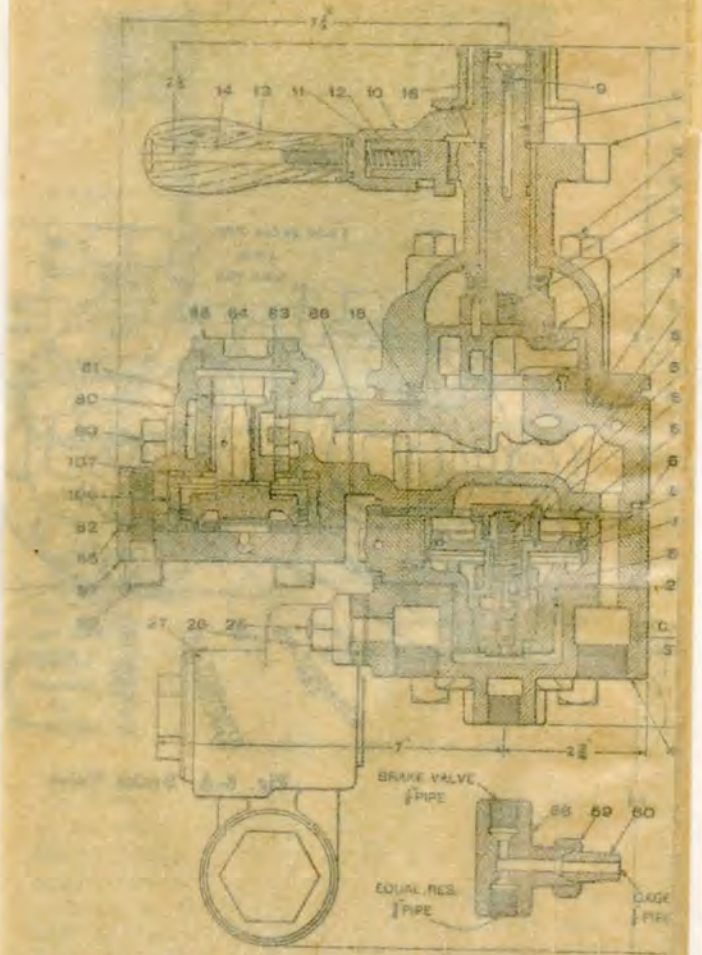


Fig. 6, Section Through Brake Valve

1. Through the supplementary reservoir charging port *i*, past charging check valve 14 (at the left), into the supplementary reservoir, charging it to brake pipe pressure.
2. Through feed groove *k* into Chamber G, thence through port *o* to the auxiliary reservoir, likewise charging that reservoir to the same pressure as the brake pipe. From chamber G the air can also flow through port *m* in the slide valve and port *n* in the seat to port *l* and the supplementary reservoir.

CHARGING THE QUICK ACTION PORTIONS: Brake pipe air flows through passage *a* to the brake pipe seat of protection valve 173 which will remain seated until a predetermined pressure is reached (governed by the protection valve spring 177) when it will be forced from its brake pipe to its atmospheric seat. This permits brake pipe air to flow from passage *a* through passage *c* to chamber A and the face of emergency piston 126, thence through feed groove *i* into chamber B. From chamber B the air can flow in three directions—to the quick action chamber, quick action closing chamber, and the cut-off and safety valve cap, as follows: (1) through port *d* to the quick action closing chamber; (2) through port *e* to the quick action chamber; (3) through port *v* and passage *f* to chamber C on the face of the cut-off and safety valve piston 76. There being no pressure in chamber D on the opposite side of the piston, said piston is forced to the right by the pressure in chamber C, holding check valve 78 unseated against the pressure of its spring 80.

The resistance increasing cavity H in slide valve 3 is open to the equalizing slide valve chamber through port *p* in graduating valve 7. Port *h″* leading to the inner face of piston 76 is blanked by the graduating valve 7.

The brake cylinder is open to the atmosphere through passage *q* to chamber I above double check valve 211 of the double check valve portion, thence through pas-

sage *r* to chamber J, past check valve 209 to passages and through the straight air pipe to the brake valve and exhaust.

Main reservoir air flows through passage *t* to the emergency valve 167 and thence through drilled port *j* into chamber L below the valve, thus keeping the valve seated.

To summarize briefly the different channels through which the various reservoirs are charged by the brake pipe:

(a) THE AUXILIARY RESERVOIR is charged directly from the equalizing slide valve piston chamber.

(b) THE SUPPLEMENTARY RESERVOIR is charged directly from the equalizing slide valve piston chamber and also from the equalizing slide valve chamber.

(c) THE QUICK ACTION CHAMBER is charged from the emergency slide valve chamber which is in turn charged from the brake pipe through a feed groove past the emergency piston in *Release* position.

(d) THE QUICK ACTION CLOSING CHAMBER is charged from the emergency slide valve chamber as described above for the quick action chamber.

SERVICE APPLICATION

Straight Air

When a straight air service application is desired, the brake valve handle is moved to *Straight Air Service* position. In this position feed valve air flows to the straight air application pipe and thence to the straight air application and release pipe, and then through the No. 15 double check valve to chamber K in the double check valve portion of the universal valve. Chamber M under check valve 206 is in communication through passage *v*, past check valve 209 and through passages *w* and *o* with auxiliary reservoir pressure. Passage *r* leads to the top or piston portion of the double check

valve proper (211) which is normally held in straight air application position so that when making such an application no movement of the double check valve is required to allow straight air pressure to pass directly from chamber J into the brake cylinder through port *r*, chamber I and passage *q* to the brake cylinder. When a straight air application is made, the air entering at K will force piston 204 downward, uncovering feed groove *x* in the piston bush, through which air flows into chamber J. At the same time the downward movement of the piston unseats check valve 206 by which auxiliary reservoir air is also admitted to chamber J, the air from the two sources passing to the top of the double check and through port *q* in the bushing to the brake cylinder, forces the piston outward and applies the brakes. The air will continue to flow in this manner until the brake valve handle is returned to *Straight Air Lap* position or, if the handle is left in *Straight Air Application* position, until the pressure in chamber J is equal to the pressure at K or sufficiently so to enable the check valve spring 207 to close valve 206, cutting off auxiliary reservoir air and moving the piston back to normal position, as explained in the following:

SERVICE LAP

Straight Air

When the brakes have been applied with sufficient force the brake valve handle is returned to *Straight Air Lap* position, cutting off the flow of air through the brake valve to the straight air pipe. As previously explained, air will continue to flow from the auxiliary reservoir to the brake cylinder until the pressure in chamber J and on the lower face of piston 204 becomes nearly equal to that in chamber K, when the check valve spring 207 will seat valve 206, cutting off communication between the auxiliary reservoir and the brake cylinder, and move piston 204 upward so as to cut off groove *x*.

RELEASE AFTER STRAIGHT AIR APPLICATION

When the valve handle is placed in *Release* position after a straight air application, air from the brake cylinder flows through passage *g* to chamber I above check valve 211; then through passage *r* to chamber J, raising check valve 209 and passing through passage *s* and chamber K to the straight air pipe and thence to the brake valve where it escapes to the atmosphere. The release spring acting on the opposite face of the brake cylinder piston then forces it back to the release position and releases the brake shoes from the wheels.

SERVICE APPLICATION

Automatic

To apply the brakes in service when operating automatically, the brake valve handle is moved to *Automatic Service* position, which permits air to escape from the brake pipe to the atmosphere. This reduces the pressure, through passages *a* and *b*, in chamber F and the upper face of the equalizing piston 4 below that in chamber G on the opposite face, causing the piston with its slide valve 3 and graduating valve 7 to move toward the lower brake pipe pressure. (This rate of reduction is not rapid enough to move the emergency slide valve piston 126 since under these conditions the quick action chamber and quick action closing chamber pressures can reduce through the piston feed groove *i* as rapidly as the brake pipe is being reduced and thus keep the pressures on the two faces of the piston balanced as they were before).

The first movement of the equalizing piston toward *Service* position closes the feed groove *k* and the supplementary reservoir charging port *l*, thus cutting off communication between the brake pipe and the auxiliary and supplementary reservoirs. The piston then engages the graduating valve, the first movement of which opens service port *f'*, blanks port *m*, connects port *h"*, through cavity *c'* to port *b'* and also connects the resistance

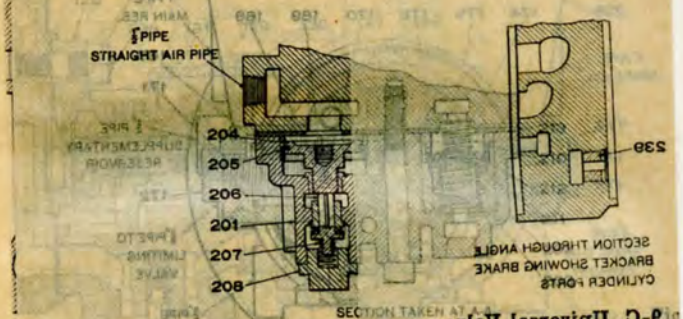


Fig. 9-B, Universal Valve

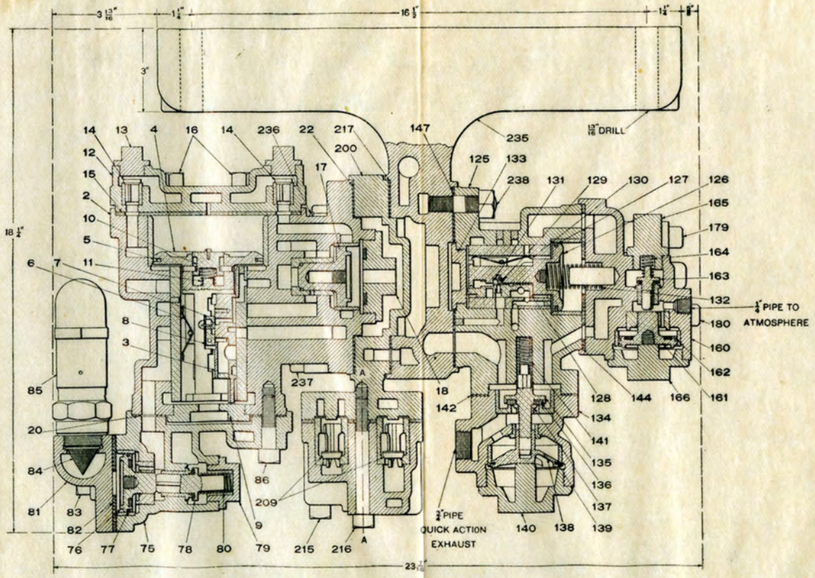


Fig. 9, Universal Valve

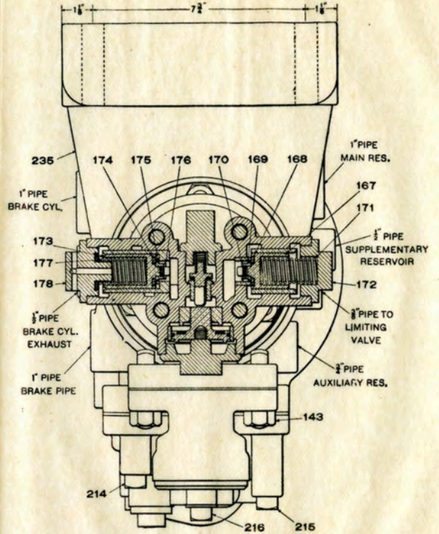


Fig. 9-A, Universal Valve

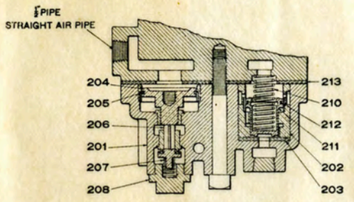


Fig. 9-B, Universal Valve

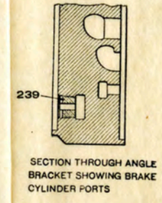


Fig. 9-C, Universal Valve

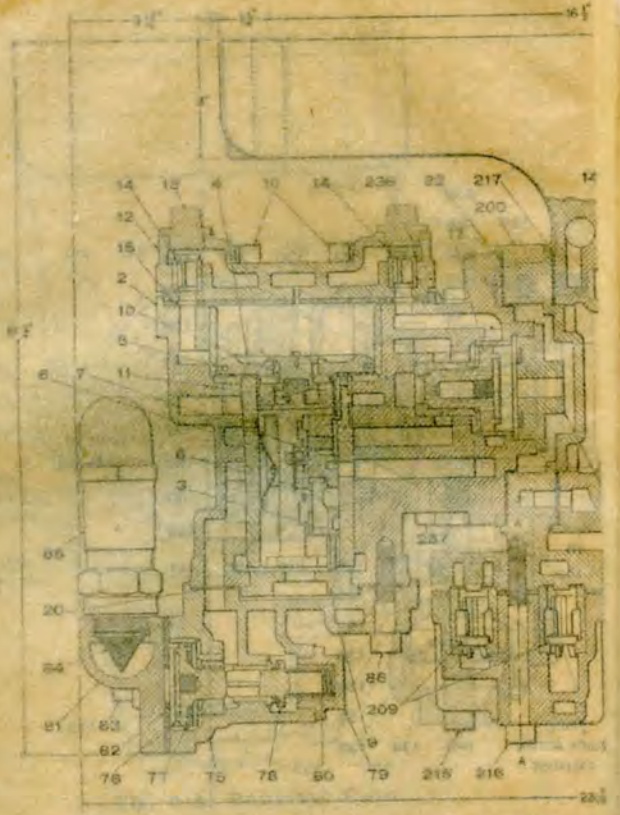


Fig. 9, Univ

increasing cavity H through port *e'* to port *d'* leading to the atmosphere, thus increasing the resistance which must be overcome before the slide valve can be moved, which insures that very light brake pipe reductions, of say below 5 lb., will not cause a brake application.

As the reduction continues, the equalizing piston is moved still further, the spider or lugs on the end of the piston stem engaging the end of slide valve 3 which is then carried along with the piston and graduating valve to *Service* position. Port f' is brought into register with port *a'*, permitting the air in chamber G (which is always in communication with the auxiliary reservoir through port *o* as previously stated) to flow through ports *f'* and *a'* to chamber N and the face of release piston 17, forcing this piston to the left (if it is not already there) and then flows through passage *g'*, past service port check valve 14 (at the right) into passage *h'* and thence into passage *h* leading to the cut-off and safety valve cap. From passage *h* the air flows past the cut-off and safety valve check valve 78 (which is unseated as explained under "Charging") to chamber E and thence through passages *u* and *i* to the under side of check valve 211 in the double check valve portion, forcing it off its seat and allowing the air to pass through port *j'* in the piston bushing to passage *q* and thence into the brake cylinder.

It will be noted that passage *h*, through which the air flows to the brake cylinder, also leads to the safety valve. Consequently, if the brake cylinder pressure were to rise above the setting of the safety valve during a service application, the safety valve would open and prevent further increase in brake cylinder pressure.

If the brake valve handle is left in *Automatic Service* position, the pressure in the brake cylinder, and consequently that in chamber D, will increase until it is nearly equal to that in chamber C when spring 80 will force check valve 78 to its seat and piston 76 to the left, thus cutting off further flow of air to the brake cylinder. This will occur just short of equalization pressure.

SERVICE LAP

Automatic

After a sufficient brake pipe reduction has been made to produce the desired application of the brakes, the brake valve handle is moved to *Automatic Lap* and further escape of air from the brake pipe prevented.

When the flow of air from the auxiliary reservoir has reduced the pressure in chamber G slightly below that remaining on the brake pipe side (chamber F), the pressure in the brake pipe will move the piston and graduating valve to *Service Lap* position. In this position, service port *f'* is lapped, thus preventing further flow of air to the brake cylinder (unless such flow has already been prevented by the closing of the cut-off and safety valve check valve 78, as explained above) and the resistance increasing cavity H is again connected through port *p* in the graduating valve to the equalizing slide valve chamber G. Further movement is prevented by the shoulder of the piston stem striking the end of slide valve 3. The slight difference in pressure which was sufficient to move the piston and small graduating valve is unable to overcome the added resistance of the slide valve; hence, there is no further movement.

It should be noted that the slide valve 3 remains in *Service* position, a movement of the piston and graduating valve being all that is required to lap the valve. Consequently, when in this position, only a slight reduction in brake pipe pressure is required to again bring the piston and graduating valve into *Service* position.

RELEASE AND RECHARGE AFTER AN AUTOMATIC APPLICATION

(A) With Direct and Graduated Release Cap in Graduated Release Position

Direct Release.—With the brake valve handle in *Release* position, the brake pipe charging port in the brake valve is open, restoring the brake pipe to its initial pressure. This increase of brake pipe pressure

in chamber F forces the equalizing piston 4 with slide valve 3 and graduating valve 7 to *Release* position, previously described; this increase of brake pipe pressure in passages *a* and *c* and chambers A and B will force the cut-off and safety valve piston 76 to the right, unseating check valve 78 and opening communication between passages *u* and *h*. The air in the brake cylinder then flows back through passage *q*, port *j'*, passages *i* and *u*, chamber E and passages *h* and *z* to chamber P, forcing the piston No. 17 to seal against the cap nut and thereby opening communication between passages *z* and *y*, permitting brake cylinder air to flow through passage *y* to the atmosphere until brake cylinder pressure has been reduced to a point at which spring 210 above double check valve 211 can close it. The double check valve then returns to straight air position and whatever air remains in the brake cylinder passes out through chamber I, passage *r*, chamber J, past check valve 209 and through passage *s* to the straight air pipe and then to the atmosphere. The auxiliary reservoir is recharged from the brake pipe through feed groove *k* and port *o*, as hereinbefore described. At the same time, port *n*, leading from the supplementary reservoir, is open through port *m* to chamber G and the auxiliary reservoir. The air which was prevented from leaving the supplementary reservoir by the former movement of the slide valve to *Service* position (and which consequently remained at its initial pressure while the auxiliary reservoir pressure was being reduced) now flows into the auxiliary reservoir and helps to recharge it.

Immediately following this operation, as well as while graduating the release of the brakes, described under the next heading, the pressures on the brake pipe and auxiliary reservoir sides of the equalizing piston are always in balance. This is important, since it insures a quick response of the brakes to any reduction or increase of brake pipe pressure, irrespective of what operation may have occurred just precedir .

If the brake valve handle is moved to *Release* position and left there, the brake pipe pressure is fully restored and the piston remains in *Release* position; the brakes being thereby fully released and the auxiliary and supplementary reservoirs fully recharged.

GRADUATED RELEASE.—Suppose, however, that after the brakes have been applied, only sufficient air is permitted to flow into the brake pipe to move piston 4 with the slide and graduating valves to *Release* position and the brake valve handle is then returned to *Automatic Lap*. Then the flow of air from the supplementary reservoir through ports *n* and *m* to the equalizing slide valve chamber G and the auxiliary reservoir, continuing after the rise in brake pipe pressure has ceased, will raise the pressure on the auxiliary reservoir side of the equalizing piston slightly above that on the brake pipe side and cause the piston No. 4 and its graduating valve to move up to *Graduated Release Lap* position. It should be noted, however, that in the movement toward the *Graduated Release Lap* position, the cavity *c'* in the graduating valve connects ports *h"* and *b*, permitting brake cylinder air in passage *h* to flow through passage *a'* to chamber N, and the face of release piston 17 (which, while the equalizing piston was in *Release* position, was forced to the right and sealed against the cap nut, as explained under "Direct Release," allowing brake cylinder air to exhaust to the atmosphere) forcing the piston to the left and preventing further exhaust of brake cylinder air.

In *Graduated Release Lap* position port *m* is blanked, which prevents further recharging of the auxiliary reservoir from the supplementary reservoir, and feed groove *k*, which cuts off the supply of air from the brake pipe to the auxiliary reservoir. Thus the brake is only partially released and a portion of the air originally in the brake cylinder still remains there. In this way the brake cylinder pressure may be released in a series of steps or graduations as desired until the cylinder pressure has reduced to a point at which spring 210

above double check valve 211 can close it. The double check valve then returns to straight air position, and whatever air remains in the brake cylinder passes out through passage *q*, chamber I, passage *r*, to chamber J; thence past check valve 209 to passage *s* and the straight air pipe. By this time the brake pipe pressure has been fully restored and the auxiliary and supplementary reservoirs fully recharged.

(B) WITH THE DIRECT AND GRADUATED RELEASE CAP IN DIRECT RELEASE POSITION.

In this position of cap 12, the graduated release port *n* is blanked, thus cutting off the supplementary reservoir. Therefore, when the brake pipe pressure in chamber F is built up after a *Service* application, the equalizing piston 4, slide valve 3 and graduating valve 7 will be moved to *Full Release* position in which the auxiliary reservoir is recharged from the brake pipe (instead of from the supplementary reservoir also, as when the direct and graduated release cap is in *Graduated Release* position) through feed groove *k* and thence through port *o*.

EMERGENCY

When it becomes necessary to stop in the shortest possible time, the brake valve handle is moved to *Emergency* position and allowed to remain there until the train stops or the danger is past. In this position the emergency exhaust port of the brake valve is open and permits of such a rapid rate of brake pipe reduction that the quick action chamber pressure cannot reduce through its feed groove *i* and past protection valve 173 as rapidly as the brake pipe pressure is being reduced through the brake valve, and consequently emergency slide valve piston 126 and its slide valve 128 are moved to their *Emergency* positions.

The first movement of the emergency piston 126 closes feed groove *i* and uncovers port *n'* permitting quick-action chamber air in chamber B to flow through

port n' in the slide valve and port l in the seat to the face of quick action piston 138, moving this piston so as to unseat the quick action valve 135, thus venting the brake pipe locally from passage a to passage m and the quick action exhaust. The lugs on the end of the piston stem then engage the slide valve and carry it to *Emergency* position. In this position communication is cut off between ports n' and l, and passage k' in the slide valve registers with ports d and l in the seat, permitting quick action closing chamber air to flow to the face of the quick-action piston and thus hold the quick-action-valve unseated. This exhaust of air below the protection valve 173 permits the spring 177 to seat the valve, cutting off communication between passages c and a and establishing communication between chamber A and the atmosphere through passages r' and s' which insures that the emergency piston will remain in *Emergency* position. The quick-action valve will remain open until the quick-action closing chamber can drain to the atmosphere through the small drilled port in the quick-action piston and the quick-action exhaust port, when it will be returned to normal position by spring 141. Port o' in the slide valve registers with port p' in the seat, permitting quick-action chamber air to flow to chamber Q and the lower face of pilot piston 161, forcing same upward and unseating check valve 163. This permits the air to exhaust from chamber L under emergency valve 167 through passage q'. (No attention should be paid to the passage leading to the pipe tapped opening marked "Limiting Valve" since the limiting valve is not used in this particular installation and the opening is, therefore, plugged). Main reservoir air in passage t above the emergency valve then forces the valve down and flows thence through passages a'' and q to the brake cylinder. Cavity t' in the slide valve No. 128 connects port f with the atmosphere, which allows the air in chamber C on the face of cut-off and safety valve piston 76 to escape to the atmosphere, and thereby permitting spring 80 to close check valve

78 and thus cut off the brake cylinder from the safety valve.

The reduction in brake pipe pressure also causes the equalizing piston with its graduating valve and slide valve to move to *Application* position, as explained under "Service," establishing communication (through port f') between port a' and the auxiliary reservoir. Auxiliary reservoir air then flows through passage a' to passage u' and chamber B (port u' being uncovered in *Emergency*) thus maintaining quick-action chamber pressure through port e and holding the emergency piston in *Emergency* position.

RELEASE AFTER EMERGENCY

With the brake pipe pressure gradually increasing after an *Emergency* application, the protection valve 173 and the equalizing piston 4 with its graduating valve and slide valve will be the first to go to *Release* position, then the emergency piston 126, followed by the pilot valve 161, check valve 163, cut-off and safety valve piston 76 and emergency valve 167.

With the equalizing slide valve 3 in *Release* position the quick action chamber is open to the atmosphere, through port e, passages u' and a', port b' in the slide valve, cavity c' in the graduating valve and port d' in the seat. With brake pipe air on the face of emergency piston 126, if this piston should fail to move promptly, as above stated, the reduction thus caused in quick-action chamber pressure would insure this piston and valve moving to *Release* position, thus opening the quick-action closing chamber port d and cutting off the connection from port e to port u'.

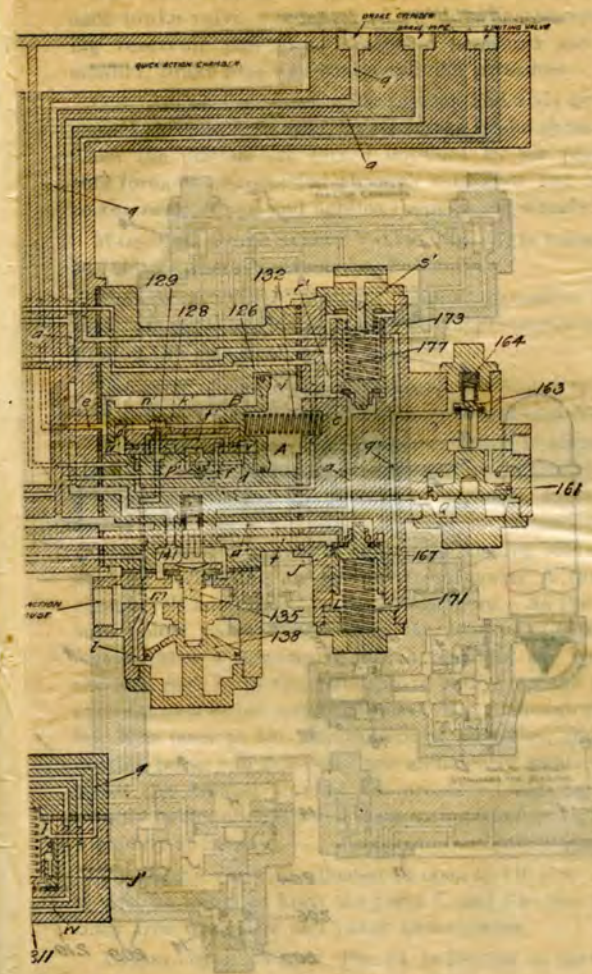
With the emergency slide valve and piston in *Release* position, port v' in the slide valve registers with port f in the seat, permitting brake pipe air to flow to chamber C on the face of cut-off and safety valve piston 76 and forces same to the right, unseating check valve 78 and permitting brake cylinder air to flow back through

passage *q*, port *j'*, passages *i* and *u* to chamber E, thence past the check valve 78 and then through passages *h* and *z* to chamber P, forcing the release piston 17 to the right (chamber N being in communication through passage *a'* with the atmosphere and connecting port *z* with port *y* leading to the brake cylinder exhaust pipe tap). This flow of air continues until brake cylinder pressure has reduced to a point at which spring 210 above double check valve 211 can close it. The double check valve then returns to straight air position and whatever air remains in the brake cylinder passes out through chamber I, passage *r*, chamber J, past check valve 209 and through passage *s* to the straight air pipe and then to the atmosphere.

The system is recharged as explained under "Automatic Service."

PROTECTION FEATURE

Should the motorman make an automatic application and then leave the brake valve handle in *Lap* position, brake pipe leakage would first cause the brake to equalize and when this leakage has reduced brake pipe pressure to a predetermined point (which is governed by the tension on protection valve spring 177) the protection valve 173 will be forced from its atmospheric seat (at the top). This cuts off communication between ports *a* and *c* and connects port *c* to the atmosphere (through ports *r'* and *s'*) past the protection valve. The sudden reduction in pressure thus caused in the emergency piston chamber A allows the quick-action chamber air in chamber B to force this piston 126 and slide valve 128 to *Emergency* position, causing the quick-action valve 135 to be opened as explained under "Emergency," thereby venting brake pipe air to the atmosphere and causing quick action. This operation results in the unseating of the emergency valve 167 and permits the main reservoirs to equalize with the brake cylinder, as previously described.



al Valve

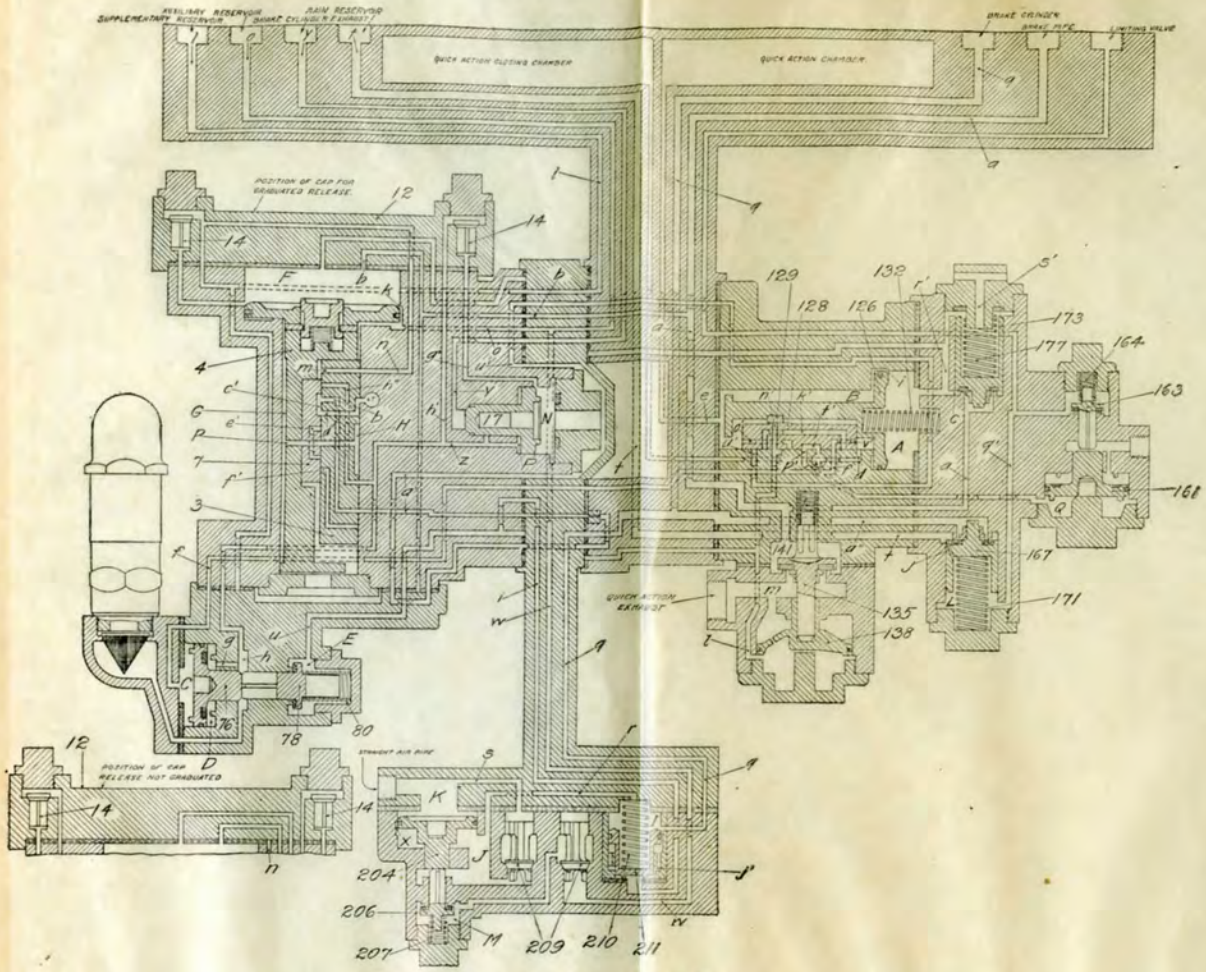


Fig. 12, Universal Valve

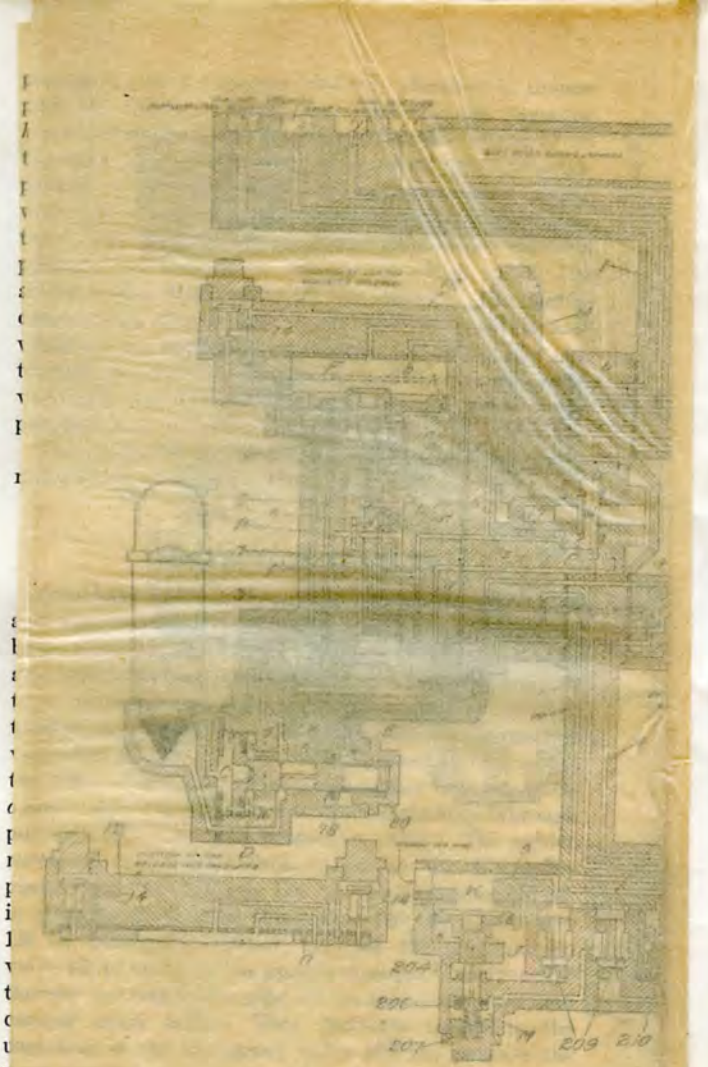


Fig. 12, Unive

Two Illuminated Duplex Air Gauges, located near each brake valve, the larger of which indicates equalizing reservoir and main reservoir pressures and the smaller, brake pipe and brake cylinder pressures.

One Brake Cylinder with pistons and rods so connected through the brake levers to the brake shoes that when the pistons are forced outward by air pressure this force is transmitted through said rods and levers to the brake shoes and applies them to the wheels.

Main Reservoir Safety Valve, Fig. 13, is connected to the first main reservoir head.

The safety valve protects against excessive main reservoir pressure due to failure of compressor governor to stop the compressor.

The parts of the safety valve are: 2, Body; 3, Cap Nut; 4, Valve; 5, Valve Stem; 6, Spring; 7, Regulating Nut.

When the main reservoir pressure, which is always in cavity A under valve 4, is sufficient to overcome the pressure exerted by the tension of spring 6, valve 4 is raised from its seat, which upward movement closes the upper end of port *d* in the valve bushing and opens port C, permitting air to flow from cavity A through chamber B and port C to the atmosphere. As the pressure below valve 4 decreases the tension of spring 6 forces valve 4 downward, which restricts the opening through port C to the atmosphere and opens the upper end of port *d* to the spring chamber E. Although chamber E is open to the atmosphere at all times, the connecting ports *f* in the body are sufficiently small to restrict the exhaust so that the pressure builds up very rapidly in chamber E and assists spring 6 in forcing valve 4 quickly to its seat.

The safety valve is adjusted to open at 110 lbs. Care should be taken to keep the ports C and *f* in the valve body free from dirt and other obstructions.

A Conductor's Valve, Fig. 14, is located on each car, with a cord, running the length of the car, attached to its handle. When this valve is opened the air in the

brake pipe flows directly through it to the atmosphere setting the brakes in emergency. It should, therefore, be used only in case of actual danger and when opened as wide as possible the valve will remain open until closed by hand.

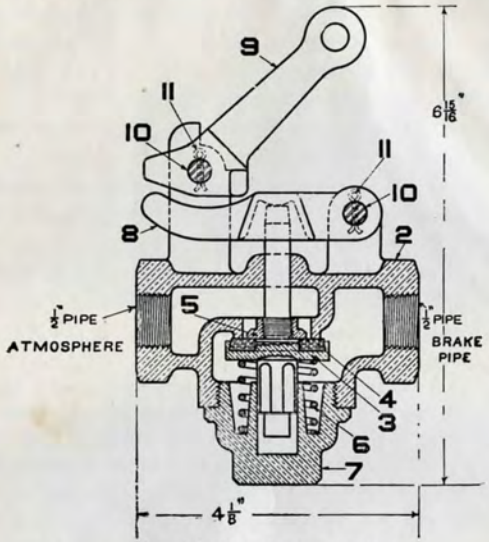


Fig. 14, Conductor's Valve

THE CENTRIFUGAL DIRT COLLECTORS, Fig. 15, are located in the main reservoir piping to the motorman's brake valves and branch pipes of the universal valve leading to the brake pipe and main reservoir. They are for the purpose of preventing pipe scale, sand, cinders, or foreign particles of any kind from reaching the valve.

The centrifugal dirt collector is so constructed that due to the combined action of the centrifugal force and gravity all dirt, etc., removed from the air falls into the bottom chamber and by means of a drain plug or cock, may be cleaned at intervals without breaking any pipe connections whatever.

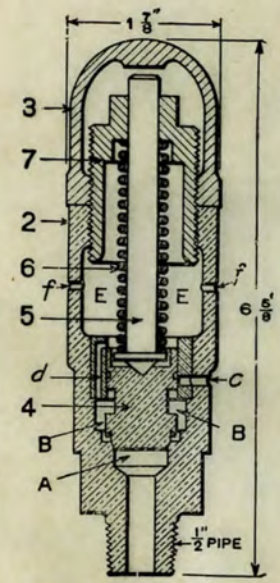


Fig. 13, Main Reservoir Safety Valve

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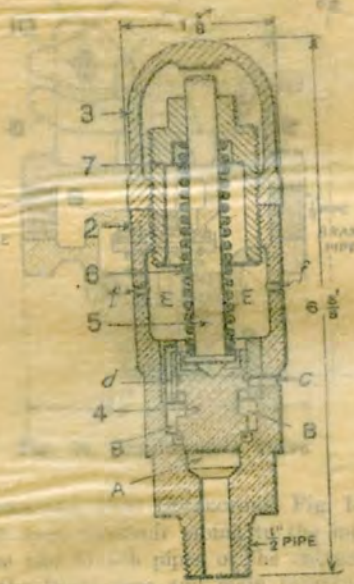

Fig. 13, Main Reservoir Safety Valve

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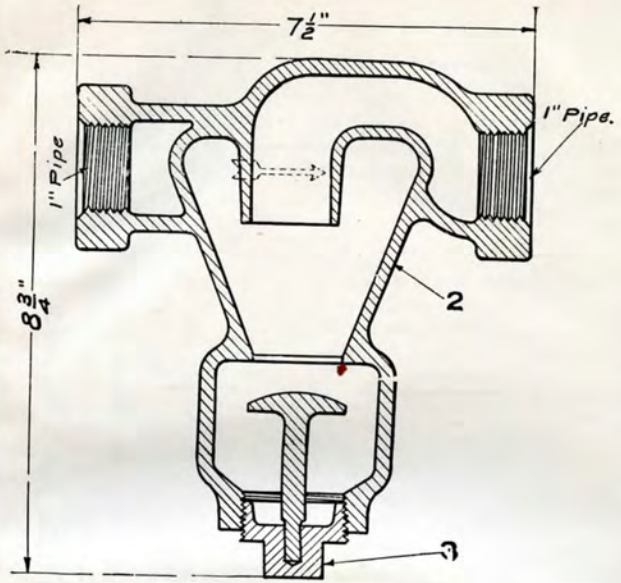


Fig. 15, Centrifugal Dirt Collector

COMBINED EQUALIZING AND REDUCTION RESERVOIRS, Fig. 16, two in number, are located underneath the car. They are made up of two compartments, the smaller being the limiting Reduction Reservoir, and the larger the Equalizing Reservoir. Their functions are fully described in connection with the brake valve.

DOUBLE CHECK VALVES, Fig. 17, two per car, are located one in the automatic control switch supply pipe and one in the straight air application and release pipe. Their function is to prevent the air from escaping through the vent port in one end of the car when the cutout cocks are open on the other end, to supply the automatic control switch, and straight air brake system.

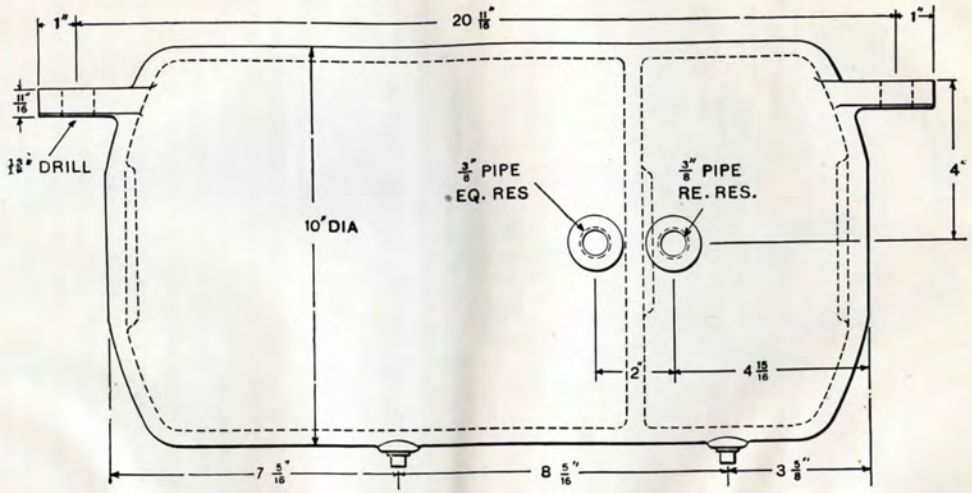
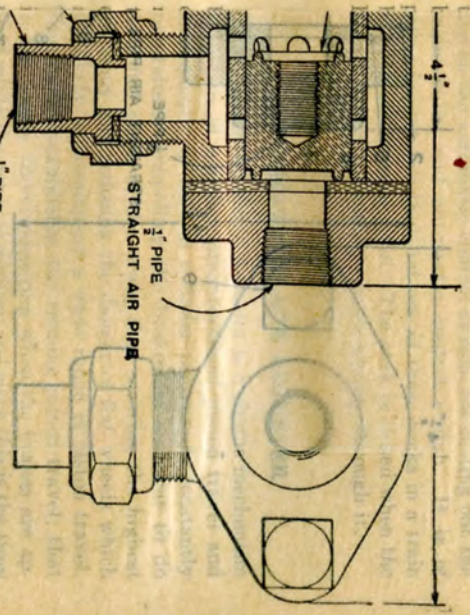


Fig. 16, Combined Equalizing and Reduction Reservoir



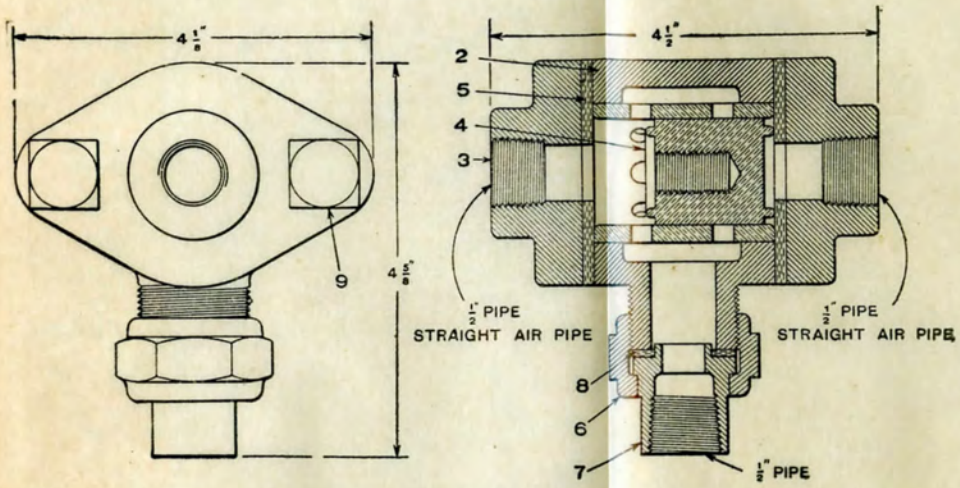


Fig. 17, Double Check Valve

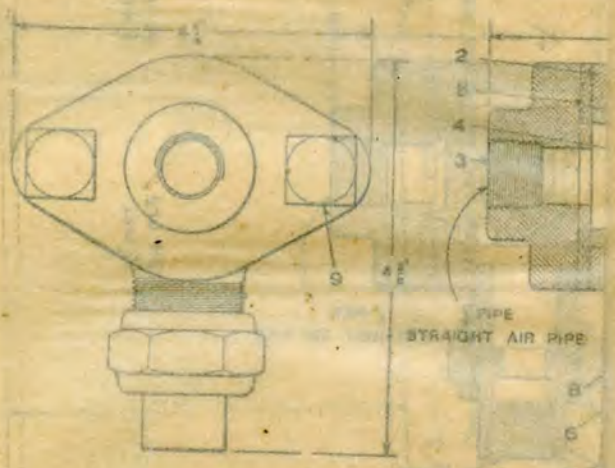


Fig. 17, Double Check Valv

Between the two seats is a piston valve 4 having on each end a leather face 5; the bushing in which it works has two series of ports, C and C′. With the valve in the position shown, port C affords a free passage of air from the front pipe connection to the double-check portion of the universal valve. Port C′ affords the same passage from the opposite end of the car when operating the brake valve on that end.

THREE-WAY CUTOUT COCK, is placed between the brake pipe and the motorman's brake valve, and has a connection to the automatic control switch, for cutting out the brake valve and automatic control switch. It is of prime importance that but one of these cocks in a train be open at the same time. The cock is closed when the handle is parallel with the pipes leading through it.

AUTOMATIC SLACK ADJUSTER

The Automatic Slack Adjuster is a simple mechanism by means of which a predetermined piston travel and consequently a uniform cylinder pressure is constantly maintained, compelling the brakes on each car to do their full share of the work, thus securing the highest efficiency and reducing the danger of flat wheels which are likely to accompany a wide range of piston travel. This device establishes the running piston travel; that is, the piston travel occurring when the brakes are applied while the car is in motion; and since this is the time during which the brakes perform their work, the running travel is most important.

The automatic slack adjuster is illustrated in Figs. 18 and 18A. The brake cylinder piston acts as a valve to control the admission and release of brake cylinder pressure to and from pipe *b*, Fig. 18, through port *a*, in the cylinder, this port being so located that the piston uncovers it when the predetermined piston travel is exceeded. When the piston so uncovers port *a*, brake cylinder air flows through pipe *b* into slack adjuster cylinder 2 where the small piston 19, Fig. 18, 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, Fig. 18A. When the brake is released and the brake cylinder piston returns to its normal position, the air pressure in cylinder 2, (See Fig. 18A), 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 lever 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 lever side strikes projection *a*, Fig. 18, 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.

To apply new shoes, turn casing 1 to the left, thus moving lever 5 toward the position shown in Fig. 18A, until sufficient slack is introduced in the brake rigging. To bring the shoes closer to the wheels and shorten the piston travel, turn casing 1 to the right.

The screw mechanism is so proportioned that the brake shoe wear is compensated for at the rate of about 1-32 of an inch for each operation of the adjuster, thereby removing the danger of unduly taking up false travel which would result in the shoes binding on the wheels.

Every time the brake cylinder is cleaned and oiled, the slack adjuster should receive the same attention, and, after each cleaning and oiling, a test of the brakes should also include one of the adjuster.

DYNAMOTOR COMPRESSOR SYNCHRONIZING SYSTEM FOR INSURING UNIFORM COMPRESSOR LABOR

One of the problems in the adaptation of motor cars to train service, in which each car carries its own air compressor, has been to insure that each compressor should furnish its proper share of the compressed air required to operate the brakes. For example, where there are two or more compressors delivering air to a common supply pipe, whichever compressor may happen to start first will supply all the air required to recharge the entire system, unless some means be provided to insure an equal division of the work among all the compressors in the train. Without this, the life of a compressor overloaded as described is considerably shortened and the running and maintenance expense must be correspondingly high.

Through the operation of this system, (See Fig. 19), all the compressors *must* start and stop *simultaneously* so that no one compressor can possibly be called upon to do more than its own share. This uniformity of compressor labor is not affected by excessive leakage on any car, incorrect adjustment of governor or relative efficiency of the compressor, or other causes.

DYNAMOTOR CLUTCH MAGNET

The dynamotor clutch magnet controls the operation of the clutch on each compressor.

Referring to Fig. 20, it will be seen that the clutch magnet consists of two portions: a bracket and a magnet valve portion. The flow of air to or from the clutch cylinder is controlled by the magnet valve portion.

When the magnet is de-energized, as shown in Fig. 20, main reservoir air entering at the pipe tapped opening marked "To Main Reservoir" flows through passage *a*, then through passage M around the stem of admission valve 515 to passage *b* whence it flows to the clutch cylinder, throwing the clutch out. When the magnet

is energized due to the cutting-in of the master governor, armature 504 is drawn toward magnet core 506, thereby pushing armature stem 505 inward, unseating exhaust valve 514 and seating supply valve 515. This action cuts off communication between passages *a* and *b* and opens the clutch cylinder to the atmosphere through passages *b* and N and exhaust opening EX.

The master governor acts as a pilot or master switch to open and close the circuits which control the clutch magnets. The cutting-in pressure is set at 85 lbs., and the cutting-out pressure 100 lbs.

OPERATION OF THE DYNAMOTOR-COMPRESSOR SYNCHRONIZING SYSTEM

The magnets are connected in parallel between the synchronizing wire and the ground, (see Fig. 19). The wiring of the system is so arranged that the opening or closing of *any* master governor in the train opens or closes the circuit controlling *all* the dynamotor clutch magnets.

All the main reservoirs in the train are connected by means of a main reservoir pipe line. The main reservoir on each car is connected to the pneumatic regulating portion of the master governor on that car. When the pressure in the main reservoir falls below the cutting-in point of its master governors, the switch is immediately closed, thereby closing the circuit controlling the dynamotor clutch magnets and causing all the compressors in the train to start simultaneously. Whether one or more of the master governors cut in at the same time is immaterial since the compressors will continue to operate and raise the pressure in the main reservoir on each car and in the main reservoir line throughout the train until such time as the governor set for the *highest* cutting-out pressure acts to open the circuit of the dynamotor clutch magnets. This opens the circuit to the dynamotor clutch magnets and stops the operation of all compressors simultaneously.

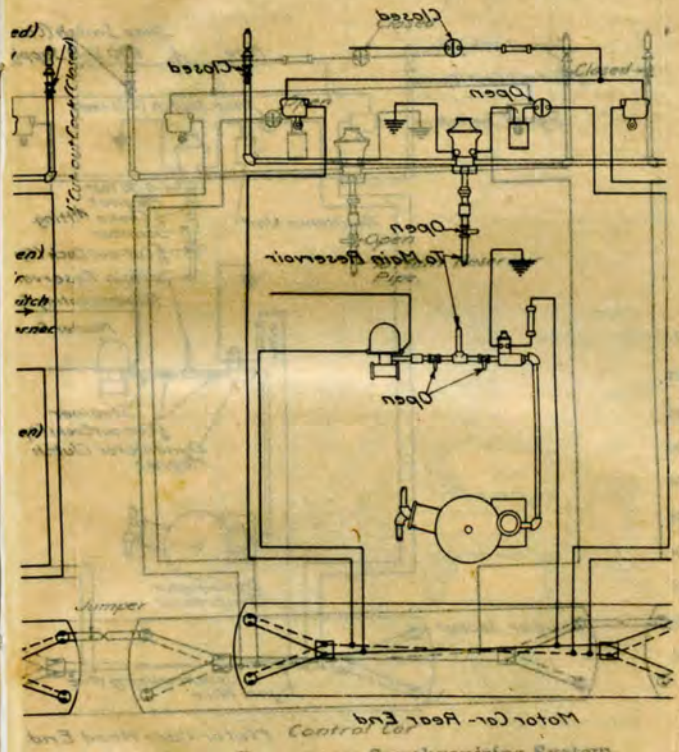


Fig. 19, Dynamotor Compressor Synchronizing System.

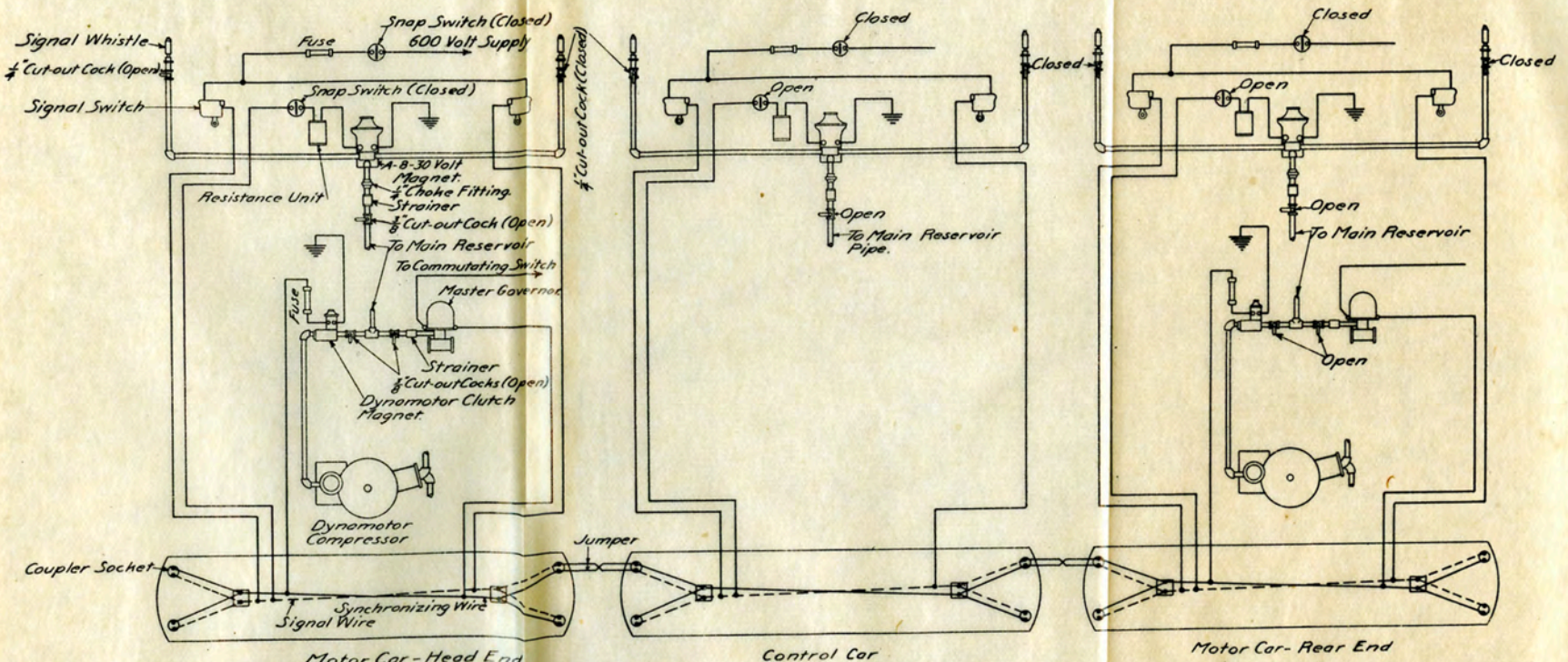


Fig. 19, Dynamotor Compressor Synchronizing System.

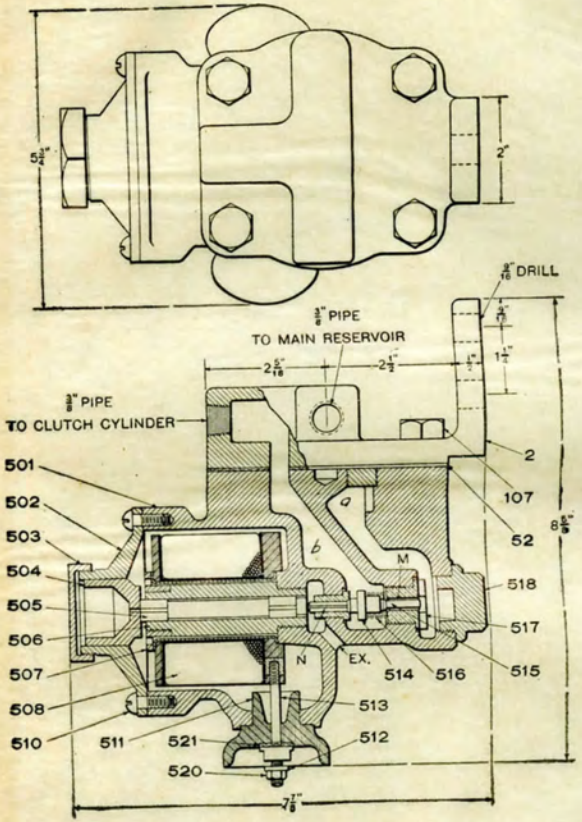


Fig. 20, Dynamotor Clutch Magnet.

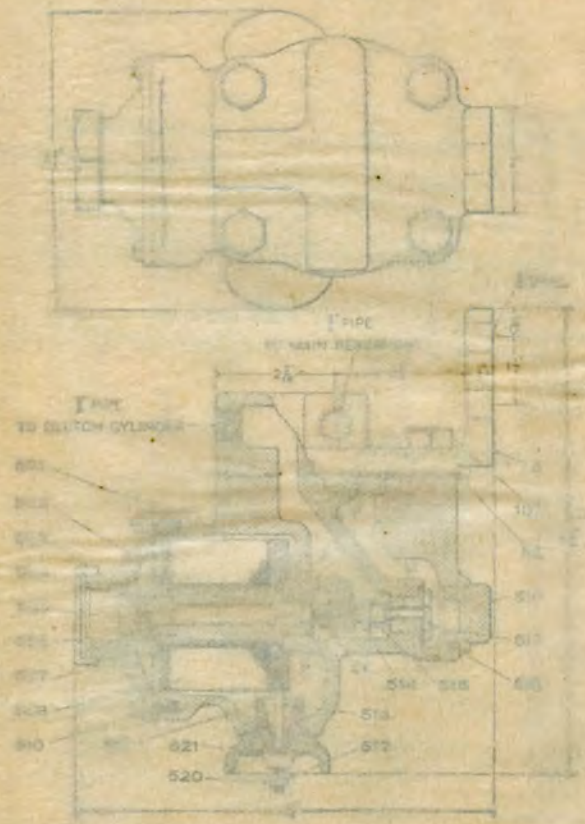


Fig. 20, Dynamotor Clutch Magnet.

INTERLOCKING SYSTEM FOR THE AIR BRAKE AND CONTROL CIRCUIT

The purpose of the interlocking system is:

1st.—To make it impossible to start the car until a predetermined pressure has been accumulated in the air brake system.

2nd.—To provide for cutting off the power circuit automatically if, from any cause, brake pipe pressure should fall below a predetermined minimum.

3rd.—To provide for cutting out the interlocking mechanism manually in such a way as to get the power on and move the car regardless of brake pipe pressure.

The parts comprising the system are an *automatic control switch*, two *by-pass switches* and a *double check valve*.

The automatic control switch, Figs. 21 and 22, is connected to the brake pipe cut-out cock underneath the brake valves, so that the operations of opening and closing the multiple unit control circuit are controlled by brake pipe-pressure at a predetermined point. It is electrically connected in the master control circuit entering each master controller. The piston 3,

Fig. 21, Automatic Control Switch

(Fig. 22), remains down and the master control circuit remains open until there is sufficient pressure in the brake pipe to overcome the tension of spring 7, when the piston will move upward, close the circuit to the master controller and permit the car to be started. If, however, it is desired for any *emergency* reason to move the car before brake pipe pressure has reached the predetermined minimum, it may be accomplished by holding one of the two by-pass switches in the interlocking system in "on" position for as long as it is desired to move the car.

ELECTRO-PNEUMATIC SIGNAL SYSTEM

The electro-pneumatic signal system is adapted for either single cars or trains which may or may not carry trailers and provides means for signalling to the motorman from any part of the train.

A tap is brought from the supply wire through the signal switches to the signal wire and another tap is taken from the signal wire through a snap switch and resistance to the magnet and thence to the ground. The signal wire runs throughout the car or train and is connected between adjacent cars by means of the train

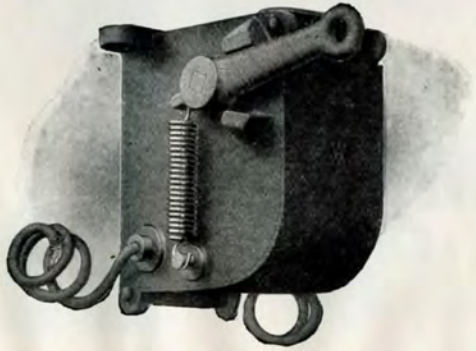


Fig. 23, Signal Switch

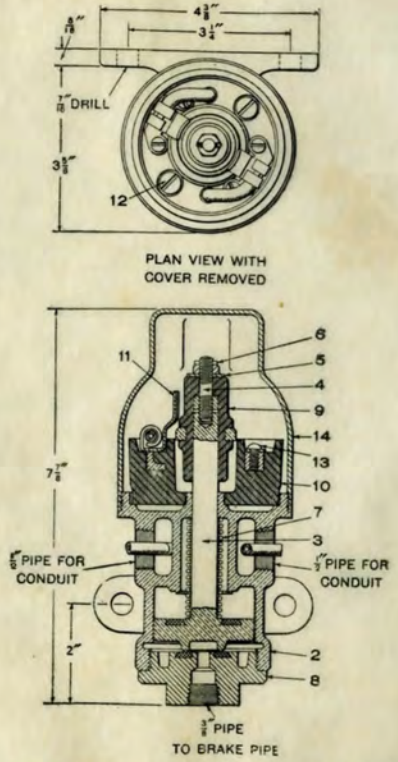


Fig. 22, Section, Automatic Control Switch

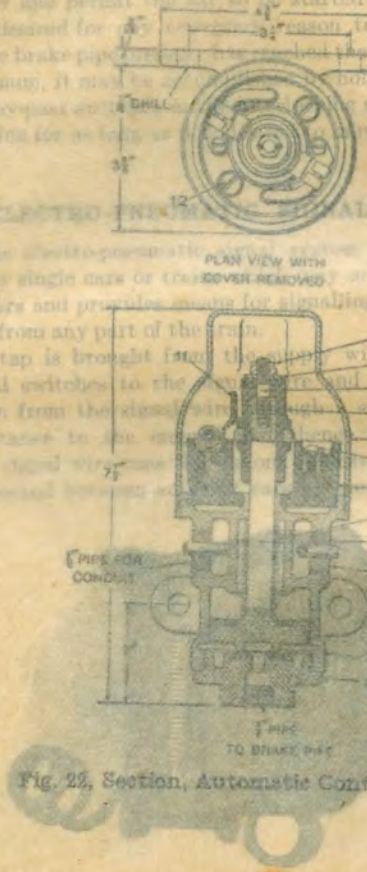


Fig. 22, Section, Automatic Control Switch

Fig. 23, Signal Switch

line jumper. Current flowing through this line serves to actuate a magnet valve which admits air to a small signal whistle located in the cab. A signal switch, Fig. 23, is located at each end of the car.

When the conductor pulls the cord attached to the switch the signal circuit is energized throughout the train, thus energizing the magnet, (Fig. 24), opening the magnet valve and causing a blast of the whistle, (Fig. 25), for such length of time or *in as rapid succession* as may be desired. The blasts cease instantly with the opening of the signal switch so that each blast is sharp and distinct from the one following and there is consequently no overlapping or danger of giving signals other than as intended.

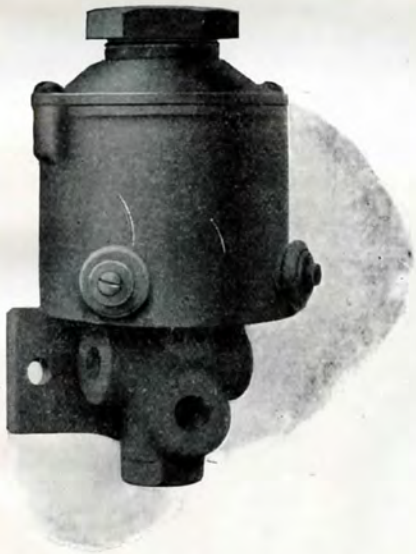


Fig. 24, Signal Whistle Magnet

Fig. 25, Signal Whistle.

But one magnet is required on a car for controlling both whistles, the magnet being located in the compartment on the No. 2 end of the car and piped to whistle at each end.

CONTROL CAR

The brake equipment of a control car, Fig. 27, consists essentially of the same apparatus as previously described for the motor car with the exception that the main reservoirs, air compressors and details of the dynamotor compressor synchronizing system are omitted, and a whistle reservoir added to supply air for the operation of the alarm whistle. The supply of air for the control cars is drawn from the motor cars through the main reservoir pipe.

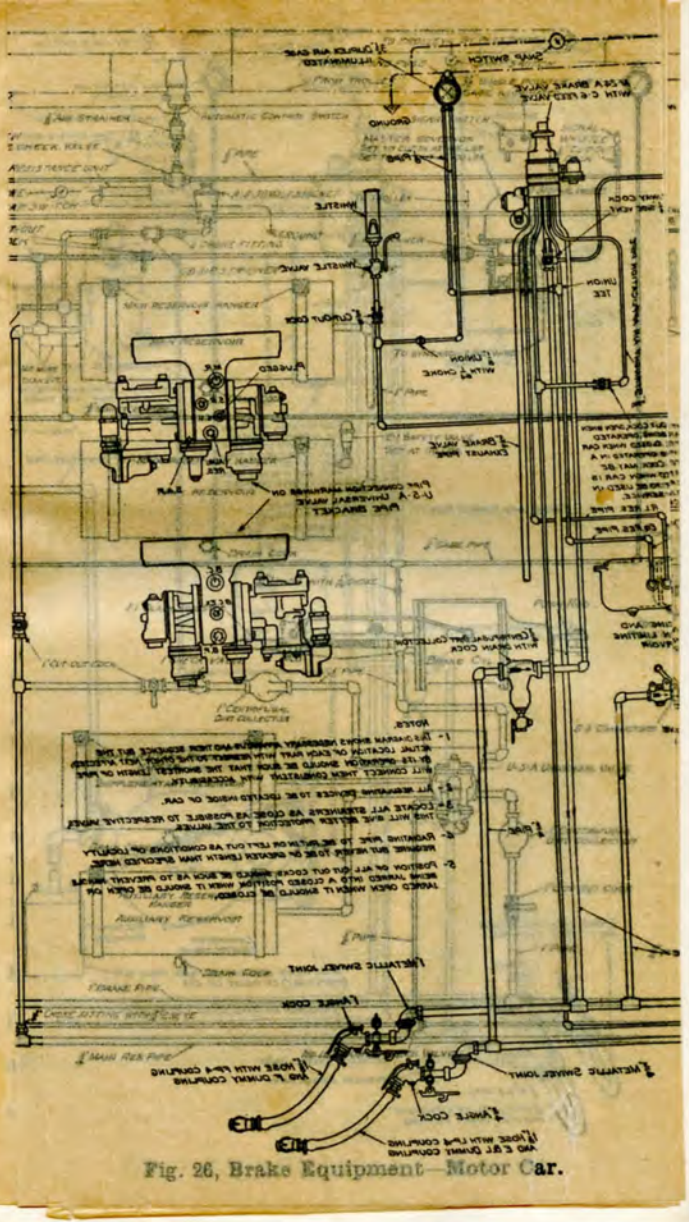


Fig. 26, Brake Equipment—Motor Car.

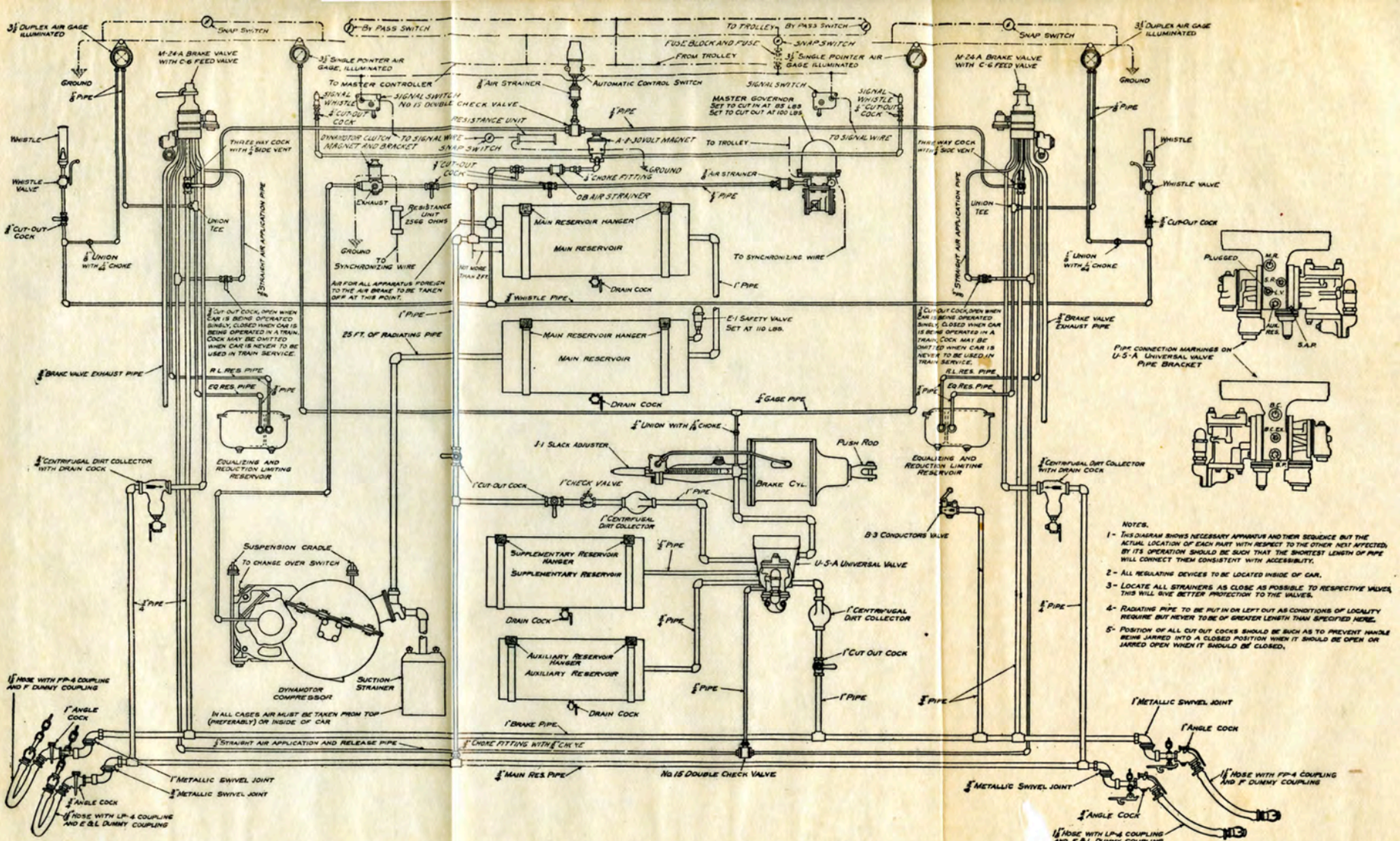


Fig. 26, Brake Equipment—Motor Car.

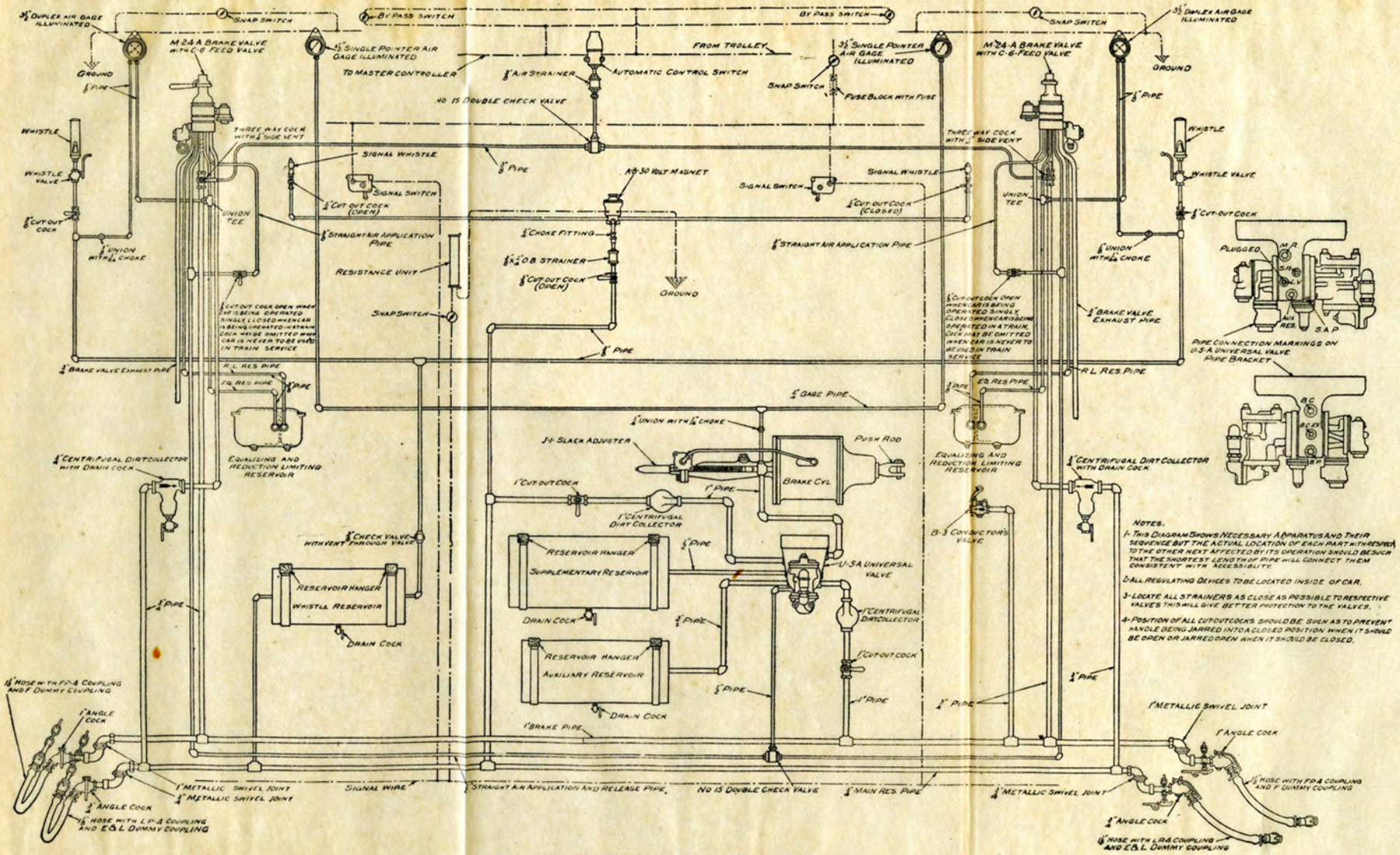
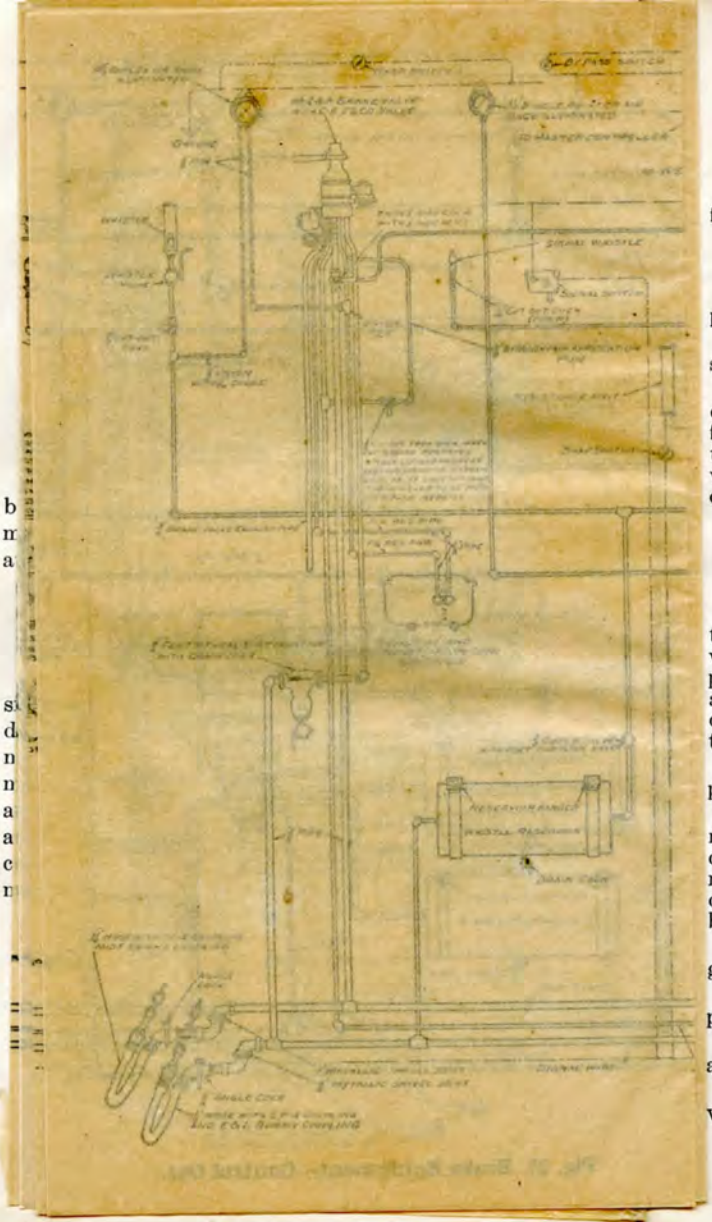


Fig. 27, Brake Equipment—Control Car.



QUESTIONS AND ANSWERS

AIR BRAKES AND PNEUMATIC SIGNALS

Q. 1. Where is the reserve supply of compressed air for operating the brakes carried?

A. 1. In the main reservoirs on the motor cars.

Q. 2. How is this air supply obtained?

A. 2. By the operation of the motor-driven compressors.

Q. 3. What other purpose does the main reservoir serve?

A. 3. To catch and hold the water which is precipitated from the air when it loses the heat resulting from compression, until drained off with the drain cocks, thereby preventing the water entering the brake system, where it would seriously interfere with the operation of the various devices.

MASTER GOVERNOR

Q. 4. How is the main reservoir pressure regulated?

A. 4. By the master governor automatically closing the electric circuit to the dynamotor clutch magnets when the main reservoir pressure has reduced to the low pressure adjustment, thus starting the compressor; and automatically opening this circuit and stopping the compressor when the pressure has been increased to the high pressure adjustment.

Q. 5. By what means are the cutting in and out pressures of the governor adjusted?

A. 5. With the two regulating screws on the pneumatic end of the governor; the one for regulating the cutting out pressure is indicated by the letters H. P., meaning high pressure, cast in raised letters, and the one for regulating the cutting in pressure is indicated by the raised letters L. P., meaning low pressure.

Q. 6. At what main reservoir pressure should the governor start and stop the compressors?

A. 6. It should start at 85 pounds and stop at 100 pounds.

Q. 7. How is the cutting out pressure of the governor adjusted?

A. 7. With a test gauge attached to the main reservoir, start the compressor and let it run until either

the governor opens the circuit, or the desired maximum main reservoir pressure is obtained.

If the compressor stops before the desired maximum pressure is reached, increase the tension of the H. P. regulating spring with its screw, then reduce the main reservoir pressure until the compressor starts and note at what pressure it stops, repeating this operation until the proper cutting out adjustment is obtained. If, however, it is found that the compressor continues to run after the desired maximum pressure is obtained, release the tension on the HP screw until the compressor stops, at or below the pressure required, then proceed as previously described.

Q. 8. If, while adjusting the HP side of the governor, it is found that the compressor starts and stops with a small range of main reservoir pressure, what should be done?

A. 8. Release the low pressure screw at once sufficiently to reduce the cutting in or starting pressure below the desired minimum pressure.

Q. 9. How is the cutting in pressure of the governor adjusted?

A. 9. After completing the HP adjustment, regulate the cutting in pressure with the LP screw in the same manner as described for obtaining the HP adjustment, except that the special point to be noted is the pressure at which the compressor starts. When the adjustment is completed, tighten the adjusting screw jam nuts; note if this has changed the governor adjustment, and make such further changes in adjustment as may be found necessary.

Q. 10. How should the governor switch fingers be adjusted?

A. 10. When the switch is closed there should be a small amount of clearance between the inner end of the regulating screw in each finger and its stop, thereby insuring the fingers being held in contact with the circuit closer with the full force of the finger spring. The gap between the finger adjustment screws and their stops should also be sufficient to permit the contact end of the fingers to move inward about a 1-16 inch when the switch is open, thus providing for a reasonable amount of wear on the face of the contacts, and insure the circuit being closed and opened on a point of the finger just above the position which carries the current when the switch is closed.

The adjustment of the fingers and contour of the contacts should be such that the circuit is opened and closed on both sides of the switch at practically the same instant.

Q. 11. What are the principal points to be given attention when a governor is being inspected?

A. 11. See that the compressor starts and stops at the correct pressures; that the contact fingers are properly adjusted; that the contact faces are in good condition; that all portions of the switch are perfectly clean, and that there is no leakage of air past the piston rod, valves or exhaust port. The faces of the switch contacts and the circuit closer piston rod should then be very lightly coated with a suitable lubricant.

AIR COMPRESSORS

Q. 12. Briefly describe the air compressor.

A. 12. The air compressor has two cylinders, each of which is fitted with a suction and discharge valve, and has a single acting piston driven with a suitable connecting rod from the crank shaft, which in turn is driven through a herring bone gear and pinion by a direct current dynamotor.

Q. 13. How are the cylinders, rods and crank shaft lubricated?

A. 13. By the splash system. The crank case is filled with oil to a level fixed by the top of the filling fitting, which is located in the end of the crank case. The cranks dip into the oil at each revolution and splash or throw it into the cylinders and various bearings.

Q. 14. How often should the crank case be filled with oil?

A. 14. As often as is necessary to keep the oil level close to the top of the filling fitting. It should never be permitted to drop more than one-half inch below this point.

Q. 15. How are the gear and pinion lubricated, and how is the oil supply controlled?

A. 15. By the gear teeth dipping into the oil at the bottom of the gear case, which is supplied by the seepage past the gear end bearing of the crank shaft. The surplus oil accumulated in the gear case is carried by the gear up to the pinion and armature shaft bearing oil well thus maintaining the lubrication for this bearing.

Before starting a new or repaired compressor, fill the gear case until the oil touches the teeth on the lowest point of the gear.

Q. 16. What becomes of the surplus oil entering the oil well of the pinion end bearing for the armature shaft?

A. 16. After the oil well is filled to the desired height the surplus overflows into a passage leading back into the compressor crank case.

Q. 17. How are the bearings of the armature shaft lubricated?

A. 17. By the well-known oil and waste method. The oil level is automatically maintained in the pinion end bearing by oil supplied from the gear case, but the commutator end bearings must be filled occasionally. The oil level in both of these bearings should always be kept up to or near the top of the filling opening.

Q. 18. What special attention should be given the air compressor on inspection?

A. 18. (a) Note if it is pounding, and if so, locate the cause and correct it before it gives excessive wear in the bearings, necessitating expensive repairs or possibly a total failure of some of the parts.

(b) Note the intake to determine if both cylinders are taking in air and if the intake is strong. A backflow indicates an unseated or broken inlet valve; a lack of, or a weak intake, a broken or unseated discharge valve; a cylinder head gasket blown out between the cylinders, or that the intake strainer is clogged with dirt.

(c) Note if any considerable amount of oil vapor issues from the vent opening in the crank case cover, as this indicates packing ring leakage or air cylinders over-heating.

(d) Remove oil plugs from the filling openings of the crank case and armature bearings to determine if they are poperly filled with oil.

(e) Note if external oil leakage is occurring from any of the air compressor gasket joints, and if so apply the necessary remedy. This trouble is usually caused by small burrs or dirt on the metal surface of the joints, or improperly tightened nuts.

Q. 19. What special attention should be given the large cylindrical intake strainer, also the smaller strainer on the crank case vent?

A. 19. The curled hair should be removed from them. the hair and screens washed in gasoline once per

month and at such intermediate intervals as may be found necessary to keep them in condition to permit a free flow of air through them.

MAIN RESERVOIRS

Q. 20. How often should the main reservoir be drained?

A. 20. Each day, or as much oftener as is required to prevent the accumulation of more than one-half gallon of water.

UNIVERSAL VALVE

Q. 21. What is the Universal Valve?

A. 21. An Automatic Operating Valve placed on each car of a train to perform the functions of admitting and exhausting air to and from the brake cylinder.

Q. 22. Why is it called the Universal Valve?

A. 22. Because it is so designed that by starting with a common base, parts may be added making it suitable for the entire range of air brake service.

Q. 23. How does the Universal Valve operate?

A. 23. By increase or decrease in brake pipe pressure.

Q. 24. What features has the Universal Valve?

A. 24. Service, emergency and straight air features.

Q. 25. Are the emergency and service features separate?

A. 25. Yes.

Q. 26. What advantage is gained in having the service and emergency portion separate?

A. 26. Elimination of undesired quick action and ease in location of trouble.

Q. 27. What advantage is gained in the addition of a straight air portion?

A. 27. A simple flexible brake for single car operation.

Q. 28. What are the functions of the Universal Valve?

A. 28. The Universal Valve automatically performs the following functions:

Charging 1. Admits air to the auxiliary and supplementary reservoirs from the brake pipe when charging the system from zero.

2. Admits air to the auxiliary reservoir from the supplementary reservoir and brake pipe when recharging after a service application.

3. Admits air to the quick action chamber and quick action closing chamber and to the cut-off and safety valve chamber C.

4. Admits main reservoir air to emergency valve chamber L.

Service Straight Air 1. Admits air to brake cylinder from brake valve and auxiliary reservoir through double check valve portion.

Lap Straight Air 1. Blanks all ports.

Service Automatic 1. Connects resistance increasing cavity of slide valve to atmosphere.
2. Admits air to brake cylinder from auxiliary reservoir.

Lap Automatic 1. Admits air to resistance increasing cavity from slide valve chamber G.
2. Blanks all other ports.

Release 1. Vents air from the brake cylinders to atmosphere.

Emergency 1. Admits main reservoir air to brake cylinder.
2. Closes communication between brake cylinder and safety valve.
3. Admits air from quick action chamber to face of quick action piston.
4. Vents brake pipe air locally to atmosphere.
5. Vents quick action closing chamber air to atmosphere.

Protection Feature 6. Vents air from face of protection valve to atmosphere in case brake pipe pressure drops below 35 lbs., and thus admits air from main reservoir to brake cylinder as in emergency.

Q. 29. What other pressure fluctuations besides that of the brake pipe will operate the Universal Valve?

A. 29. Increase or decrease in pressure in the straight air application and release pipe.

Q. 30. Is there always pressure in the straight air application and release pipe?

A. 30. No, only in application position.

Q. 31. What is the effect of putting pressure in this pipe?

A. 31. Air enters chamber K in the double check valve portion of the universal valve forcing piston 204 downward. This uncovers feed groove X in the piston bushing through which air flows into chamber J. At the same time the downward movement of the piston unseats check valve 206 by which auxiliary reservoir air is also admitted to chamber J. The air from the two sources then passes to the top of the double check valve 211 and thence to the brake cylinder.

Q. 32. What occurs when the rise of pressure in the straight air application and release pipe is stopped?

A. 32. Air will continue to flow from the auxiliary reservoir to the brake cylinder until the brake cylinder equalizes with the pressure in the straight air application and release pipe.

Q. 33. What occurs if the pressure is allowed to continue building up?

A. 33. The pressure in the straight air application and release pipe will raise to the feed valve setting, 65 lbs. When the auxiliary reservoir and brake cylinder pressure equalizes, the rise in brake cylinder pressure is continued through the straight air application and release pipe.

Q. 34. What is the effect of reducing brake pipe pressure at moderate rate?

A. 34. The pressure in the auxiliary and supplementary reservoirs is left higher than that in the brake pipe, creating a differential of pressures on the opposite sides of the service piston. The first movement of this piston moves the graduating valve which connects the resistance increasing cavity H in the slide valve with the atmosphere. This materially increases the resistance which must be overcome before the slide valve can be moved, thus insuring that a very light brake pipe reduction of say below 5 lbs. will not cause a brake application. As the differential increases, the slide valve is moved to application position. The complete movement now of the graduating and slide valve to application position closes the exhaust and charging ports of the auxiliary and supplementary reservoirs and connects the auxiliary reservoirs with the brake cylinder.

Q. 35. What occurs when the brake pipe reduction is stopped?

A. 35. The auxiliary reservoir air continues to flow to the brake cylinder increasing the brake force until its pressure is slightly lower than that of the brake pipe which then moves the service pistons and valves to lap position, cutting off by means of the graduating valve further flow of air from auxiliary reservoir to brake cylinder. This movement of the graduating valve again connects the resistance increasing cavity with auxiliary reservoir pressure. The slight difference in pressure which was sufficient to move the piston and small graduating valve is unable to overcome the added resistance of the slide valve, and they are stopped in service lap position.

Q. 36. What feature is obtained by connecting the resistance increasing cavity in the slide valve with the auxiliary reservoir pressure in service application position?

A. 36. The slide valve is made very sensitive to release because of its being more nearly balanced.

Q. 37. What occurs if the brake pipe pressure reduces at a moderate rate?

A. 37. Pressure will build up in the brake cylinder to equalization point of brake cylinder and auxiliary reservoir pressure, and when the brake pipe pressure reaches 35 lbs, the setting of the protection valve, this valve is forced from its seat causing a very rapid reduction of the remaining brake pipe pressure. This causes the emergency portion of the Universal Valve to go to emergency position and admit air from the main reservoir to the brake cylinder.

Q. 38. In what way does a continued automatic brake application with brake valve differ from a continued straight air application?

A. 38. In straight air 65 lbs. brake cylinder pressure is obtained, while in automatic but 50 lbs. brake cylinder pressure is obtained.

Q. 39. If the brake pipe pressure is 70 lbs. how many pounds reduction is required to fully apply the brake in service application?

A. 39. Twenty pounds, as this causes the brake cylinder and auxiliary reservoir to equalize at 50 lbs.

Q. 40. How are the brakes released?

A. 40. By increasing the brake pipe pressure until it is higher than that in the auxiliary reservoir.

Q. 41. How high must the brake pipe pressure be raised to insure a complete release of the brakes?

A. 41. To the full pressure normally carried in the brake pipe.

Q. 42. What is the result of raising the pressure in the brake pipe in steps of say three pounds?

A. 42. The release of air from the brake cylinder will be graduated; i. e., a portion of the air will be discharged to the atmosphere and the exhaust port then closed, thus only partially releasing the brakes.

Q. 43. How is this graduated release feature of the Universal Valve obtained?

A. 43. By supplementary reservoir air flowing into the auxiliary reservoir while the valve is in release position, thus raising the auxiliary reservoir pressure slightly higher than the brake pipe pressure has been raised, causing the valve parts to move to release lap position.

Q. 44. Is any other benefit derived by the use of the supplementary reservoir?

A. 44. Yes. A quick recharge of the system on account of the large local supply of air. The supplementary reservoir recharges the auxiliary reservoir completely up to within approximately 5 lbs. of the normal pressure carried, so that the main reservoirs have but to restore the brake pipe pressure in recharge.

Q. 45. How is the quick action operation of the Universal Valve produced?

A. 45. In two ways:

1st. By reducing the brake pipe pressure more rapidly than the quick action chamber pressure can reduce through its feed grooves and past the protection valve unseating it.

2d. By continuing brake pipe reduction either quickly or slowly below 35 lbs., as explained under protection feature.

Q. 46. Where does brake cylinder air come from in emergency?

A. 46. From the main reservoir. When the protection valve has been unseated the emergency slide valve piston is moved to emergency position; this in turn releases quick action chamber air which unseats quick action piston making a local reduction of brake pipe air to atmosphere. Main reservoir air then forces emergency valve down and flows to the brake cylinder. At the same time the safety valve is cut off from the brake cylinder so that full pressure is maintained.

Q. 47. For what purpose is the safety valve attached to the Universal Valve?

A. 47. To prevent excessive brake cylinder pressure during service application.

Q. 48. What is the setting of the safety valve?

A. 48. Sixty-two pounds.

Q. 49. What attention should be given the Universal Valve on inspection?

A. 49. With the brake applied and released it should be noted if there is any leakage at the universal valve exhaust or vent ports, or past the joints or gaskets. The Universal Valve should also be operated to see that it performs properly both in graduated application and graduated release which will be indicated by the cylinder gauge in car and by sound in the Universal Valve or movement of the brake cylinder piston.

BRAKE VALVE

Q. 50. What is the purpose of the Brake Valve?

A. 50. For controlling the operation of the brakes as follows:

To connect the main reservoir pipe to the brake pipe through the feed valve while the brake valve is in release position.

To permit the motorman to apply or release the brakes in either straight air or automatic according as to whether he has a single car or a train.

Q. 51. How is the brake application brought about by the Brake Valve?

A. 51. In straight air application the straight air application and release pipe is connected with feed valve pressure. In automatic application the brake pipe pressure is exhausted to atmosphere any desired amount, the flow of air to atmosphere being automatically regulated according to the length and volume of the brake pipe thereby making the time required for the service application of the brakes on various lengths of trains as nearly uniform as possible.

Q. 52. With what volumes of air is the Brake Valve connected?

A. 52. By piping to the main reservoir, brake pipe, straight air application pipe, release pipe, equalizing reservoir and limit reduction reservoir, also by suitable ports with the atmosphere.

Q. 53. Briefly describe the brake valve?

A. 53. The brake valve consists of a body or casing containing a rotary valve, which is rotated on its seat by the brake valve handle for the purpose of obtaining proper combinations of ports and passages in its several positions; an equalizing piston which divides the equalizing reservoir and brake pipe volumes and operates under certain conditions to open an exhaust valve for discharging brake pipe air to the atmosphere; also a reduction limiting feature which restricts the amount of brake pipe reduction so that the brake pipe pressure cannot be reduced below the pressure at which the brake cylinders and auxiliary reservoirs on the train equalize in service, which is 50 lbs. pressure. The valve body also has attached the feed valve for reducing the pressure from the main reservoir to the desired brake pipe pressure.

Q. 54. How many positions has the brake valve and how are they designated?

A. 54. Seven; beginning at the left end of the quadrant they are as follows: Release, Straight Air Lap, Straight Air Application, Automatic Lap, Service, Handle Off position and Emergency.

Q. 55. What are the purposes of the equalizing and reduction limiting reservoir?

A. 55. This reservoir is divided into two chambers of unequal size, the larger or equalizing chamber is connected to and is simply an enlargement of the equalizing chamber in the brake valve from which air is discharged by the motorman when applying the brakes in service application. The smaller or reduction limiting chamber is connected to the brake valve in such a manner that when making service application feed valve pressure is admitted to the chamber. When this pressure, which is also on the face of the limiting valve piston, slightly exceeds that pressure, which is in the back of the piston, viz., equalizing reservoir pressure, the piston moves cutting off communication between the equalizing reservoir and the atmosphere and the brake pipe and atmosphere.

Q. 56. State what passages are open in each position of the brake valve and the purpose of same.

A. 56. Release Position.—A large passage is open from the main reservoir pipe through the feed valve to the brake pipe for charging and maintaining the pressure in the latter; another passage is open from the brake pipe to the equalizing reservoir for charging this

reservoir and maintaining the equilibrium of pressures in these two volumes; also a passage open from the reduction limiting reservoir through which its air is exhausted to the atmosphere, and a straight air application and release port are connected to the brake valve exhaust.

STRAIGHT AIR APPLICATION.—In this position air at feed valve pressure is supplied to the straight air application pipe. The equalizing reservoir, equalizing piston exhaust and brake pipe and straight air release pipe ports are blank.

STRAIGHT AIR LAP POSITION.—In this position all port connections are the same as in release, except the straight air application and release ports are blanked.

AUTOMATIC LAP.—In this position the equalizing discharge valve piston exhaust port is connected to the brake valve exhaust, and all other ports are blank.

AUTOMATIC SERVICE POSITION.—Brake pipe air is exhausted direct to the atmosphere through the limiting valve exhaust port and brake valve exhaust pipe. Equalizing reservoir pressure will exhaust until the air in the chamber above the equalizing piston has been sufficiently reduced below the brake pipe pressure which will then cause the equalizing piston to rise, exhausting brake pipe air to the atmosphere through the equalizing discharge valve exhaust port and brake valve exhaust. The reduction limiting reservoir port is open to the feed valve pressure and the straight air application and release pipe ports are blank.

HANDLE OFF POSITION.—In which the handle may be removed. Straight Air Application and Release ports are connected to the brake valve exhaust. All other ports are blank.

EMERGENCY POSITION.—In which the brake pipe is connected direct to the atmosphere. The straight air application pipe is also open to feed valve pressure through a large port in the rotary valve, thus allowing feed valve air to maintain brake cylinder leakage on operating car only.

Q. 57. What occurs if, when making a service application with a very short train or a single car, the direct exhaust passage from the brake pipe through the rotary valve to the atmosphere reduces brake pipe pressure more rapidly than a preliminary exhaust port can reduce equalizing reservoir pressure?

A. 57. When the brake pipe pressure becomes slightly lower than the equalizing reservoir pressure the latter forces the equalizing piston downward, compressing

a spring which is interposed between the piston and its exhaust valve, uncovering grooves in its cylinder which causes the excess air in the equalizing reservoir to flow into the brake pipe, thus maintaining substantially an equilibrium of these pressures and preventing such a rapid reduction of brake pipe pressure as would tend to produce undesired quick action operation of the brakes.

Q. 58. What occurs when, with the brake system charged to 70 lbs. the brake valve handle is moved to service position and left there?

A. 58. Air is discharged from the equalizing reservoir and chamber above the equalizing piston and brake pipe pressure on the lower side of this piston causes it to rise and discharge brake pipe air to atmosphere. The reduction limiting reservoir is connected to feed valve pressure and when the pressure in this reservoir and the equalizing reservoir equalizes the reduction limiting valve piston moves cutting off ports and preventing further brake pipe reduction. These two reservoirs will equalize at 50 lbs. pressure, so that it is impossible to get over a 20 lb. reduction.

Q. 59. What occurs if, when releasing the brakes on a long train the equalizing reservoir is charged higher than brake pipe pressure due to its small volume and being near the source of supply?

A. 59. The equalizing piston being of the collapsible type is forced down compressing the spring which is interposed between the piston and the valve uncovering grooves in the cylinder walls which permit the excess air in the equalizing reservoir to flow into the brake pipe and equalize these two pressures. As a result an absolute equality of brake pipe and equalizing reservoir pressure is assured and it is possible at any time during the release of the brakes to move the brake valve to application position and secure an immediate response of the brakes.

Q. 60. What attention should be given to the Brake Valve on inspection?

A. 60. Ascertain if the rotary and key move easily and oil them through the oil holes provided in the body and key at such intervals as will prevent their working hard on the road; note if leakage is occuring at the exhaust ports with the handle in the release, running or lap position; that both service exhaust ports close tight when the handle is moved to service position and left there until the brakes are fully applied; also, that the

rotary valve and body gaskets are free from leakage, which will usually be determined by applying the brake, placing the brake valve handle on lap and noting if equalizing reservoir pressure increases.

BRAKE CYLINDERS

Q. 61. How does the brake cylinder operate and what is its purpose?

A. 61. The piston of the brake cylinder has a leather packing, making an air tight joint between it and the cylinder walls, and when compressed air is admitted to the cylinder to apply brakes, the piston and its rod are forced outward, the latter against the end of the cylinder lever and the force is transmitted through the levers and rods to the brake shoes on the wheels. Then to release the brake the air is permitted to exhaust from the brake cylinder to the atmosphere.

Q. 62. How far should the cylinder piston travel out when the brakes are fully applied?

A. 62. Until shoes are hard against wheels. Piston travel should be between five and seven inches.

Q. 63. How is the piston travel regulated?

A. 63. By dead levers when new brake shoes are applied. The correct travel is then maintained by the automatic slack adjuster.

Q. 64. Why is it important to keep the brake piston travel uniform at all times, and on all cars?

A. 64. Because long piston travel weakens the power of the brake and increases the air consumption. Short piston travel increases the power of the brake, and a mixture of long and short piston travel brakes in a train produces shocks by slack action and is liable to cause wheel sliding on the cars with short piston travel.

Q. 65. How can brake cylinder leakage on motor cars be detected?

A. 65. By applying the brake with a full service application, and watching the brake-cylinder gauge hand. If the pressure reduces the cylinder is leaking.

Q. 66. How can brake cylinder leakage on control cars be detected?

A. 66. By applying the brake with a full service application, then note if the piston moves back and listen for the sound of air escaping by the piston rod.

Q. 67. How often should brake cylinders be inspected for piston travel and leakage?

A. 67. Each day.

SUPPLEMENTARY RESERVOIR

Q. 68. What is the purpose of the supplementary reservoir?

A. 68. To carry a supply of air—first, for assisting in quickly recharging the auxiliary reservoir; second, for assisting in regulating the universal valve during the graduated release.

MAIN RESERVOIR PIPE

Q. 69. For what purpose is the main reservoir pipe used?

A. 69. The main reservoir pipe runs throughout the train and furnishes the main reservoir air to the controlling brake valve. It also connects each universal valve through which main reservoir air is supplied to the brake cylinder in emergency application.

ELECTRO-PNEUMATIC SIGNAL SYSTEM

Q. 70. For what purpose is the electro-pneumatic signal used?

A. 70. Electro-pneumatic signal system provides means for signalling to the motorman from any part of the train.

Q. 71. What equipment constitutes the electro-pneumatic signal system?

A. 71. One snap switch for supplying current to the signal system.

One signal switch for energizing the signal wire running throughout the train.

One snap switch for controlling the operation of the signal magnet valve.

One resistance for limiting the current to the signal magnet valve.

One signal magnet valve for admitting air to the signal whistle.

Two signal whistles for communicating the signal.

Q. 72. For what purpose is the signal wire used?

A. 72. To transmit signals from any car in the train to the cab from which the motorman is operating.

Q. 73. How is the signal switch operated?

A. 73. By the cord attached the switch is closed, thus energizing the magnet, opening the magnet valve and causing a blast of the whistle for such length of time as may be desired.

Q. 74. With this system can overlapping signals be given?

A. 74. No; the signal blast ceases instantly with the opening of the signal switch, so that each one is sharp and distinct from the other, and there is consequently no overlapping or danger of giving signals other than as intended.

Q. 75. How often should brake cylinder, universal valve, slack adjusters, brake valve, and feed valve be cleaned and lubricated?

A. 75. Each time the car is in the shop for general repairs, and every three months during service.

AUXILIARY RESERVOIRS

Q. 76. For what purpose is air in auxiliary reservoir used?

A. 76. For operating the universal valve in conjunction with brake-pipe air and for supplying air to the brake cylinder when applying brakes.

Q. 77. What will be the effect of reducing auxiliary and supplementary reservoir pressure by opening the auxiliary and supplementary reservoir drain cocks, while the brake is applied?

A. 77. It causes the brake to release.

Q. 78. When using the auxiliary and supplementary reservoir drain cocks for releasing a brake, how long should they be held open?

A. 78. Until the brake releases as indicated by an exhaust of air from the exhaust port of the universal valve.

MAIN RESERVOIR

Q. 79. For what three purposes is the main reservoir air used?

A. 79. 1st. For charging the brake pipe.

2nd. For assisting in charging the auxiliary and supplementary reservoirs and obtaining graduated release.

3rd. For increasing the brake cylinder pressure in emergency applications above the maximum pressure obtainable in service applications.

BRAKE PIPE

Q. 80. For what purpose is the brake-pipe air used?

A. 80. For operating the universal valve in conjunction with the auxiliary and supplementary reservoir air; also to charge the auxiliary and supplementary reservoirs.

AUTOMATIC SLACK ADJUSTER

Q. 81. What is the purpose of the slack adjuster?

A. 81. It automatically adjusts the foundation brake rigging and thereby prevents the brake cylinder piston travel increasing as the brake shoes are decreased in thickness by wear.

Q. 82. Describe its operation.

A. 82. When the brake cylinder piston travels too great a distance during a brake application, its packing leather uncovers and admits brake cylinder air to a small port and through a small pipe to the slack adjuster cylinder. In this cylinder is a leather packed piston backed by a strong spring and fitted with a pawl on the end of the piston stem. When air is admitted to the cylinder as described, the piston is moved to the opposite end of its cylinder, compressing its spring and moving the pawl into engagement with a ratchet nut. When the brake is released the air is exhausted from the slack adjuster cylinder, and the spring is then free to exert its force on the pawl and turn the ratchet nut, which, being mounted on a screw attached to a jaw connected to the cylinder end of the back cylinder lever, pulls the lever away from the cylinder a given distance, thus shortening the brake piston travel an equal amount. This operation is repeated with each brake application until the brake piston packing leather fails to open the small port. When the brake piston travel is again increased by brake shoe wear the slack adjuster operation is repeated.

Q. 83. How should the slack in the brake rigging be adjusted when starting a car out with all brake shoes nearly full thickness, and why?

A. 83. Turn the fluted end of the slack adjuster ratchet nut to the left until the cylinder lever is about one-quarter inch from the lug on the brake cylinder head; let out the slack at the top end of the dead levers as far as possible and adjust the piston travel by adjusting the length of the bottom brake rods on the trucks, care being taken to obtain similar release angularity

of the truck live levers, also brake shoe clearance in the two trucks. This procedure is to obtain the maximum amount of take-up in the slack adjuster; to provide the maximum movement for the upper end of the truck live lever to prevent fouling when the operation of the slack adjuster changes its angularity, also to provide ample take-up in the dead lever stop for taking up part of the slack to reduce live lever angularity if this should become necessary before brake shoes are replaced.

Q. 84. How is the slack let out when replacing worn brake shoes?

A. 84. By unscrewing the slack adjuster nut until the necessary shoe clearance is obtained. If, owing to the number of shoes to be replaced, backing off the slack adjuster does not provide the necessary shoe clearance, obtain the clearance by letting out the slack at the top end of the dead lever.

Q. 85. Is the brake piston travel the same when standing and running?

A. 85. No, it is greater when running; therefore, when adjusting piston travel by hand make it the same on the same class of cars in service.

Q. 86. How should the slack adjuster be tested on inspection or at such intervals as may be specified?

A. 86. Back off the ratchet nut until the brake piston travels beyond the adjuster port, apply the brake and note if there is any leakage in the adjuster pipe connections or cylinder packing. Next release the brake, noting if the ratchet nut revolves slightly.

Q. 87. When should the slack adjuster cylinder be cleaned and lubricated?

A. 87. Each time the brake cylinder receives such attention.

PILOT AND EMERGENCY VALVES

Q. 88. Where is the pilot valve located?

A. 88. In the master controller, and has a mechanical connection to the button on the controller handle and an air pipe connection to the emergency valve.

Q. 89. For what purpose is it used?

A. 89. To operate the emergency valve.

Q. 90. Where is the emergency valve located?

A. 90. In the Motorman's Compartment, and is connected to the brake pipe and pilot valve.

Q. 90. How does it operate and for what is it used?

A. 91. By releasing the controller button when the controller handle is in "Off" position the pilot valve is opened. This reduces the pressure on top of the piston in the emergency valve, causing it to rise and open up a direct connection from brake pipe to atmosphere, which results in an emergency application of brakes throughout the train. This device is intended to stop a train automatically in case the motorman should become disabled.

Q. 92. What attention should be given these valves?

A. 92. Both valves should be cleaned and lubricated whenever the brake valve is cleaned.

Q. 93. In case both or either of these valves should become defective on the road, what should be done?

A. 93. Cut them out by closing the one-inch cutout cock in brake pipe connection to the emergency valve.

LEAKAGE

Q. 94. What is the maximum permissible leakage rate from the system?

A. 94. Three pounds per minute, and it should be as much less than this as possible.

Q. 95. How should the equipment be tested for leakage?

A. 95. With the brake valve handle in released position by noting the rate of fall of main reservoir pressure after it has reached the maximum and the compressor stopped.

Q. 96. If the total leakage is excessive, how can the trouble be located?

A. 96. By cutting off the air supply to the brake valve, closing the one-inch cocks from the main reservoir in the brake pipe line leading to the universal valve, lapping the brake valve and noting the rate of fall of pressure in main reservoir pipe and brake pipe respectively.

Q. 97. What should be done next?

A. 97. Restore cocks and valves to normal position, coat the joints and other likely points for leakage with soap suds and look for bubbles, this to include the universal valve and pipe joints between it and the two one-inch cutout cocks, also the hose if the leakage is located in the brake or main reservoir pipes.

MAKING UP TRAINS

Q. 98. After the cars have been switched together, what must be given attention from the ground preparatory to taking a train out of the yard?

A. 98. Couple the brake pipe and the main reservoir pipe, open all cocks in these pipes between cars, close them at the ends of the train and hang up the hose. See that the one-inch cutout cocks to the universal valve are open and the reservoir drain cocks closed, that the governor and clutch magnet cut out cocks are open, also that there are no leaks that can be detected by sound, also that the brakes apply and release on all cars.

Q. 99. What should be done inside the cars preparatory to taking a train out of the yard?

A. 99. The motorman starting from the rear car should see that the brake valve handles are removed, the brake valves and whistle cutout cocks are closed, and compressor switches are closed, and illuminated gauge switches off, place the brake valve in the front cab of the leading car in release position, open the brake valve, signal whistle and alarm whistle cutout cocks and turn the illuminated gauge switch on. When the train is fully charged, apply the brakes with a 20-pound service application and wait for a signal to release. The trainmen or inspectors at inspection stations will see that the signal line switch is cut in, and when the brakes apply, notify the motorman by four blasts of the signal whistle from the rear car.

Q. 100. What must a motorman know positively before starting a train?

A. 100. That the brakes are operative throughout the train and that they are charged with 70 pounds pressure.

Q. 101. What else should be done before the train reaches the main line?

A. 101. When the train has reached a speed of six to eight miles per hour, the motorman should apply the brakes with a 10-pound reduction to determine if the brake power is sufficient to safely control the train. Trainmen will note if the brakes apply on their cars, and if not, give signal and have train stopped immediately and ascertain the cause.

Q. 102. What should the motorman do when changing from one cab to another?

A. 102. Apply the brake with a 15-pound reduction, then close the three-way cutout cock under the brake valve, also the cutout cock in the straight air brake pipe, turn the illuminated gauge switch off and remove the brake valve handle.

These operations to be reversed in the cab from which the train is to be operated, the brake valve immediately moved to release position and note if brakes release.

HANDLING TRAINS

Q. 103. What special attention must be given to air pressure while the train is in motion and particularly when approaching a point where a stop might or will be required?

A. 103. It must be known, by frequent observation of the air gauge, that the brake pipe is fully charged.

Q. 104. In what position should the brake valve handle be carried except when brakes are applied?

A. 104. Release position.

Q. 105. When a brake application is required, how should the brake valve be operated?

A. 105. Move the brake valve handle directly to service or emergency application position as required.

Q. 106. If an emergency application of the brakes is required on account of danger to life or property, how long should the brake valve handle be left in emergency position?

A. 106. Until the stop is completed.

Q. 107. If a service application is required, how long should the brake valve handle be left in service position?

A. 107. Until a sufficient reduction is registered on the brake pipe to produce the desired amount of braking power, then move the handle to lap position.

Q. 108. How heavy a service application should be made?

A. 108. Never less than 5 pounds brake pipe reduction and from this to a full service reduction, (20 pounds), depending upon the requirements.

Q. 109. Why should the brakes never be applied with less than 5 pounds brake pipe reduction?

A. 109. Because this amount of reduction is necessary to insure moving the cylinder piston beyond the leakage groove and apply the brake, and to guard against a failure of the brake to release.

Q. 110. What would occur if the brake valve handle were moved to service position and left there?

A. 110. The brakes would be fully applied with a service application and the brake valve would then automatically close the brake pipe exhaust.

Q. 111. Why has the brake valve been arranged to automatically limit the maximum service brake pipe reduction?

A. 111. To automatically guard against brake pipe pressure being reduced below the pressure at which brakes are fully applied, i. e., the auxiliary reservoir and brake cylinder equalization, which is 50 pounds from a normal 70-pounds brake pipe pressure, thereby guarding against waste of brake pipe air and insuring prompt release of all brakes when brake pipe pressure is increased.

Q. 112. How are brakes released?

A. 112. By increasing brake pipe pressure in release or running position above the auxiliary reservoir pressure.

Q. 113. How should the brakes be operated when making a service stop?

A. 113. They should be applied with nearly a full service application at a distance from the desired stopping point, which, if the full brake force was retained, would stop the train short of the desired point, then when the speed becomes low, release some of the pressure from the brake cylinders and thereby reduce the braking force, by moving the brake valve handle to release position and back to lap, which produces a small rise in brake pipe pressure and results in a graduated release operation of the universal valves. This graduated release operation should be repeated if it is found that the train is going to stop short of the desired point. If the track is level the release of the balance of air from the brake cylinder is accomplished by placing the brake valve handle in release position and leaving it there. This operation should be started just before the stop is completed.

Q. 114. Why should the brakes be operated as described?

A. 114. To obtain the highest brake force while the speed is high and the action of the brakes less likely to be disagreeably noticeable to passengers; to prevent an excessive rate of retardation when the speed becomes low; to guard against wheel sliding and to complete the stop with such a low brake cylinder pressure that disagreeable surges cannot occur at the stop.

Q. 115. How is emergency application of the brakes produced?

A. 115. In two ways: By reducing brake pipe pressure faster than auxiliary reservoir pressure can reduce by flowing into the brake cylinder; also by reducing brake pipe pressure below thirty (30) pounds. It is therefore clear that an emergency application of brakes is always available, irrespective of any previous degree of service application of the brakes.

Q. 116. What should a trainman do if, when the train is starting or running, it is necessary to stop it immediately to guard against danger to life or property?

A. 116. Open the conductor's valve wide and leave open until stop is made. Immediately after the stop is completed move the conductor's valve handle back to its closed position.

Q. 117. If the brakes apply suddenly by a reduction not made by the motorman, what should he do?

A. 117. Move the brake valve handle to emergency position and leave it there until stop is completed. Then return it to release position in order that trainmen may locate the opening in the brake or main reservoir pipe by sound of escaping air.

Q. 118. What is the probable cause if while on the road, brake pipe pressure increases materially above the normal?

A. 118. It may be due to feed valve or leaking rotary valve.

Q. 119. If a brake fails to release from the operation of the brake valve, what should the trainmen do?

A. 119. Open the drain cocks of the auxiliary and supplementary reservoirs until the brake releases, then close them promptly. If a brake sticks several times successively cut it out by closing the one-inch cutout cocks on both sides of the universal valve and release by opening the auxiliary and supplementary reservoir drain cocks, leaving them open and notify the motorman.

Q. 120. Should brakes be cut out unless absolutely necessary?

A. 120. No, because it reduces the available brake force, therefore the safety of the train.

Q. 121. What should be done if an air hose fails on the road?

A. 121. Replace it with one from supply in baggage compartment or remove one from end of train.

Q. 122. What action should be taken if a defect is noted in the operation of brakes or in any part of the brake apparatus?

A. 122. Report it to the proper official at the earliest opportunity in order that such action may be taken as will guard against delays to trains en route. Such defects must also be reported promptly upon arrival of the train at a terminal.

PART II.

ELECTRICAL EQUIPMENT

GENERAL DESCRIPTION OF MULTIPLE UNIT CONTROL SYSTEM

1. The Electric Equipment as applied to the electric motor cars of the Portland, Eugene and Eastern Railway Lines, comprises two distinct sets of controlling apparatus, viz.: the master control and the motor control. The master control is operated by the motorman. The motor control depends for its operation on the master control.

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

3. Every motor and control car is equipped with master control apparatus, the function of which is to operate the motor control. An important feature of the master control is the train cable, comprising seven conductors or wires, running the entire length of the train, with suitable cable jumpers between the cars. On every motor and control car a connection is made from this cable to the master control apparatus of that car. At the motorman's cab a connection is made from the train cable to the master controller, consequently the entire train cable can be energized and all of the

motor control apparatus connected thereto can be operated through either master controller on any motor or control car in the train. This system is known as the multiple unit control.

DESCRIPTION OF THE MOTOR CONTROL APPARATUS

THE MOTOR CONTROL CIRCUIT is the path for the current from the trolley wire through the motor control apparatus and motors to the track rails. It includes the following apparatus:

One Roller Type Pantograph Trolley, which collects current from the trolley wire.

One Main Fuse, which protects the motors and motor control apparatus against excessive currents in case the circuit breaker fails to operate.

One Main Switch, by which the current can be cut off from the motor control circuit for inspection or in case of defective apparatus.

One Circuit Breaker, which protects the motors and motor control apparatus against excessive currents.

One set of 15 Contactors, which close and open the circuits to the motors.

One Commutating Switch for changing motor and auxiliary circuits to permit operating on either 600 or 1500 volts potential. This switch also provides means for cutting out either pair of motors in case of an emergency.

One Reverser, which determines the direction of car movement.

One Set of Motor Rheostats which limits the flow of current to the motors when accelerating.

PANTOGRAPH TROLLEY.—Each motor car is equipped with one roller type pantograph trolley which collects current from the trolley wire, and is referred to in these instructions as the collector. It is constructed of steel tubing reinforced with tie rods. The frame carries an iron roller which collects current from the trolley; also

two auxiliary contact bars, one on either side of the roller but insulated from the frame, which are provided for operating the time limit potential relay when passing under the contact brushes installed in the overhead line. Each collector is provided with a set of springs which are connected to bell cranks for raising the collector frame and maintaining an even pressure on the wire at various heights. The frame is so constructed that it has an operating range of from 17′ to 23′ above the rail.

Two air cylinders are provided for lowering the collector and an auxiliary air cylinder is also provided for unlocking it, permitting it to rise. A mechanical latch is provided so that when the collector is placed in its lowest position it automatically latches.

With the roller in contact with the overhead wires all parts of the frame and base are energized, the base being insulated from the car roof with four porcelain insulators.

With available current and air pressure provision is made for raising and lowering all collectors in the train simultaneously by operating a switch located in the motorman's cab, and individually by operating an air valve also located in the motorman's cab. Without available current or air pressure, provision is also made to raise and lower the collector. To raise it a hand pump, located inside of each motor car, is provided; to lower it an emergency air reservoir located under the car, is provided which supplies air to the lowering cylinder through the electro-pneumatic valve.

THE MAIN FUSE is located on the roof, near the collector. It is made of thin copper ribbon, and is contained in a box composed of insulating material. Sheet iron pole pieces, in conjunction with two coils, one at each end of the fuse box, provide a powerful magnetic blow-out for extinguishing the arc when the fuse blows. The fuse is held in place by copper clamps fastened with thumb screws. It may be renewed after the collector has been placed in its lowest position and locked.

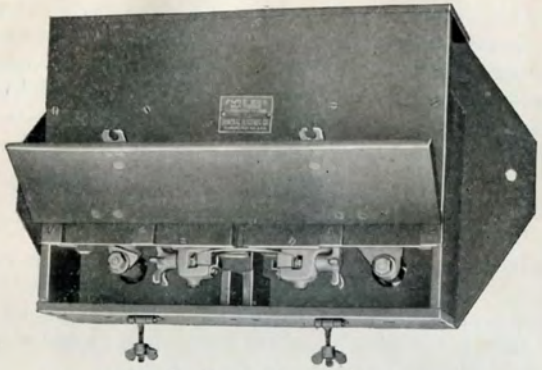


Fig. 29, Fuse Box, MA-35-A

THE MAIN SWITCH is a single pole, single throw, knife blade switch, enclosed in a box located under the car. It is a safety device to protect anyone when working around the car. It should always be opened before examining or working on the motor or control apparatus. The switch must be operated with the hook provided for this purpose. *Under no circumstances should the main switch be opened while the train is being operated.*

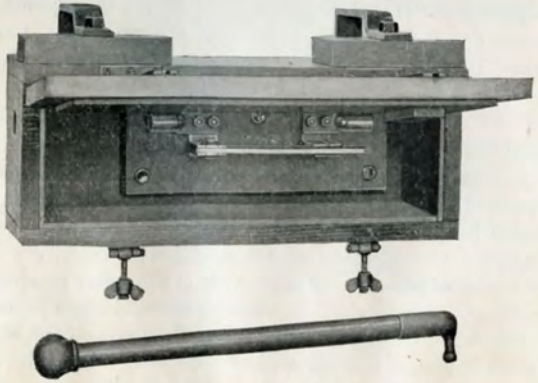


Fig. 30, Main Switch, MS-71-A

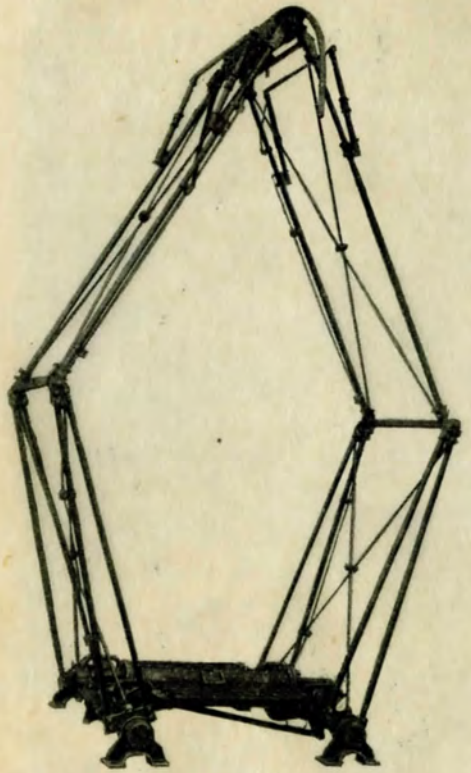


Fig. 28, Pantograph Trolley, US-122

Fig. 28, Pantograph Trolley, US-122

Fig. 30, Main Switch, MS-71-A

THE CIRCUIT BREAKER is similar in its construction to a contactor, but designed to carry and break the full current taken by the motors on the car. It is closed by means of an electro-magnet which is energized by momentarily closing a switch (MS-13-B), located in the Motorman's Cab. The circuit breaker is held in the closed position mechanically and opens automatically when excessive current flows through the motor circuits on that car.

The motorman can also trip the circuit breaker by operating the circuit breaker switch in the opposite direction to that of the setting position. Since the setting and tripping circuits of all circuit breakers in the train are connected through the train cable, they are closed and opened simultaneously by operating the circuit breaker switch. Any one circuit breaker in the train, however, may open automatically, independent of the others.

The circuit breakers are normally closed when the train is ready for operation.

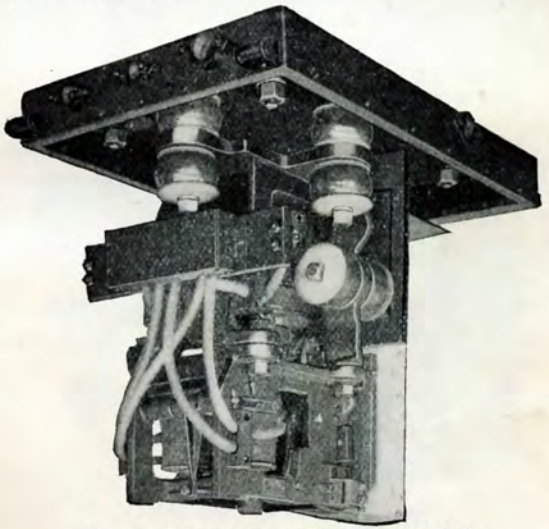


Fig. 31, Circuit Breaker, DB-111-A-1

THE CONTACTORS, 15 in number, are enclosed in a box known as the contactor box, located under the car. This box consists of an iron frame provided with sheet iron covers lined with insulating material and the covers can be readily removed for inspection of contactors. The contactors are supported in the box with insulated bolts, and the inside of the box is heavily lined with fireproof insulating material to prevent short circuits that otherwise might be caused by the arcing of the contactors when they open the motor circuit.

The contactor is an electrically operated switch. Its component parts are an iron magnet frame, and a solenoid coil within which operates a plunger connected to a hinged arm that, when the master controller is operated, engages with a contact fixed in the moulded arc chute.

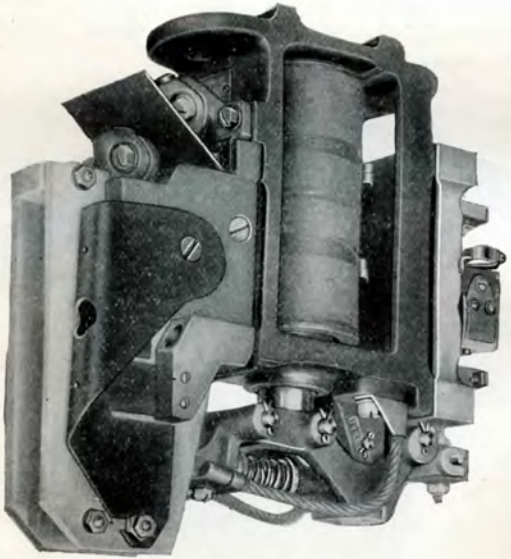
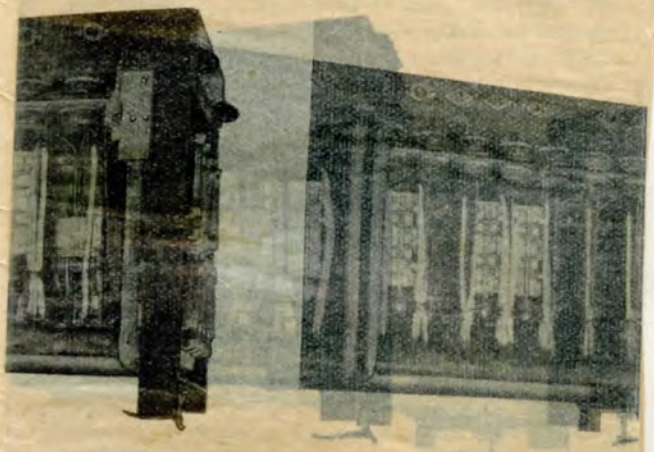


Fig. 32, Contactor, DB-260-D.



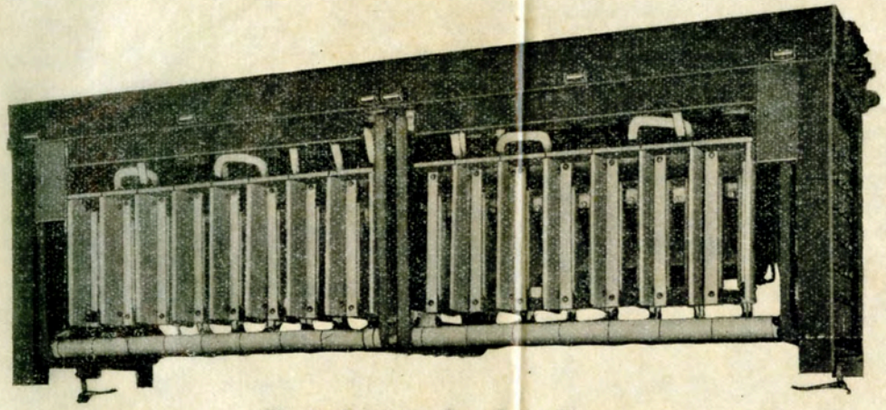


Fig. 33, Contactor Box, Front View

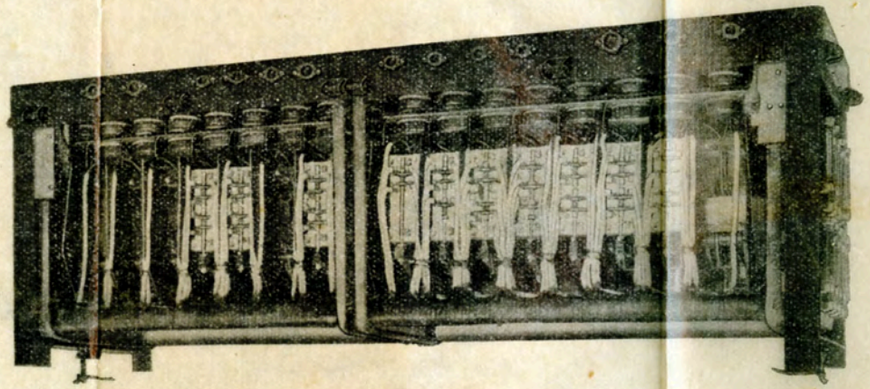


Fig. 34, Contactor Box, Rear View

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Fig. 33. Contactor Box, Fr

In the arc chute is a powerful magnetic blow-out, the coil of which is connected in series with the circuit controlled by the contactor.

The movable parts are provided with double springs which permit wiping and a rolling action at the moment of contact, to insure the proper pressure at the contacts regardless of wear. The movable portion of the contactor is operated by the electro-magnet which is energized through the master controller and train cable.

The contactor's function is to open and close the motor circuits. Their operations are controlled through the master control circuits, and the different combinations are made automatically or at the motorman's will. The circuits for operating the contactors are so interlocked that it is impossible to close them in other than their proper sequence.

THE COMMUTATING SWITCH is located under the car. It consists of two insulated cylinders, having mounted thereon a number of copper contacts. The main cylinder is arranged to commutate the motor resistance and control connections to permit full speed operation on 600 volts; while the other cylinder, provided with a motor cut-out switch, permits disconnecting one pair of motors in the case of an emergency, without interfering with the operation of the other pair. The main cylinder is arranged to be thrown both pneumatically and manually. The motor cutout cylinder is operated by hand only.

The motor cutout cylinder is provided with an auxiliary control cutout switch which opens the operating circuit of the series contactors in the motor control circuit, preventing improper combinations of the motor circuit when operating with a pair of motors cut out. Under normal operating conditions the handle of this switch should be in the central position.

The switch handle in the "No. 1 and 2 out" position indicates that No. 1 and 2 motors are cut out. The handle thrown to "No. 3 and 4 out" indicates that No. 3 and 4 motors are cut out. With the switch thrown

Fig. 35, Commutating Switch, DH-179-A

in either of the cut out positions, the pair of motors left in the circuit will not operate until the controller handle reaches the parallel position.

To operate a commutating switch on a single motor car, air is admitted direct to one of the cylinders through the *valve switch*. In trains of more than one car the commutating switches on the succeeding motor cars are operated electro-pneumatically as each succeeding car passes under the insulated section in the trolley wire. This is accomplished by means of a potential relay which is equipped with contacts that close the circuit for operating the electro-pneumatic valves when the collector is passing under the insulated section. The current for the operation of the electro-pneumatic valves is obtained through the electrical contacts of the valve switch upon the head motor car, thereby making it necessary to hold the valve switch in the closed

position while the entire train is passing under an insulated section.

THE REVERSER is enclosed in an iron box, located under the car, near the contactor box.

The movable part of the reverser is a cylinder, controlled by two electro-magnets, one for each direction of motion of the car. These magnets are operated by current through the master controller and the train cable, the connections being so interlocked that only one magnet can be energized at a time.

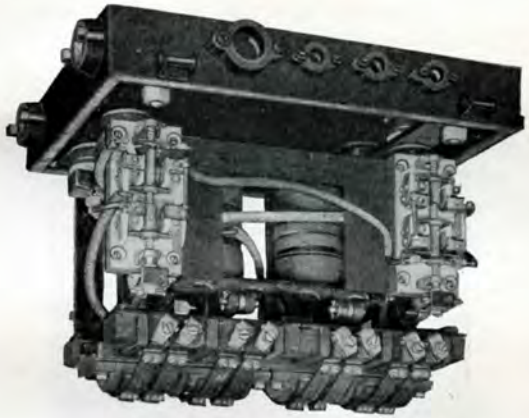


Fig. 36, Reverser, DB-415-A-4

The cables from the motor field coils are connected to the contact fingers on the reverser. The connections necessary to produce the forward and reverse movements of the car are established by means of contact pieces mounted on, but insulated from, the cylinder.

The control connections for the reverser are so arranged that unless the reverser is in the proper position, control current is cut off from the contactors; consequently, the motor circuit is not completed and the motors on that car receive no current.

When the reverser is in the correct position it is electrically locked, and cannot be operated while the motors are taking current; it is always closed, either in the forward or reverse position, depending upon whether the master controller handle has been moved to the left or to the right.

The function of the reverser is to change the direction of the current through the main motor fields. This in turn changes the polarity of the field and causes the motor to rotate in the opposite direction.

THE RHEOSTATS are located beneath the car, near the contactor box. They are made up of cast iron grids mounted between pressed steel end frames. The grids are provided with slotted lugs at both top and bottom, permitting them to be easily removed from the frame by loosening the supporting rods. Cables connect the various sections of the rheostat to different contactors.

Fig. 37, Rheostat, RG-Form A

The rheostats are used to regulate the current to the motors when starting, accelerating or moving at slow speeds. They are cut out entirely when the controller is placed in either the series or the parallel running positions.

MOTORS

Every suburban motor car is equipped with four 75 h. p., 600-1500 volt motors with a gear ratio of 3.35 to 1. Every interurban motor car is equipped with four 110 h. p., 600-1500 volt motors with a gear ratio of 2.7 to 1. When operating from 1500 volt trolley, two of these motors are connected in series and are treated as a single unit as far as their control is concerned. When operating from 600 volt trolley, provision is made through the commutating switch so that the four motors are connected in parallel in pairs, and each pair is also treated as a single unit as far as its control is concerned.

The suburban car motors are designed to handle successfully trains consisting of one motor car and one control car. The interurban car motors are designed to handle successfully trains consisting of two motor cars and one control car.

The gear ratio is proportioned so that the maximum speed of a single motor car on level tangent track, with 700 volts at the motor terminals, will be approximately 40 miles per hour for suburban cars and 50 miles per hour for interurban cars.

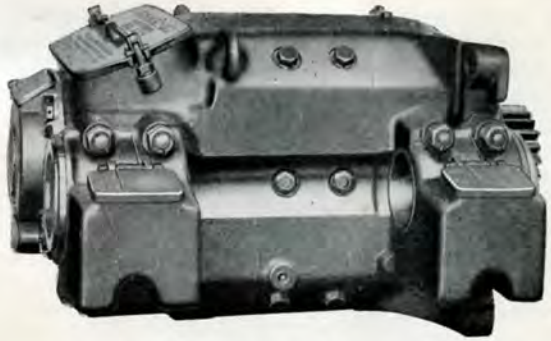


Fig. 38, GE-205 Motor

The six principal parts of the motor are the magnet frame, field coils, armature, commutator, brush holders and bearings.

THE MAGNET FRAME is made of soft steel cast in one piece. It encloses completely the armature, commutator, brush holders and field coils.

THE ARMATURE is made of soft steel punchings (known as the core), mounted directly on the shaft. Slots are provided in this core to receive the coils. The coils are made of copper wire and are insulated from the core and each other by sheet mica and a specially prepared tape. The terminals of each coil are brought out and soldered to the commutator segments. The armature coils are held in place in the slots by steel wire bands.

THE COMMUTATOR is made up of a number of copper segments, insulated from the armature shell by a mica cone, and are separated and insulated from each other by sheet mica. These segments are made of the highest grade of copper and are slotted at the back end to receive the armature coils.

THE BRUSH HOLDERS are made of cast brass designed to receive carbon brushes. The brushes slide in finished ways and are held in place against the commutator by independent pressure arms which are actuated by means of springs giving a uniform pressure on the brushes throughout their entire working range. The brush holder yoke is insulated from the motor frame by a combination pressed mica and porcelain insulator, and is designed to give a range of adjustment to allow for commutator wear.

THE FIELD COILS are made up of insulated strap copper wound on a form. These forms are fitted over the pole pieces and are spring supported and designed to be clamped securely by the pole pieces when the latter are bolted in place. The terminals of the coils are connected in series with the armature through the reverser.

BEARINGS.—All bearings are designed for oil and waste lubrication. The armature linings are bronze sleeves

finished all over and babbitt lined. Thickness of the babbitt metal is such that it will not permit the armature to rub on the pole pieces in the event that it is melted out by over-heating.

DESCRIPTION OF MASTER CONTROL APPARATUS

THE MASTER CONTROL CIRCUIT forms the path for current from the dynamotor through the master controller and train cable to the operating coils of the motor control apparatus.

The essential parts of the master control comprise the following apparatus:

Two (2) Master Controllers which operate the contactors and reverser of the motor control.

Two (2) Master Controller Switches to cut off the current from their respective master controllers.

One (1) Main Control Switch, through which the circuit is completed to the master controller switches.

One (1) 7-wire Train Cable which connects the master controllers to the motor control apparatus.

Two (2) 7-point Train Cable Connection Boxes, through which the master controllers, coupler sockets and the control cutout switches are connected.

Four (4) 7-point Train Cable Coupler Sockets to which train cable jumpers are connected.

One (1) Train Cable Jumper which connects the 7-wire train cable between cars.

One (1) Set of Resistance Tubes which limits the current in the master control circuits.

One (1) Current Limit Relay which limits the rate of acceleration on each car.

One (1) Potential Relay which opens the master control circuit when power is cut off from the car, and completes the circuit for operating the commutating switch.

One (1) Time Limit Potential Relay to open the control circuit of the motors upon approaching insulated sections in the trolley wire.

Two (2) Circuit Breaker Switches for setting and tripping circuit breakers.

One (1) Control Cutout Switch to disconnect the master control circuits from the train cable.

One (1) Main Control Fuse to protect the master control circuit against excessive current.

One (1) By-Pass Relay to shunt the current limit relays.

One (1) Protective Relay for protecting the control circuit against 1500 volt potential.

THE MASTER CONTROLLERS, two in number, are located in the motorman's cab, one at each end of the car, except on a passenger and baggage car which is equipped for single end operation only. The function of the master controller is to regulate at the will of the motorman, the supply of current to the train cable for operating the reverser and contactors.

The master controller contains a single movable contact cylinder and stationary fingers mounted on an insulated support. The controller has a single handle for both forward and reverse direction of train movement. To reverse it is necessary to throw a small lever which is mounted upon the cap plate of the master controller. Four points are indicated on the cap plate for forward direction and two for reverse. The second point in either direction is called "series". In the forward direction the fourth point is called "parallel". There are but two running points for the controller handle, viz.: the "series" and the "parallel". The other points are resistance points and not running points. Care should be exercised in the manipulation of the controller handle on these points, whereon it should not be held for longer periods than necessary.

THE MASTER CONTROLLER SWITCHES, two in number, are located one above each master controller. The master controller switch is a single pole pivoted switch provided with a magnetic blowout. Its function is

Fig. 39, Controller, C-35-D.

Fig. 40, Master Controller Switch, MS-5-B

to cut off current from the master controller when not in use. It also serves as a means of opening the master control circuit in the event of failure of the master controller.

The Main Control Switch is a single pole, knife blade, quick break switch, located on the switchboard. Its function is to cut off current from the master controller switches, circuit breaker set and trip switches and trolley operating valve switches. This switch is closed only on the car from which the train is being operated.

The Train Cable is composed of seven insulated conductors, all covered, for identification purposes, with different colored braids. Its function is to connect any master controller to the motor control apparatus. It passes through two connection boxes and terminates at the coupler sockets at each end of the car. The seven wires are used as follows:

No. 1. (Red)—Accelerating or pick-up.
No. 2. (White)—Series connection of motors.
No. 3. (Green)—Parallel connection of motors.
No. 4. (Green and White)—Operating reverser in one direction.
No. 5. (Blue)—Operating reverser in other direction.
No. 6. (Red and Black)—Tripping the circuit breaker.
No. 7. (Black)—Setting the circuit breaker.

The Train Cable Connection Boxes, two in number, located beneath the car, are used to connect the master controllers, coupler sockets, control cutout switch, circuit breaker and reversers to the train cable. The terminals attached to the ends of the entering conductors are attached to the screw studs that are held on an insulating board in the connection box.

Conductors provided with the same colored covering are connected together, except at No. 2 connection box on each car, where Nos. 4 and 5 wires (which operate the reverser) are crossed in order to cause the direction of the car movement to agree with the position of the controller handle on both controllers.

The Train Cable Coupler Sockets (7-point), four per car, are attached to the under side of the car platforms. A socket consists of a malleable iron box containing a body of moulded insulation into which are set seven split bronze plugs, every one attached to a conductor of the train cable. Every socket is provided with a hinged cover designed to hold the jumper plug in place, and to prevent the entrance of dirt and moisture when no jumper is inserted.

The Train Cable Jumper (7-wire), used to connect the train cables on adjacent cars, consists of a short length of 7-conductor cable with a coupler plug attached to each end. The plug contains seven insulated contacts, connecting the individual wires.

The Current Limit Relay (DB-579-A-3), located on the switch-board of motor cars, is provided for the purpose of producing an automatic operation of the master

control circuit. This relay has a series coil which is connected in circuit with one of the motors and two shunt lifting coils, with plungers and contacts which are alternately connected in series with the control circuit. When the master control circuit alternately lifts the plungers of this relay, for each step of the acceleration it opens the No. 1 wire and interrupts the contactor pick-up circuit until the current flowing through the motor circuit coil falls below a predetermined amount, and permits the plunger by dropping to complete the pick-up circuit for the next step.

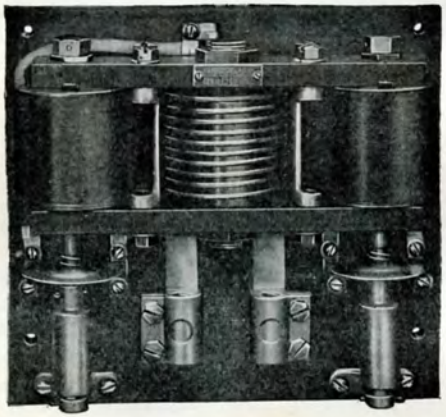
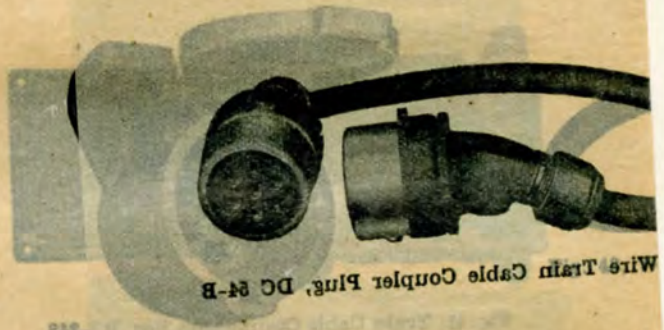


Fig. 44, Current Limit Relay, DB-579-A-3

THE POTENTIAL RELAY is located under the motor car. This relay consists of one coil and has potential flowing through it at all times when the collector is on the trolley wire and the main switch is closed. This coil is connected through a fuse (Fig. 45-A), located below the main switch box, between a point in the motor circuit (ahead of the first motor) and the ground. If for any



Wire Train Cable Coupler Plug, DC 84-B

Fig. 42, Coupler Socket, DA-78-C

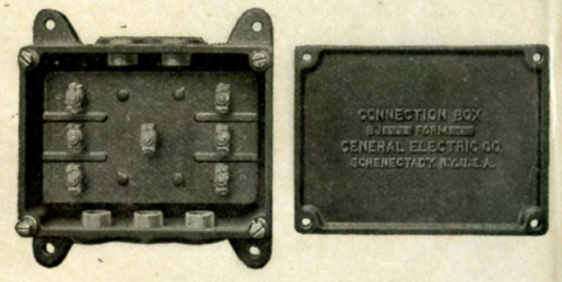


Fig. 41, Train Cable Connection Box, BJ-348

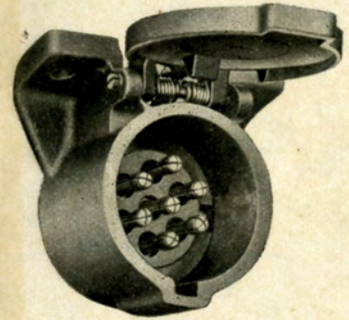


Fig. 42, Coupler Socket, DA-78-C

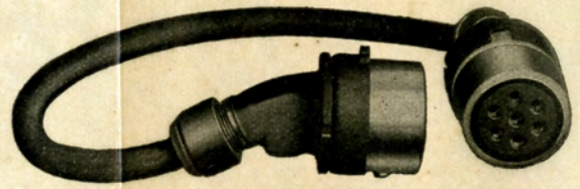


Fig. 43, 7-Wire Train Cable Coupler Plug, DC 54-B

reason the main current supply to any motor car is interrupted, this relay will open the master control circuit on that car.

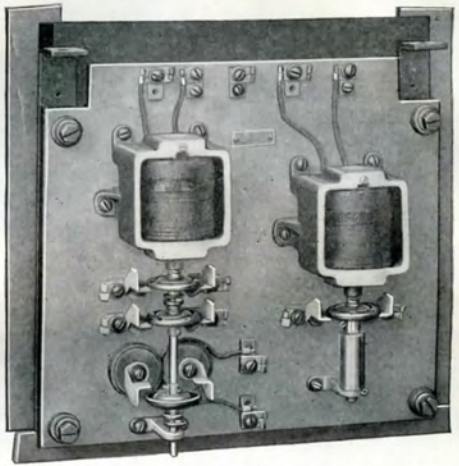


Fig. 45, Potential Relay, DB-617-A-1

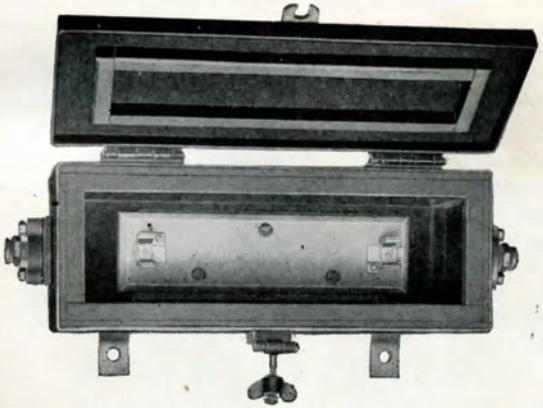


Fig. 45-A, Fuse Box, MA-33-A

When current is again restored, the relay will close and complete the master control circuit. The contactors on the car affected will then pick up in their proper sequence as if the motorman had thrown the controller handle to the "Off" position and immediately returned it to its original position.

This relay is mounted, together with the Time Limit Potential Relay, in a separate box near the contactor box, and obtains its current supply through a fuse installed in the MA-33 fuse box located on the roof of the car at the pantograph end.

The Time Limit Potential Relay, located in the same box with the potential relay, is inserted in the master control circuit so that upon approaching insulated sections in the trolley wire, the operating circuits of the individual motor car will be opened irrespective of any movement of the master controller handle. This is accomplished by a brush contact at either end of an insulated section, which energizes a contact on the collector, that is connected to the time limit potential relay.

The time adjustment feature of this relay is such that the control circuit when opened will not close until the collector has left the energized trolley wire, thus preventing arcing and burning of the collector and trolley wire when passing under insulated sections. This relay circuit is protected by a 5 amp., 1500 volt fuse located in the power fuse box upon the roof.

Circuit Breaker Setting and Tripping Switch, one located in each motorman's cab, is provided with a single handle having springs to return it to the neutral position. Moving the handle to the "set" position energizes the circuit breaker setting coils throughout the train. Moving the handle to the "trip" position energizes the circuit breaker tripping coils throughout the train.

The switch is within reach of the motorman and can be used in emergency to cut off the power from the entire train.

Fig. 46, Circuit Breaker Set and Trip Switch, MS-13-B

The Control Cutout Switch, mounted on the switchboard of motor car, consists of a set of copper contacts mounted on an insulated drum, and two sets of fingers fastened to the switchboard. It is provided for disconnecting the train cable from the master control circuit to the contactors, reverser and circuit breaker.

Control Fuses are inserted in the control circuits between the cutout switch and the operating coils of contactors, reverser and circuit breaker. These fuses are located near the control cutout switch on the switchboard. Their function is to protect the individual circuits in which they are inserted.

The By-pass Relay is mounted on the switchboard of the motor car. Its function is to shunt the current limit relays and thereby permit hand control operation on grades or at times when the train acceleration is unusually slow.

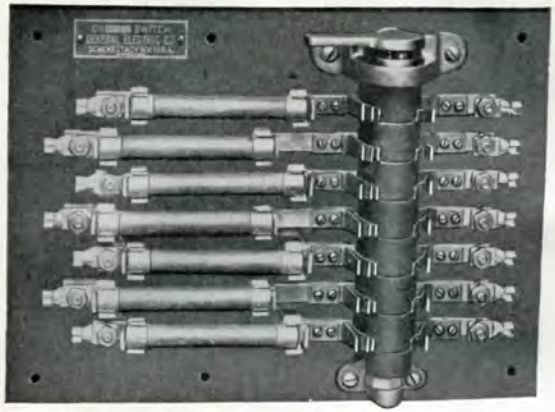


Fig. 47, Control Cutout Switch, DH-15-C

When the master controller handle is turned to the "on" position the operating coil of this relay is connected to the circuit breaker setting wire by an interlock on Contactor No. 2 and can be energized by operating the circuit breaker switch, thus closing the master control pick-up circuit through the relay contacts.

The acceleration of a car or train is accomplished by momentarily closing the circuit breaker switch in the "set" position and immediately returning it to the neutral position. These operations should be repeated at intervals of sufficient duration of time to give a smooth acceleration. *The foregoing method of operation is prohibited, except at times of unusually slow train acceleration, that otherwise would result in overheated motor rheostats.*

PROTECTIVE RELAY.—Each motor car is equipped with one protective relay located under the car. This relay is provided to prevent high voltages being impressed upon the control or auxiliary circuits if the com-

Fig. 48, By-Pass Relay, DB-113-E-1

mutating switch upon that particular car is thrown for 600 volts while the collector is in contact with the 1500 volt trolley wire. To accomplish this the relay consists of two coils, one coil wound to operate at 250 volts while the other one is wound to operate at 800 volts. When operating on a 600 volt circuit the 250 volt coil operates a relay which closes a small contactor for operating the dynamotor-compressor; also closes a contact for closing the control circuit for operating the contactors.

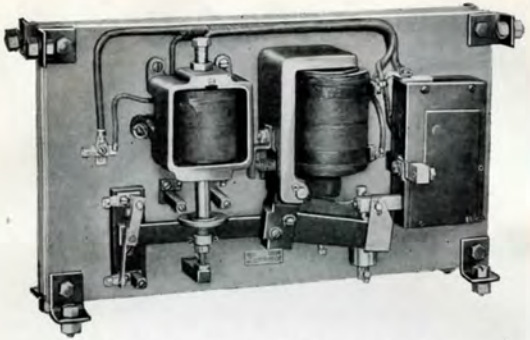


Fig. 49, Protective Relay, DB-603-A-1

When operating on 1500 volts, and in case the commutating switch has not been thrown to the corresponding voltage, the coil wound for 800 volts will be energized, closing the relay contacts, shunting the circuit around the 250 volt coil, which will prevent this relay from closing, thereby opening the control and auxiliary circuits.

THE SWITCHBOARD is located in a compartment at one end of the car, and has mounted thereon the following apparatus:

MOTOR CAR:

Upper Section:

1 Main Control Switch No. 5.
1 Main Control Fuse (MC).
1 Dynamotor Bus-Line Tie Switch No. 6.
1 Dynamotor Bus-Line Transfer Switch No. 7.
1 Dynamotor Bus-Line Switch No. 8.
1 Dynamotor Bus-Line Fuse (B).
3 Lighting Switches Nos. 1, 3, 4.
9 Lighting Fuses.
1 Cab Heater Switch No. 2.
1 Cab Heater Fuse (MH).
1 1500 Volt Switch Compartment, containing 1 Dynamotor Compressor Switch No. 9 and Fuse (DC), 1 Car Heater Switch No. 10 and Fuse (CH).

itchboard, Control Car

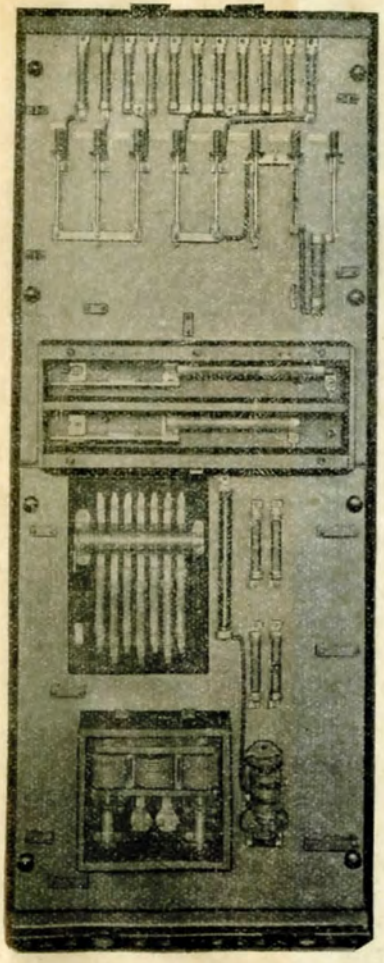


Fig. 50, Switchboard, Motor Car

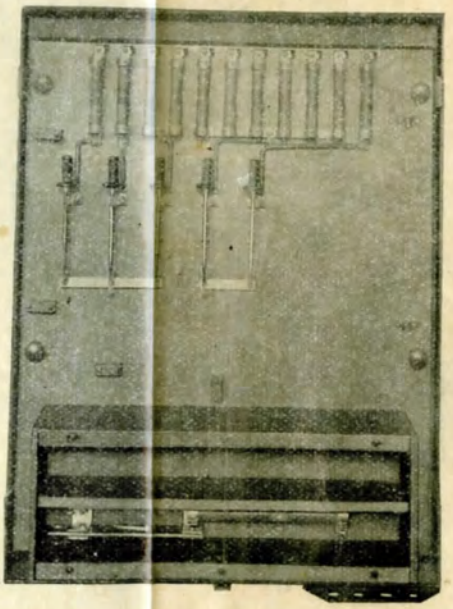


Fig. 51, Switchboard, Control Car

Fig. 60, Switchboard, Motor Car

Lower Section:

1 Current Limit Relay (DB-579-A-3).
1 By-pass Relay (DB-113-E-1).
1 By-pass Relay Resistance Tube (RR).
1 Control Cutout Switch (DH-15-C).
2 Trolley Operating Fuses (23 and 24).
7 Control Fuses (1, 2, 3, 4, 5, 6, 7).
2 Commutating Switch Operating Fuses (25 and 28)

CONTROL CAR:

1 Main Control Switch No. 5.
1 Main Control Fuse (MC).
3 Lighting Switches Nos. 1, 3, 4.
9 Lighting Fuses.
1 Cab Heater Switch No. 2.
1 Cab Heater Fuse (MH).
1 1500 Volt Switch Compartment containing 1 Car Heating Switch No. 10 and fuse (CH).

DESCRIPTION OF AUXILIARY CONTROL APPARATUS

THE AUXILIARY CONTROL APPARATUS comprises the following:

One (1) 10-wire Auxiliary Train Cable.

Four (4) 10-point Auxiliary Train Cable Coupler Sockets.

One (1) 10-point Auxiliary Train Cable Jumper which connects the auxiliary train cable between adjacent cars.

Two (2) 10-point Auxiliary Train Cable connection boxes through which the auxiliary apparatus is connected to the train cable.

Two (2) Collector Operating Switches to operate one or more collectors.

Two (2) Electro-pneumatic Valves to operate the collectors independently or collectively.

Two (2) Valve Switches to operate the commutating switch.

Two (2) Electro-pneumatic Valves to operate the commutating switch.

THE TEN WIRE TRAIN CABLE is composed of ten wires which are used to connect the auxiliary control apparatus.

The wires are used for the following purposes:

No. 21. (Red)—Signal Circuit.

No. 22. (Green and White)—Compressor Synchronizing.

No. 23. (Red and White)—Pantograph Trolley Control (raise).

No. 24. (Green)—Pantograph Trolley Control (lower).

No. 25. (Black and White)—Commutating Switch Control (1500 volt position).

No. 26 and 29. (Red and Green, and Black, respectively)—For Dynamotor Bus-line No. 1.

No. 27 and 30. (Blue, and Red and Blue, respectively)—For Dynamotor Bus-line No. 2.

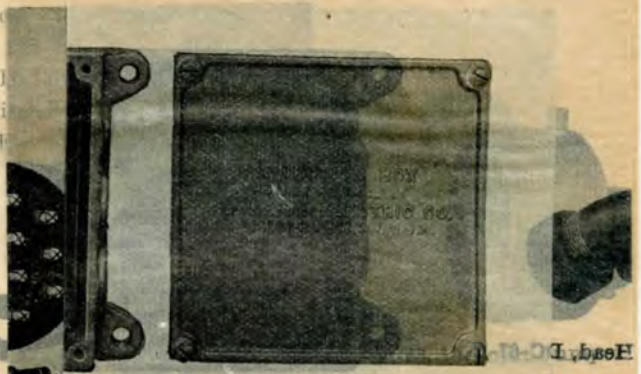
No. 28. (White)—Commutating Switch Control (600 volt position).

THE TEN-POINT TRAIN CABLE COUPLER SOCKETS, four per car, are attached to the under side of the car platforms. These coupler sockets are similar to those described under Master Control Apparatus, except that they contain ten split bronze plugs instead of seven.

THE TEN-POINT TRAIN CABLE JUMPER, one per car, is used to connect the train cables between adjacent cars. This cable consists of a short lenth of 10-conductor cable, terminating in coupler plugs, attached to each end. The plugs contain ten insulated contacts connected to the conductors.

THE TEN-POINT TRAIN CABLE CONNECTION BOXES, two in number, located under the car, are used to connect the train cable to the coupler sockets and auxiliary control apparatus.

COLLECTOR OPERATING SWITCH, one located in each motorman's cab, is provided for electro-pneumatic operation of all collectors in a train. This switch is similar in construction and operation to the circuit breaker setting and tripping switch, (Fig. 46), and receives its energy through the master control switch. When the handle is moved to the right it energizes, through wire No. 24, the magnet coil of the electro-



Cable Connection Box, BJ-335-A

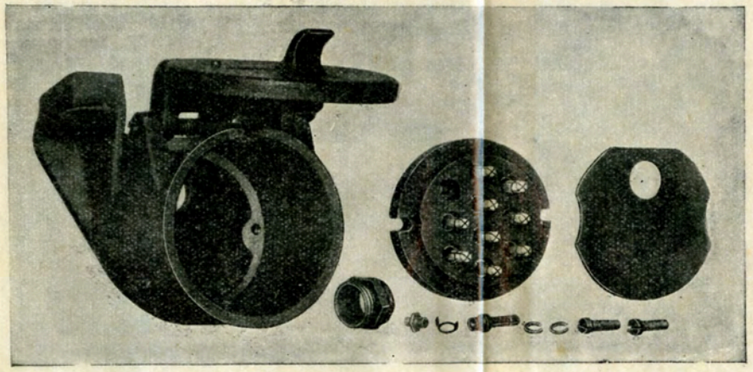


Fig. 52, 10-Point Coupler Socket, DA-45-B

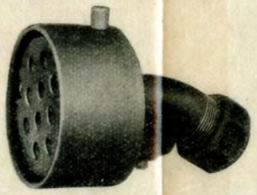


Fig. 53, 10-Point Jumper Head, DC-67-C

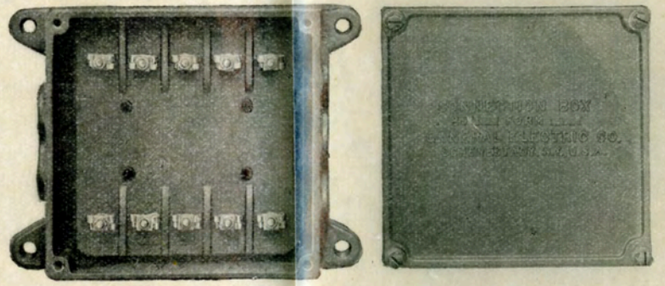


Fig. 54, 10-Point Train Cable Connection Box, BJ-335-A

Fig. 52, 10-Point Coupler Socket

neumatic valve which controls the downward movement of the collector. When moved to the left it energizes, through wire No. 23, the magnet coil of the electro-pneumatic valve which controls the upward movement of the collector.

To Raise All Collectors in the Train.—First, raise the one on the operating motor car by operating the handle of the electro-pneumatic valve. The other collectors throughout the train can then be raised electrically by moving the collector operating switch handle to the left.

To Lower All Collectors in the Train.—Move the switch handle to the right.

Electro-Pneumatic Valves, two in number, located in the motorman's cab at one end of the motor car, are provided for operating the collectors. The valve consists of a solenoid, coil and plunger with an air valve attachment. The solenoid coils are connected to wires 23 and 24 in the 10-point train cable, to provide for the control of the collectors throughout the train and receive their energy through the collector operating switch. These valves, when operated by hand, control the collector on an individual car only. When operated by the collector operating switch, they control the positions of all collectors throughout the train.

Fig. 55, Electro-Pneumatic Valve, Type TE-Form B

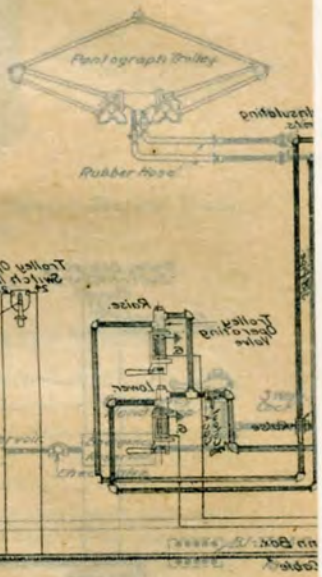
The Valve Switch, one located in each motorman's cab (motor cars only), is provided for operating the commutating switch. It is a combination electrical

switch and air valve that is designed for hand operation, and has a detachable handle which is part of the motorman's equipment. Moving the handle to the left gives the 1500 volt position, and moving it to the right gives the 600 volt position of the commutating switch. Air is then admitted to one of the cylinders on the commutating switch, throwing it to a corresponding position. The valve switch should be operated when the collector is passing under insulated sections between 600 and 1500 volt trolley lines, and should be held in position for operating the commutating switch until all succeeding motor cars have passed under the insulated section.

Fig. 56, Valve Switch, MS-91-A

In cases where motormen are operating from a control car, and it is necessary to operate the commutating switch, the conductor, upon the prescribed signal (one long and one short blast of the whistle, thus ——— —), will operate the valve switch in accordance with the foregoing instructions.

THE COMMUTATING SWITCH ELECTRO-MAGNET VALVES, two in number, located under the motor car, are provided for operating the commutating switches throughout the train. These magnet valves are similar to the electro-pneumatic valves provided for the control of the collectors. They receive their current supply through the valve switch located in the motorman's cab.



ig. 56-A, Diagram of Connections, Collector Operating Va

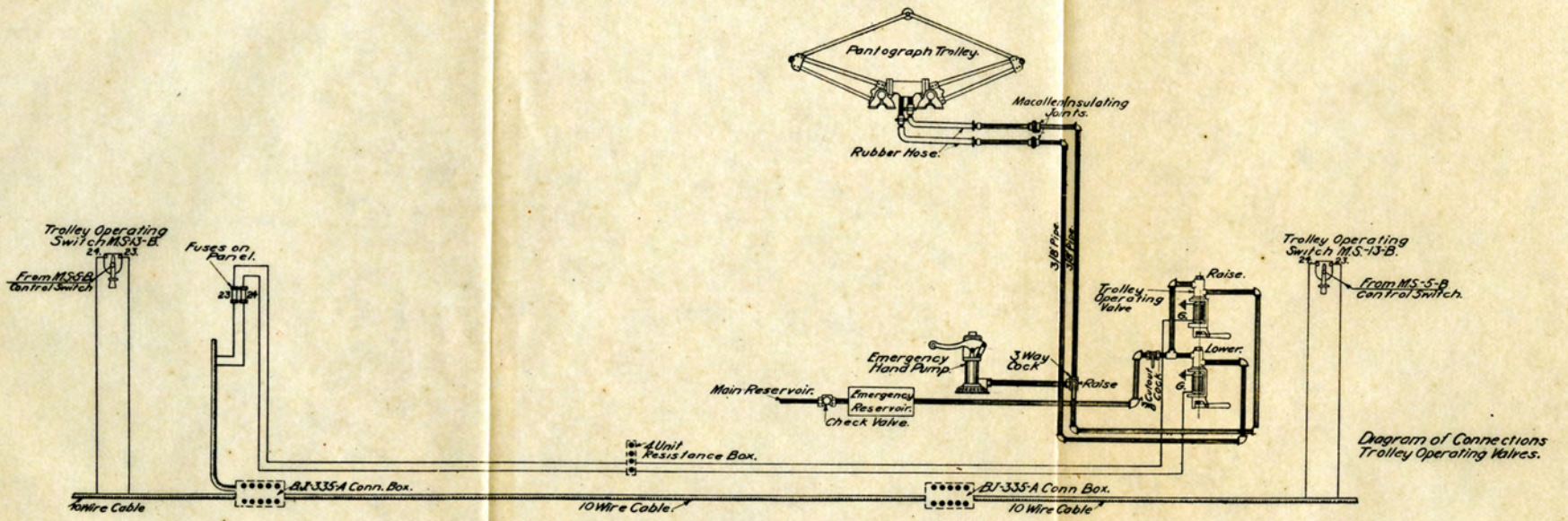


Fig. 55-A, Diagram of Connections, Collector Operating Valves.

Fig. 57, Commutating Switch Electro-Magnet Valve, TE-12-A-11.

PRINCIPLE OF AUTOMATIC CONTROL

When the controller handle is placed on the first point, current passes from the master controller switch through the master controller to the train cable and connection boxes on the various cars, thence through the 7-point cutout switches and control fuses (located in the car panels), to the contactors and the reversers upon each motor car. After the reversers have been thrown to their correct position, interlocking contacts on them establish a circuit through the operating coils on the contactors which close and complete the motor circuit from the collector to ground through the main fuse, main switch, circuit breaker, contactors Nos. 2 and 1, commutating switch, armature No. 1, reverser, field No. 1, reverser, commutating switch, armature No. 2, reverser, field No. 2, reverser, commutating switch, rheostats, contactors Nos. 14 and 7, rheostats, contactor No. 5, commutating switch, armature No. 3, reverser, field No. 3, reverser, commutating switch, armature No. 4, reverser, field No. 4, reverser, commutating

switch, current limit relay, commutating switch, ground. The motors are now connected in series with all resistance in the circuit.

When the handle is placed in the second or series position, the No. 1 wire (series accelerating), is energized, and through the current limit relay the contactors are closed in sequence to cut out the resistance in five steps.

When the handle is placed in the parallel running position, the series parallel connection of the motors is established and wire No. 3 (parallel accelerating), is energized. Contactors Nos. 3, 14 and 7 are now open, and No. 15 closes, completing ground for No. 1 and No. 2 motors; contactors Nos. 8 and 9 also close and complete connection from trolley for Nos. 3 and 4 motors, and through the action of the current limit relay, the contactors are closed in sequence, to cut out the resistance in four steps. The motor current is now taking two similar or parallel paths.

To Reverse the Direction of Car Movement, the auxiliary lock on the master controller must be turned. The master controller handle must then be turned to the right. The first point is similar to the first point in the forward direction. When the handle is placed in the second or series position the contactors are closed in sequence and the resistance in series with the motors is cut out. No provision is made for parallel operation in the reverse direction. *The controller should never be thrown to reverse position beyond the first point when train is moving in a forward direction.*

The automatic operation of the contactors is accomplished through interlocking switches operated mechanically in connection with the contactors. Every resistance contactor, in closing, prepares the control circuit for the next step, and also transfers its operating coil from the accelerating or pick-up wire to the No. 2 series wire. Simultaneously, wire No. 1 (accelerating wire), operates the current limit relay, which opens the accelerating circuit and thereby prevents the immediate closing of the contactor for the following step. When

the current in the motor circuit coil of the relay falls to a predetermined minimum, the plunger drops and reestablishes the circuit through wire No. 1, which closes another resistance contactor. This sequence of operation is repeated until the resistance in series with the motors is entirely cut out.

When it is desired to operate the train at slow speed the master controller handle should be moved to the first point only. If it is necessary to increase the speed slightly, the controller handle should be moved to the second point, where the automatic consecutive closing of the resistance contactors will commence, an action that may be arrested at any point, by returning the controller handle immediately to the "first" position. *Unnecessary operation of the controller in the foregoing manner is prohibited.* Under normal conditions the handle shall be placed in the second or fourth position.

When the handle is returned to the "off" position, the current supply is cut off from the train cable; the contactors then open the motor circuits. If the motorman releases the handle, a spring will return it to the "off" position, automatically cut off the power, and will cause emergency application of the brakes to the entire train.

The controller is equipped with an auxiliary lock to prevent operating the controller from forward to reverse position, and in order to go from the forward to reverse position it is necessary for the motorman to place the auxiliary lock in the desired position.

DYNAMOTOR AIR COMPRESSOR

The dynamotor air-compressor, located underneath the motor car, is a combination machine wherein two functions have been combined in a single unit. The same machine which serves as a dynamotor for delivering 600 volts for the master control and lighting circuits, also is used to operate the air compressor, the latter being connected to the continuously running dynamotor

by means of a multiple disc clutch. This clutch is normally held by a suitable spring in a closed position so that the compressor is connected to the dynamotor. Whenever the air in the main reservoir reaches a predetermined pressure the operation of the air compressor governor admits air to a small cylinder, which disconnects the clutch and causes the compressor to stop, but allows the dynamotor to continue running.

The dynamotor consists of a series and a shunt field and armature with two armature windings and commutators. The two armature windings are in series across the 1500 volt circuit, and the connections are so arranged that if desired one-half of the windings may be disconnected and the machine allowed to run on one winding as a compressor motor only. This change automatically takes place when passing over an insulated section from 1500 volt to 600 volt potential.

When operating on a trolley of 600 volts potential, direct connections through the commutating switch to the trolley voltage are made for supplying the lighting and control circuits. When operating on 1500 volts potential the lighting and control circuits are tapped from the center of the field winding, as shown on Fig. 58.

When the machine is operated as a dynamotor-compressor, current flows through the series turns, strengthening the field and enabling the machine to start without taking much current. When current flows to the load circuit, part of it is drawn from the line through the first armature winding and one-half of the series field turns, and part is drawn from the second armature winding which is acting as a generator, consequently its course is through the second half of the series field turns in the opposite direction to that of the current in the first half.

Current from the dynamotor is distributed throughout the train by means of bus lines which are contained in the 10-point control cable. The bus lines are protected by bus fuse "B" located on the upper section of the switchboard.

Fig. 57-A, Power Fuse Box, MA-32-A.

The dynamotor circuit is controlled by switch No. 9, located in the 1500 volt compartment on the switchboard.

INSTRUCTIONS FOR OPERATING DYNAMOTORS

Under normal train operation, trains consisting of two or more motor cars, the dynamotor on the leading motor car *must be connected to dynamotor bus No. 2*, and when switches Nos. 7, 8 and 9 are in the position as shown on Diagram 1, Figure No. 58, the current for the service lights and control circuit for the entire train will be supplied by this dynamotor. The dynamotor on the motor car on the other end of the train will be connected to bus No. 1, (see Diagram No. 4, Figure No. 58), and when switches Nos. 7, 8 and 9 are in the position as shown on the diagram, the current for the car cleaning

lights, headlight, and cab heaters will be supplied for the entire train by this dynamotor. The relative positions of the switches on any additional motor cars in a train must be as shown on Diagram No. 3, Figure No. 58.

The arrangement of the switches on the switchboards is identical on all types of motor cars. Bus line transfer switch No. 7 is provided for connecting the dynamotor on that car to either bus line. To insure that the bus line transfer switches are placed in their proper positions, the train direction will always be taken into consideration before closing these switches. Transfer Switch (No. 7), on the leading motor car shall be placed in its upper position (See Diagram No. 1, Figure No. 58), and in its lower position on all other motor cars (see Diagram No. 4, Figure No. 58).

More than one dynamotor shall not be connected to the same bus line at the same time. To determine whether a dynamotor is already connected to a given bus line, close either switch No. 3 or 4, and note if lights burn. In cases where trains are made up of three motor cars and one control car, the dynamotor of the intermediate motor car will be considered spare, and switches Nos. 6, 7, 8 shall be as shown in Diagram No. 3, Figure No. 58. When operating a single car train Switch No. 6 must be closed.

Positions of Switches on the Switchboard of Leading Motor Car Under Normal Operation—

No. 10—Closed when heat is required.
No. 9—Closed.
No. 8—Closed.
No. 7—Closed, Upper Position.
No. 6—Open.
No. 5—Closed.
Nos. 1, 3, 4—Closed when lights are required.
No. 2—Closed when cab heater is required.

Positions of Switches on the Switchboard of Rear Motor Car Under Normal Operation—

No. 10—Closed when heat is required.
No. 9—Closed.

No. 8—Closed.
No. 7—Closed, Lower Position.
No. 6—Open.
No. 5—Closed.
Nos. 1, 3, 4—Closed when lights are required.
No. 2—Closed when cab heater is required.

Positions of Switches on Switchboard of Intermediate Motor Cars Under Normal Operation—

No. 10—Closed when heat is required.
No. 9—Closed.
No. 8—Open.
No. 7—Either position.
No. 6—Open.
No. 5—Open.
Nos. 1, 3, 4—Closed when lights are required.
No. 2—Open.

Switch No. 6 is provided to connect the dynamotor bus lines Nos. 1 and 2. This is an operation which becomes necessary when all lights are required in single car operation or when the train make-up includes two motor cars with the dynamotor on one of them disabled. Before closing Switch No. 6 the motorman shall determine that Switch No. 8 is open on the other motor car in the train.

Motormen will be held responsible for the manipulation of the dynamotor circuit switches, and their final duty upon laying up the train will be to open switches Nos. 5, 6, 8, 9, and 10.

The dynamotor air compressor switch and car heating switch (Nos. 9 and 10) are enclosed in a special compartment on the switchboard. Since these switches have at all times a potential of 1500 volts they *shall be operated always with the hook which is provided for this purpose.* All other switches on the switchboard have a potential of 600 volts and shall be operated by hand. *Hook operation of 600 volt switches is prohibited.*

Before any of the collectors are raised it is the motorman's duty to ascertain that all switches throughout the train are in their proper positions.

DYNAMOTOR AIR COMPRESSOR TROUBLES

Dynamotor air compressor troubles are usually manifested by failure of the lights. The two principal causes of failure in the dynamotor circuits are defective dynamotor-compressor fuses or power fuses. If either fuse is defective the dynamotor-compressor will not operate.

The dynamotor fuse (DC) located in the 1500 volt compartment on the switchboard of motor cars shall not be renewed until after the dynamotor-compressor switch (No. 9) has been opened.

The Power Fuse ("P") is located on the roof; its renewal, therefore, consumes considerable time; hence, whenever possible, the train shall be run to the terminal where the fuse will be replaced by an inspector. When a power fuse fails, therefore, it is advisable to disconnect the disabled machine from the bus line and connect a spare dynamotor thereto. When it is necessary for the motorman to renew a power fuse, in order to operate the train, before going upon the roof he shall lower all collectors in the train and assure himself that they are locked. When on the roof he must take every precaution not to make contact with the overhead wires, because such contact is liable to result fatally.

It will be noted on the dynamotor-compressor diagram that the dynamotor circuit is not connected directly to buses Nos. 1 or 2, but through Switch No. 8 and bus fuse "B" to Switch No. 7. The service lights throughout the train receive power from bus line No. 2; all other light circuits are connected to bus line No. 1. A defective bus fuse, therefore, has the same effect on the light circuits as a defective power fuse or dynamotor-compressor fuse, but can be distinguished therefrom by opening the dynamotor switch (No. 9); if an arc occurs at the switch point when opened, a defective bus fuse is indicated. The bus fuse shall not be renewed until after Switch No. 8 has been opened.

LIGHTING SYSTEM

The car is lighted by series Railway Incandescent Lamps, five connected in series in all circuits and protected by individual fuses (3 amp. capacity), located on the switchboard.

The lamps receive their current supply from the dynamotor bus lines and are controlled by two single pole knife blade switches (No. 3 and No. 4), located on the switchboard. Switch No. 3 controls car cleaning circuits; switch No. 4 the service and step-light circuits.

The dome and marker lamps are controlled by two-way snap switches located in the vestibule at either end of the car. The wiring for this circuit is arranged so that when the dome lights are cut out, the marker light circuit is energized and the markers lighted.

The headlight is of the luminous arc semaphore lense type and is connected in series with the combined steadying and dimming resistance on an individual circuit supplied with current from switch No. 1, located on the switchboard. A 600 volt double pole, double throw switch, enclosed in an iron box and located in the motorman's cab, is provided for the motorman's convenience in controlling the light. With the handle in the upper position the headlight will burn at full brilliancy; with the handle in the lower position, the lamp is dimmed to a low brilliancy; with the handle in the neutral position the circuit is disconnected from the lamp. The headlight circuit is protected by fuse HL, (10 amp. capacity), which is also located on the switchboard.

Trainmen and motormen are responsible equally for the manipulation of the lighting switches. It is the trainmen's duty to open the service light switch, (No. 4), on all cars when not in revenue service, to see that the cars are properly lighted and to report any defects to the motorman. *The unnecessary use of the lights is prohibited.*

INSPECTION AND CARE OF LUMINOUS ARC HEADLIGHT

TRIMMING: To trim the lamp, insert the electrode in the lower holder and clamp it in position with its upper end projecting $1\frac{1}{2}''$ to $2''$ above the holder. A readjustment of the lower electrode should be necessary once only during its life, and the life of this electrode should be from fifty to seventy-five hours' continuous service. The lower electrode should be centrally located with relation to the upper electrode and should be maintained in this alignment. The life of the upper electrode should be from 2000 to 3000 hours' continuous service. Should the upper electrode become burned off on one side, it must be filed off squarely and lowered to the proper position by means of the adjustment holes in the chimney.

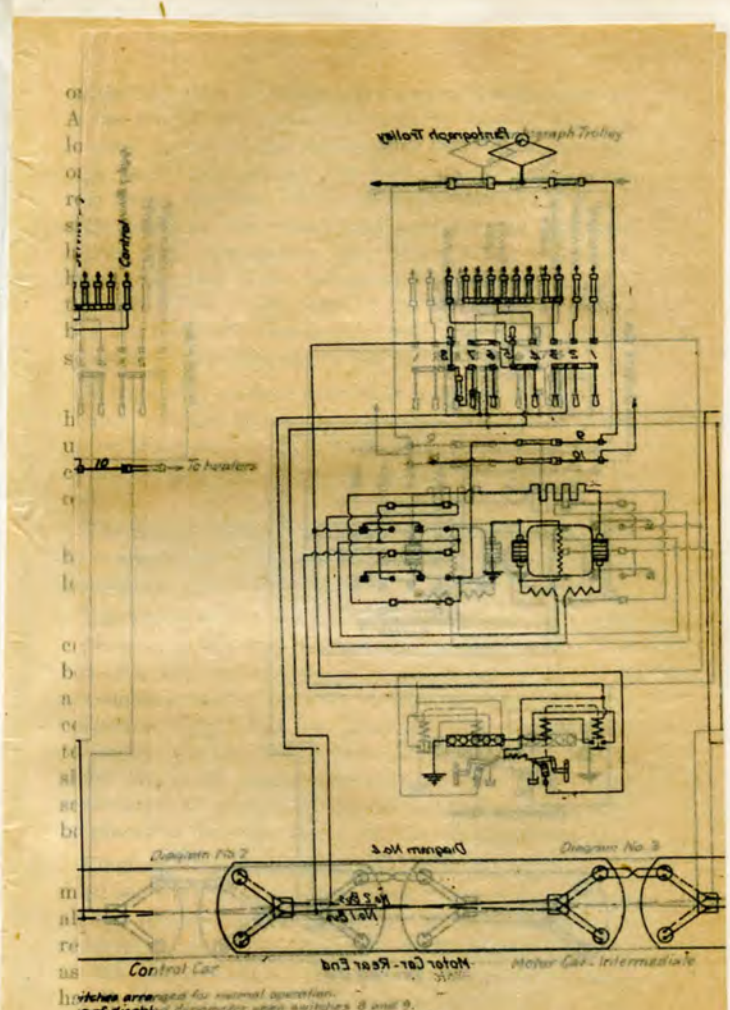
ADJUSTMENT: The headlights shall be adjusted when leaving the shop. When the lamp is hung on the car the proper adjustment for the beam can be maintained by manipulating the two thumb screws and buffers placed through the legs at the bottom of the casting.

CLEANING: The lamp should be cleaned not less than once a day, the draft chimney cleaned with a brush which is provided for that purpose. Care should be exercised to remove all fume deposits on both the inside and the outside of the glass door. After cleaning the glass it should be polished with tissue paper or old newspaper. The reflector should be wiped with a soft material, cheese cloth preferably.

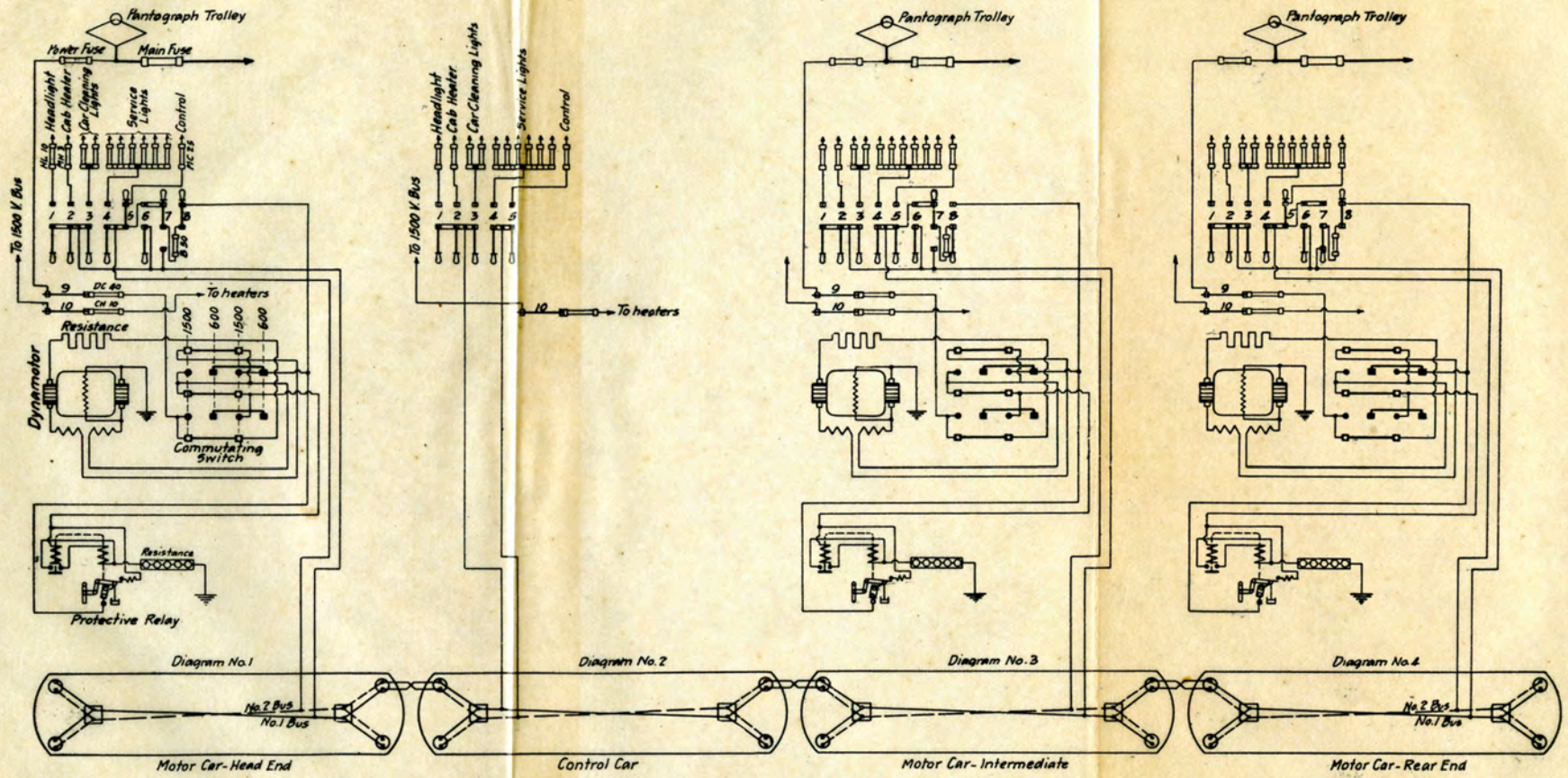
INSPECTION: The mechanism of the lamp should be carefully inspected for loose screws and electrical connections. The movable parts should be operated to see that they move freely.

HEATING SYSTEM

Every car is heated by a number of 400-watt double coil electric heaters, distributed throughout the car and connected in series. A 1500 volt bus line is installed



58, Switch and Dynamotor-Compressor Train Connection



Note :- All switches arranged for normal operation.
In case of disabled dynamotor open switches 8 and 9.
Switch 6 always open except for single dynamotor operation.

Fig. 58, Switch and Dynamotor-Compressor Train Connections

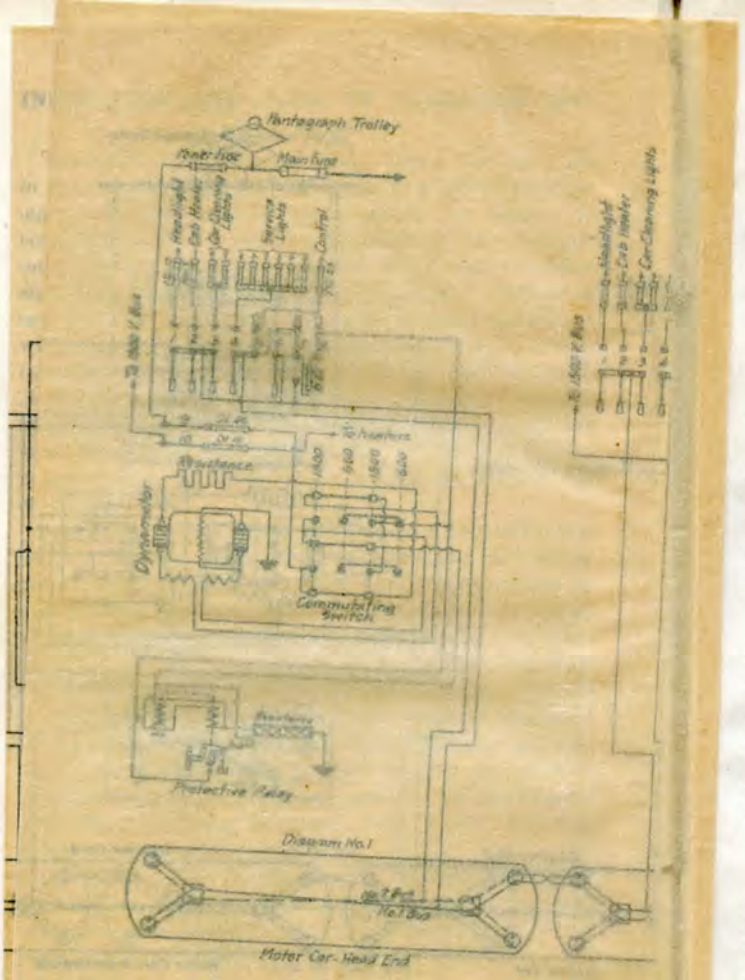


Fig.

on the car roof, which supplies current for the heaters. A bus line switch, with a detachable handle (Fig. 59), located in one of the motorman's cabs on motor cars only, is provided so that but one collector supplies current to the bus line. With the handle in place it is possible to close the switch and energize the 1500 volt heater bus throughout the train. The detachable handle is a part of the motorman's equipment, and it is the duty of the motorman to see that but one heater bus line switch is closed on a train. Trainmen are responsible for the heating of the cars.

If necessary to heat cars while standing in yards, all heater jumpers should be connected to the collector up on the head car, and the bus line switch for heaters closed on this car; all other bus line switches must be open.

The heater circuit on the individual car is protected by a single fuse (CH) and controlled by switch No. 10, located on the switchboard.

The 1500 volt bus line is located on the car roof, and is connected to the bus line switch through a connection box (Fig. 60), and terminates at either end of the car in a coupler socket, (Fig. 61), similar to the train cable coupler sockets. Bus line jumpers, (Fig. 62), are used to connect the bus line on adjacent cars and consist of a short length of single conductor cable. The coupler sockets are so located on the car that the jumpers may be placed in their position from the car platform.

Employes, before connecting up the heater bus jumpers, must see that the detachable handles are removed from all bus line switches on the train before attempting to remove or place bus line jumpers in coupler sockets, as the heater circuit with the bus line switch closed, handle in place, carries 1500 volts potential, and should one come in contact with the exposed conductors such contact is liable to result fatally.

Portable heaters are provided for heating the motorman's cab. Plug-in sockets are located at a convenient

point in the motorman's cab and supplied with current from the switchboard at 600 volt potential. The motorman's cab heating circuit is protected by fuse (MH) and controlled by No. 2 switch located on the switchboard.

EMERGENCY APPARATUS

The Master Controller Emergency Air Brake Attachment consists of a button in the controller handle, a small pilot valve located in the controller and an emergency valve located in the brake-pipe connection.

The pilot valve, Fig. 64, is operated by an eccentric collar on the controller cylinder shaft which unseats the valve when the controller handle is unlocked and released. This causes the emergency valve, (Fig. 65), to operate and opens the brake pipe to atmosphere, resulting in an emergency application of brakes throughout the train.

The emergency valve cutout cock, connected in the brake pipe, located near the controller, is provided for cutting out both the pilot and emergency valves should they become defective. The handle to this cock is sealed in its open position. It is the duty of the motorman to note that this valve is sealed at all times and should it become necessary to break the seal and close the cock, the matter should be reported to the proper officials. Under no circumstances must a car be retained or placed in service with defective master controller emergency air brake apparatus.

HAND PUMP AND EMERGENCY RESERVOIR

All motor cars are equipped with a hand operated pump to supply air for raising the collectors when main reservoir pressure is not available. The pump is located inside the car and provision is made, by means of a 3-way cutout cock, (Fig. 55-a), for connecting the pump to the operating cylinder of the collector. The normal

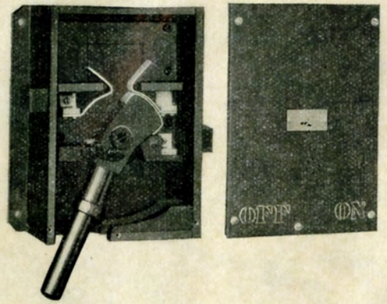


Fig. 59, Heater Bus Line Switch, MS-92

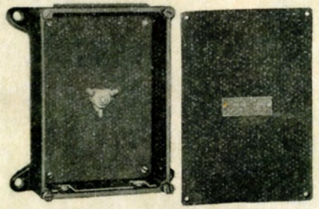


Fig. 60, Heater Bus Line Connection Box, BJ372-A

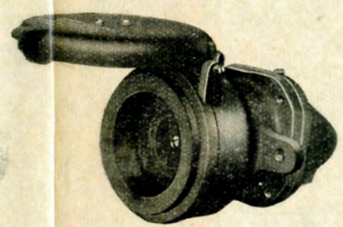


Fig. 61, Heater Bus Line Coupler Socket, DA-103

Fig. 62, Heater Bus Line Coupler Plug, DC-75

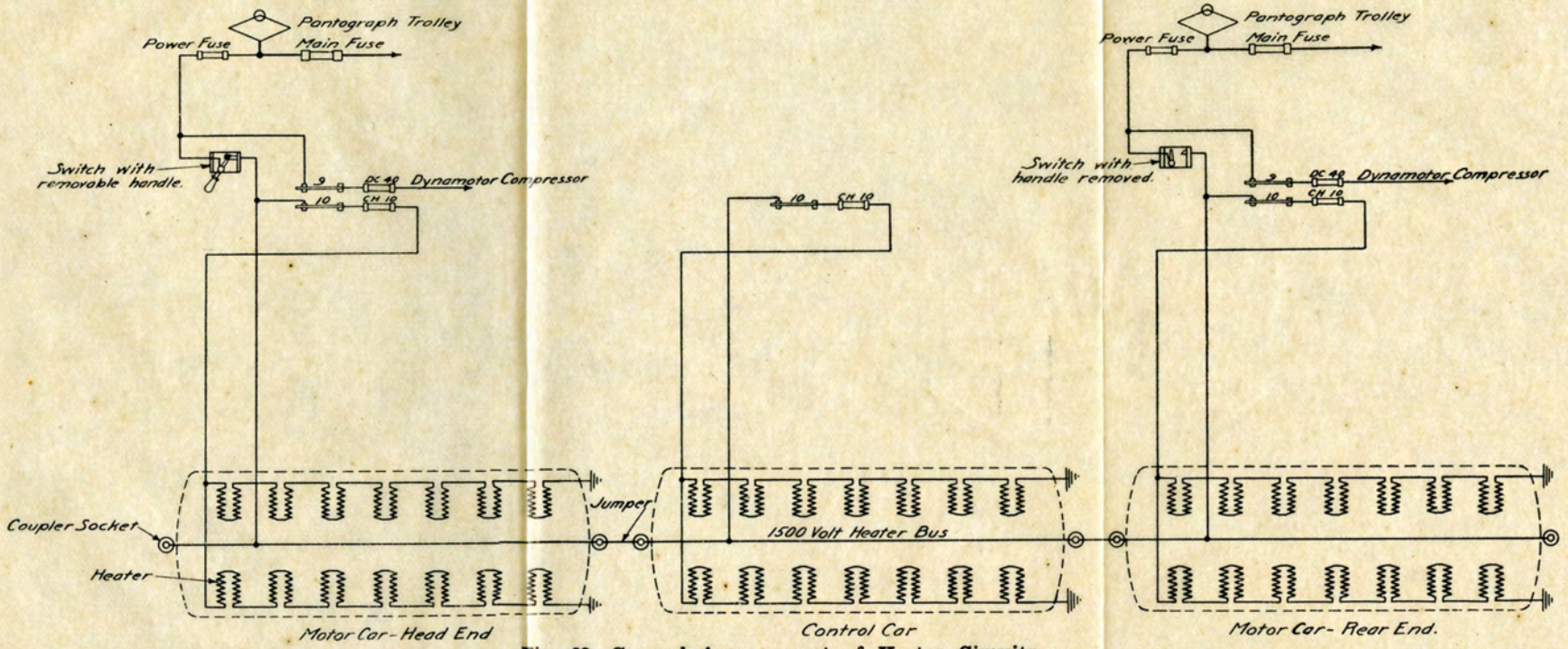


Fig. 63, General Arrangement of Heater Circuits

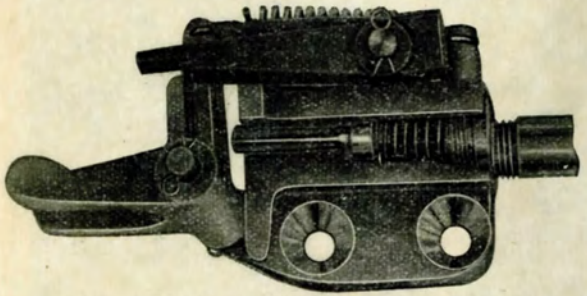


Fig. 64, Pilot Valve

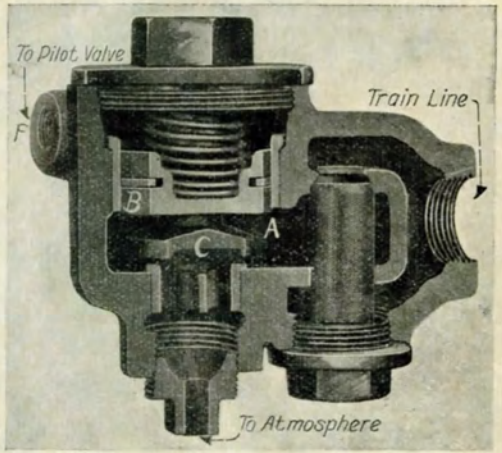


Fig. 65, Emergency Valve

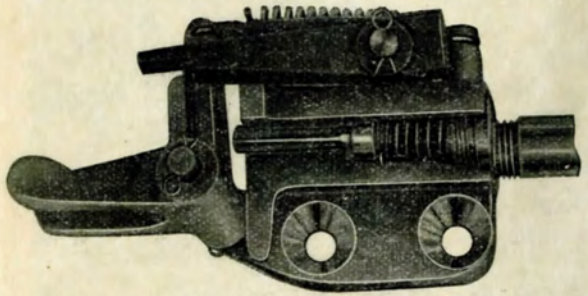


Fig. 64, Pilot Valve

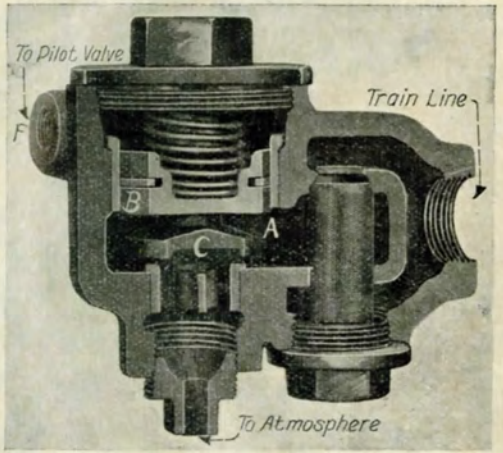


Fig. 65, Emergency Valve

Fig. 84, Pilot Valve

position of the handle on the 3-way cock is in line with the main piping.

Each motor car is equipped with an emergency reservoir with a check valve between it and the main reservoir, through which air is supplied for raising and lowering the collector. This reservoir carries a reserve supply of air, which is used in case the supply from the main reservoir should fail.

TRAIN OPERATION

The apparatus will be inspected and the train will be put in condition for operating by inspectors or by trainmen at points where inspectors are not located. The motorman, however, will be held responsible for the operation of the apparatus while in his charge; therefore, he should familiarize himself with the location, use and operation of the equipment.

PREPARATIONS FOR STARTING

When the train is turned over to the motorman he shall—

First.—Pass along the outside of the train, carefully noting that the motor cutout handles of all commutating switches are in the central position and all Main Switches are closed.

Second.—Pass through the train, close the dynamotor air compressor switches, and see that the control cutout switches are closed on all cars. Close the main control switches on motor cars at both ends of the train and the master controller switch at the head end of the car from which the train is to be operated. If there is main reservoir pressure on all cars raise the collector on an end motor car by operating the handle on the upper collector valve. Then move the collector operating switch to the left, which raises the collectors on the other motor cars in the train. Without main reservoir or emergency

reservoir pressure it will be necessary to raise the collector on each car by means of the hand pump.

THIRD.—Pass along the outside of the train and see that all the collectors are in the raised position, and that the dynamotor air compressors are operating.

FOURTH.—Take position in the motorman's cab, note the air pressures on the gauges, and set the circuit breakers by moving the circuit breaker switch to the "set" position.

FIFTH.—Test the Air Brakes in accordance with the Air Brake Instructions.

Trainmen are responsible for the proper connection of all electric and air brake couplers, the position of all angle cocks and the coupling of safety chains on the train.

COASTING: Advantage should be taken of coasting wherever possible. *Locking of the controller handle while coasting, or when the train is standing, (except when it is necessary for the motorman to leave the cab)*, is prohibited.

RUNNING POSITION: The second and fourth points on the master controller are running positions and the train shall not be operated with the controller handle on intermediate points.

SERVICE STOPS will be made with care and accuracy, avoiding undue shock to the passengers and to the equipment in general.

TO STOP THE TRAIN IN THE EVENT OF AIR BRAKE FAILURE: Reverse the motors, stopping at the first or "switching" point and holding it in this position until the train comes to a stop.

NOTE.—The motors must not be reversed when the brakes are applied.

RULES FOR MOVING TRAINS UNDER ABNORMAL CONDITIONS

Cars or trains shall not be moved by employes, except hostlers in the discharge of their duties, unless authorized by the motorman.

Whenever it is necessary to move a car or a train from other than the head end controller, (failure of equipment in service for example), the motorman shall remain on the head end to give signals and to operate the air brakes. He shall assign a trainman to operate the controller from which the train is to be moved.

Preparatory to moving a train under such conditions it is the motorman's duty to see that the switches are in their proper positions and that the signal apparatus is cut in and the controller emergency valve cut out on the car to be operated.

The "assigned" motorman shall be governed by the electric communicating signals for all movements of the train except in the forward direction, for which movement the motorman on the head end of the train is responsible, and the "assigned" motorman shall not start the train until the motorman signals him by the alarm whistle.

TRAIN FAILURE

Train failure, i. e., failure of a train of one or more cars to move or to reach full speed when the directions for train operation have been followed, may be due to one or more of the following causes:

1st. Failure of power.
2nd. Defect in master control circuit.
  (a) Main control fuse (MC) defective.
  (b) Grounded train cable or jumper.
  (c) Poor contact of master controller fingers.
  (d) Loose or disconnected train cable jumper.
  (e) Poor contact in master controller switch.
3rd. Defects in dynamotor circuit.
  (a) Power fuse "P" defective.
  (b) Dynamotor Compressor fuse "DC" defective.
  (c) Error in position of switches on switchboard.
  (d) Bus fuse "B" defective.
4th. Defects in motor control circuit.
  (a) Circuit breakers open.
  (b) Main fuse defective.
  (c) Main switch open.
5th. Failure of air brakes to release.

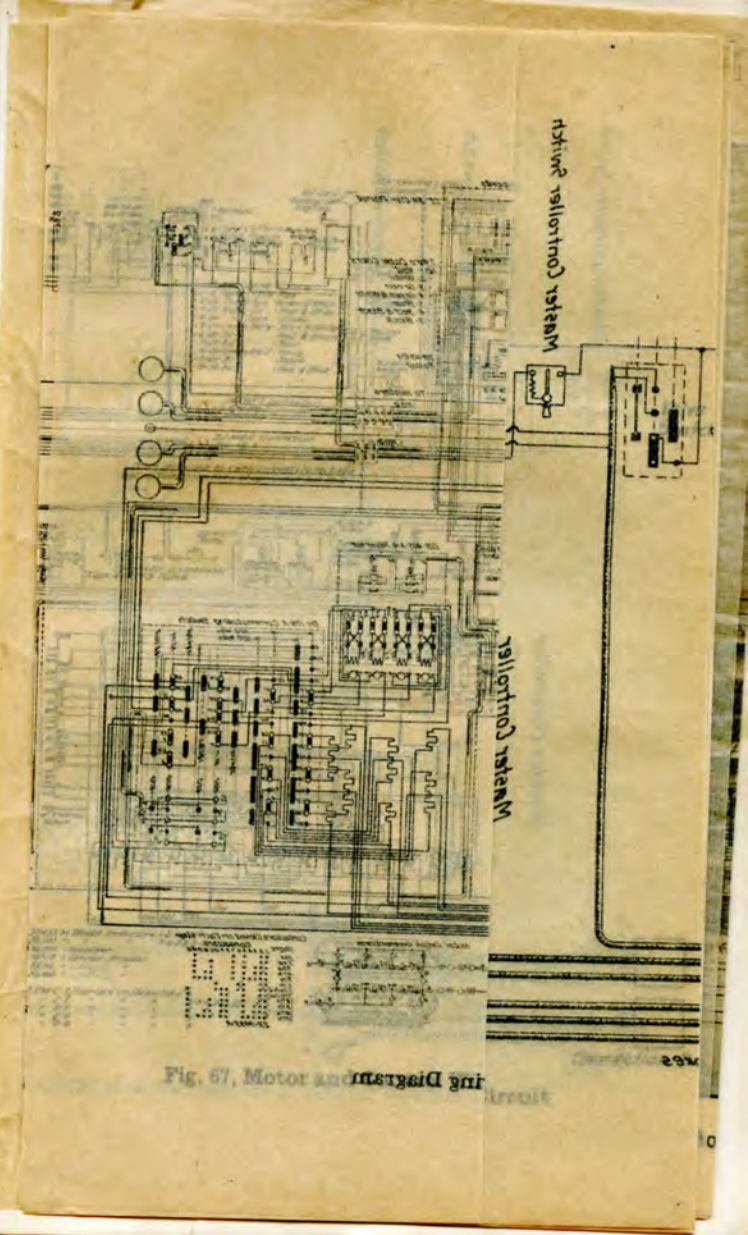
FAILURE OF POWER

A failure of power can be detected by observing if the dynamotor compressors are operating or whether other trains are moving on the same line.

DEFECTS IN MASTER CONTROL CIRCUIT

To Determine Whether the Master Control Circuit Is Open.—Turn the master controller handle to the first position and open the master controller switch. Arcing at the switch will indicate that the master control circuit is closed. No arcing noticeable indicates that the master control circuit is open and that the master control fuse is defective. A fuse that shows no indication of defect should be tested by opening the car cleaning light Switch No. 3 and bridging across from the blade to the switch point with the fuse to be tested; if an arc occurs when removing fuse a good fuse is indicated.

To Determine Whether the Train Cable Is Grounded.—Operate the master controller. If the main control fuse blows, it indicates that one or more wires of the train cable are in contact with the ground, and the cable is said to be grounded. If the main control fuse blows a second time, the motorman should proceed to get the train under way as follows: Close the cutout cock under the brake valve, remove the brake handle, and the master controller key, also lock the reversing handle and go to the middle of the train; for example, in a four-car train, remove the train jumper completely between the second and third car; cut in the brake-valve, master controller switch and the main control switch on the third car; if upon operating from this car the train does not move, cut out the brake valves and switches and return to the head of the train, renew the main control fuse and proceed. This procedure will locate ordinary troubles in the train line and will permit the motorman to run the train to a terminal. Always



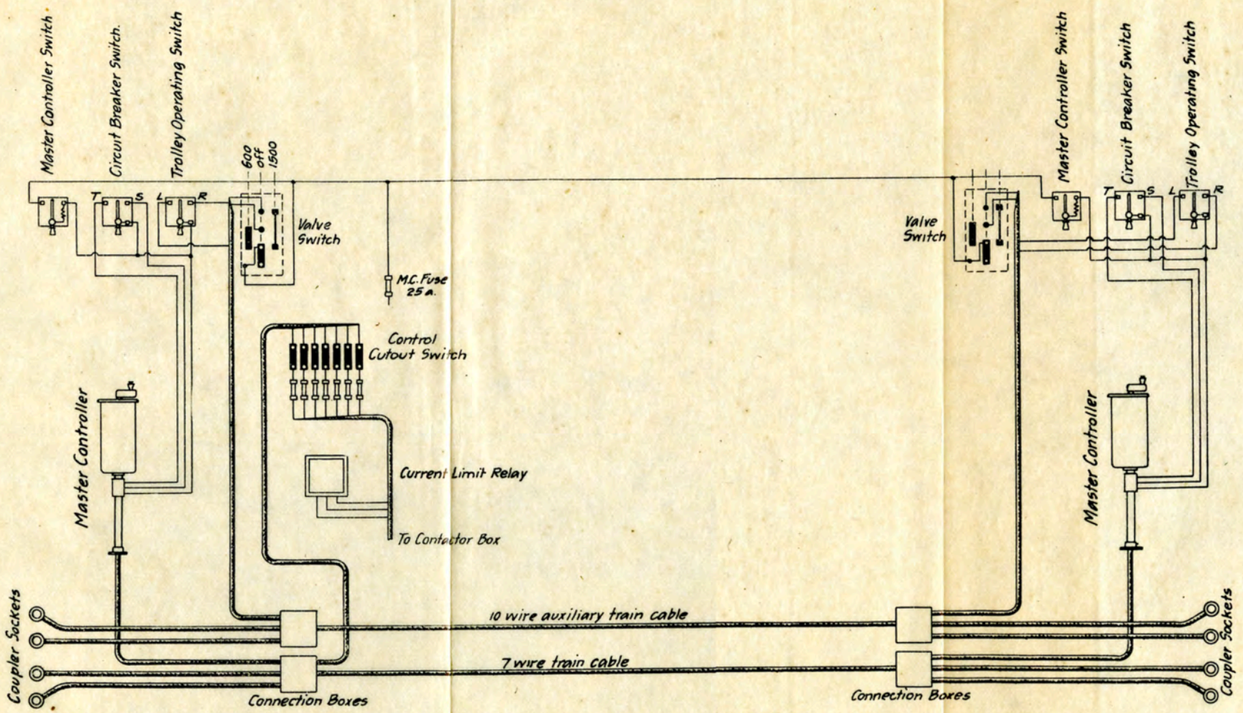


Fig. 66, General Arrangement of Master Control Circuit

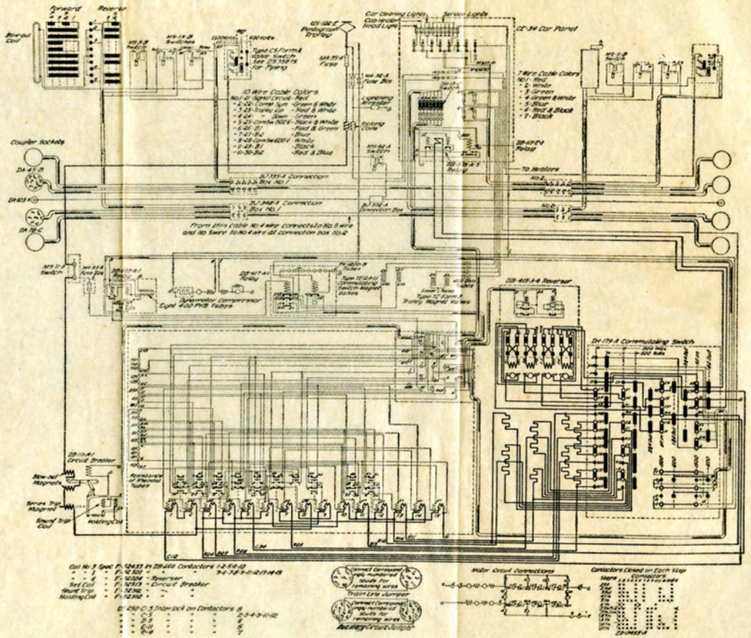


Fig. 67, Motor and Control Wiring Diagram

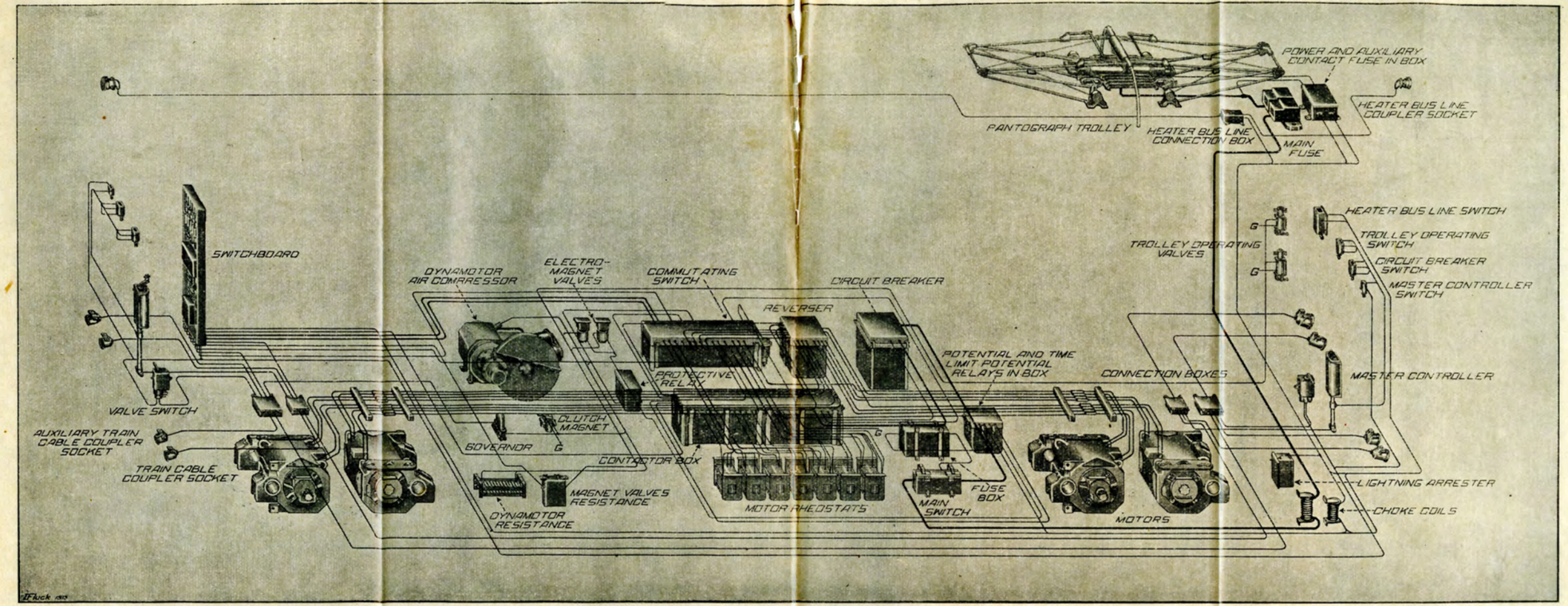


Fig. 68, Arrangement of Apparatus on Car

remember that when it is necessary to operate from any other than the head end car, the "Rules for Moving Trains under Abnormal Conditions," shall be strictly followed.

After reaching a terminal, to determine whether the ground is in the train cable or in a jumper, remove all train cable jumpers and test every car independently. If the trouble is not located on any of the cars, replace the jumpers one at a time, making a test on every one separately. When a defective jumper is found it should be removed and marked for identification.

To Detect Poor Contact of the Master Controller Fingers.—Open the master controller switch, remove the cover from the controller and turn the handle slowly, noting if all fingers make contact on the segments. If any are found to be out of adjustment and cannot be readily readjusted by the motorman, a trainman should be placed on the head end of the second motor car to operate the train.

To Detect Loose Train Cable Jumpers.—If there is a loose train cable jumper in the train, only the motor cars ahead of the jumper will operate. Trainmen must notify the motorman immediately when any motor car is not operating; and if the schedule cannot be maintained, the motorman should make an examination for loose train cable jumpers.

DEFECTS IN THE MOTOR CONTROL CIRCUIT

To Detect Defective Motors.—If one or more circuit breakers in a train open when starting, turn the controller handle to the "off" position and move the handle of the circuit breaker switch to the "set" position. If a circuit breaker again opens, cut out the car on which it is located by opening the main and control cutout switches and proceed. In case there is but one motor car in the train, place the commutating switch handle in the "1 and 2 Out" position and set the circuit breaker.

If it opens again it indicates that the trouble is in Nos. 3 and 4 motors. Turn the commutating switch handle to "3 and 4 Out" position and proceed.

To Detect Defective Main Fuse.—When the main fuse blows, the motors on that car are inoperative. This fuse is located on the roof; its renewal, therefore, consumes considerable time, and whenever possible the train shall be run to the terminal where the fuse will be replaced by an inspector. When it is necessary for the motorman to renew a main fuse in order to operate the train, before going upon the roof he shall lower all collectors and assure himself that they are locked. When on the roof he must take every precaution not to make contact with the overhead wires, because such contact is liable to result fatally.

GENERAL DIRECTIONS

In the Event of Fire on any car in the train the motorman must open all circuit breakers by moving the circuit breaker switch to the "trip" position. He must then open the switch or switches that control the circuit or circuits affected.

Unusual Noises in train movement should be located at once. To avoid delay the trainmen shall notify the motorman so that proper steps may be taken to locate the defect. If the noise is located within a motor, the main and control cutout switches on that car must be opened.

Insulated Sections in Overhead Trolley Wire.—All crossings with foreign trolley wires are insulated, and dead sections in the overhead construction occur at such places. Also section insulators are inserted in the overhead construction at certain points.

Contact Poles.—Contact poles equipped with a sufficient length of wire are provided for moving cars off the insulated section in cases where the car has been stopped under such sections with the collector resting on the insulated parts. This contact pole is carried

underneath the car. Before removing this pole from its receptacle the collector on the car that is to be moved should be lowered and locked. The contact handle shall then be placed on the main switch, and the contact end of the pole shall then be placed on the trolley wire from which the collector, under normal conditions, would make contact. In moving the car the controller handle should be placed on the first point only. *Under no circumstances shall this contact pole be placed on foreign trolley lines.* The pole and contact handle shall be removed and placed in their receptacles underneath the car before the collector is raised. Motormen are responsible for the proper operations in moving cars off insulated sections.

Care should be exercised to avoid stopping a train with a collector under an insulated section.

To Lower the Collector on Account of Defective Overhead Wires.—In the event of it becoming necessary to lower the collector and coast trains on account of defective overhead wires, or when repairs are being made on the overhead lines, the motormen shall assign a trainman to be stationed at the trolley operating valves throughout the train. The operator, upon receiving a signal from the motorman (one long blast of the alarm whistle) will lower the collector by operating the handle of the magnet valve, holding the same down until the train comes to a stop. The collector shall not be raised until the operator receives a signal from the motorman (two short blasts of the alarm whistle). It shall be the duty of the motorman to see that the instructions are fully carried out in all cases. Under no circumstances must the collector be raised until the train comes to a stop.

Defective Apparatus.—When an emergency arises that necessitates the cutting out of defective apparatus, a card shall be attached, stating the reasons for cutting out the apparatus. If it is permissible to cut in such apparatus in case of emergency, it should so state on the card attached.

MOTORMEN'S EQUIPMENT.—Motormen's equipment will be furnished jointly to two motormen. Each kit will bear a number; the motorman to whom it is assigned will be responsible for its contents. The kit shall be kept locked at all times and shall be carried in the most convenient place on the train where it is not accessible to passengers. Before turning the kit over to the motorman, its contents shall be checked against the list pasted on the inside of the cover. The contents shall be again checked after turning the kit in. Any shortages must be immediately reported.

REPORTS.—All accidents, troubles and detentions shall be reported by motormen at the end of every trip, on forms provided for this purpose.

QUESTIONS AND ANSWERS

MOTOR CIRCUIT

Q. 1. How many motors per motor car?

A. 1. Four (4).

Q. 2. How are they electrically connected?

A. 2. In pairs, two permanently in series when operating on 1500 volts, and in parallel when operating on 600 volts.

Q. 3. Explain briefly the course of the current from the collector through the motors to ground.

A. 3. From the collector, through the main fuse, main switch, circuit breaker, contactors, motor cut-out switch, reverser, commutating switch, motor rheostats, and motors to ground.

Q. 4. Where is the motor apparatus located?

A. 4. Beneath the car, except the main fuse and collector which are located on the roof.

Q. 5. What is the function of the main fuse?

A. 5. To protect the motor control circuit.

Q. 6. What is the function of the main switch?

A. 6. To open the motor circuit when necessary to inspect or repair the motor control apparatus.

Q. 7. Describe the circuit breaker and explain its function.

A. 7. It is an automatically operated switch provided to protect the motors from excess and short circuit currents.

Q. 8. Describe a contactor and explain its functions.

A. 8. It is an electrically operated switch provided to open and close the motor circuit.

Q. 9. Describe a motor rheostat and explain its function.

A. 9. It is made up of cast iron grids and when in the circuit limits the flow of current through the motors.

Q. 9a. What is the result of holding the controller on a resistance point for too long a period?

A. 9a. The motor resistances will become overheated and result in their burning out and disabling the car.

Q. 10. Describe the commutating switch and explain its functions.

A. 10. It is an electro-pneumatically operated, combination cylindrical switch, and is provided for changing the motor, rheostat, and dynamotor connections when passing from 1500 to 600 volts or vice versa. It is also provided with contacts inserted in the motor circuit to permit cutting out either pair of motors without interfering with the operation of the other pair.

Q. 10a. What would be the result if this switch is thrown on the leading motor car before shutting off the controller?

A. 10a. The commutating switch would be damaged.

Q. 11. In the event of motor failure in a train consisting of more than one motor car what should be done?

A. 11. Open the main and control cutout switches on the defective car.

Q. 12. What should be done in the event of motor failure while operating a single car?

A. 12. The motor cutout handle of the commutating switch should first be placed in the "1 and 2 out" position. If this does not remove the trouble, the switch handle should be turned to the "3 and 4 out" position. This is a manual operation for which a handle is provided on the end of the switch.

Q. 13. What is the normal position of this handle?

A. 13. Midway between the "1 and 2 out" and the "3 and 4 out" positions.

AUXILIARY CIRCUIT

Q. 14. What are the functions of the dynamotor-air-compressor?

A. 14. The dynamotor portion of the machine furnishes current at 600 volts for the master control and lighting circuits, while the air compressor end of the machine furnishes air for operating the air brakes throughout the train.

Q. 15. What precaution should be taken before starting a dynamotor-air-compressor?

A. 15. Inspect the switchboards on all motor cars in the train; insure that the switches are in their correct positions.

Q. 15a. What are the proper positions?

A. 15a. No. 9 switch should be closed on all cars, and No. 8 switch closed on the head and rear cars only, No. 7 upper position on head car, and lower position on rear car.

Q. 16. How must the dynamotor compressor switch (No. 9) be operated?

A. 16. With the portable hook furnished for that purpose.

Q. 17. Why should this switch be operated with a hook?

A. 17. To protect employes from shock as this switch carries a potential of 1500 volts.

Q. 18. How many fuses are there in the 1500 volt dynamotor compressor circuit?

A. 18. Two (2).

Q. 19. Name them and state their locations.

A. 19. The power fuse "P," located on the roof near the collector, and the dynamotor-compressor fuse "DC" located in a special compartment on the switchboard of the motor cars.

Q. 20. In the event of a dynamotor-compressor failure where should you look for the trouble?

A. 20. In either the power or dynamotor-compressor fuses.

Q. 21. How would you renew a dynamotor-compressor fuse?

A. 21. Open the dynamotor-compressor switch (No. 9), remove the fuse and insert a new one.

Q. 22. What should be done when a dynamotor-compressor fuse blows a second time?

A. 22. Open the dynamotor-compressor switch (No. 9), and disconnect the dynamotor from the bus by opening switch No. 8.

Q. 23. What should be done when the power fuse "P" blows?

A. 23. Open switches Nos. 8 and 9 in the disabled dynamotor circuit and cut in a spare dynamotor on the bus line that was previously supplied by the disabled dynamotor. When the train make-up includes only one motor car, renew the defective fuse.

Q. 24. How must the collector be operated when it becomes necessary to renew a main or power fuse?

A. 24. Lower it by mechanically operating the magnet valve on the motor car affected, restore it to position in the same manner after the fuse has been replaced.

Q. 25. Where does the dynamotor circuit begin and end?

A. 25. The dynamotor circuit begins at the collector and ends at Switch No. 8 on the switchboard.

Q. 26. How is the bus line protected from excess current?

A. 26. By 600 volt, 50 amp. capacity, fuse "B" located on the switchboard.

Q. 27. What effect has a defective bus fuse on train operation?

A. 27. The same as disabled dynamotor-compressor fuse.

Q. 28. How can you distinguish between a defective dynamotor compressor or bus fuse?

A. 28. If the bus fuse is defective an arc will be visible at the dynamotor-compressor switch No. 9 when it is opened.

Q. 29. How would you renew a defective bus fuse?

A. 29. Open Switch No. 8, remove the fuse and insert a new one.

Q. 30. What precautions are necessary before closing any bus switch?

A. 30. Close the light circuit switches to ascertain whether the bus line is not already energized.

Q. 31. When are both bus lines to be connected to one dynamotor?

A. 31. When all lights are required and there is only one dynamotor available.

Q. 32. Who is responsible for the position of the master control and dynamotor-compressor switches?

A. 32. The motorman.

Q. 33. Who are responsible for the lighting switches?

A. 33. The trainmen.

Q. 34. What are the first duties of the motorman when preparing a train for service?

A. 34. To ascertain that all switches are in their correct positions before raising the collector.

Q. 35. What is a motorman's final duty before leaving a train after completing his run?

A. 35. To open switches Nos. 5, 6, 8, 9 and 10.

Q. 36. How would you proceed to remove a heater bus line jumper?

A. 36. By grasping the plug firmly and giving it a quick, straight pull.

DEFECTS IN ELECTRIC EQUIPMENT

Q. 37. If a train fails to move after the instructions under "Train Operation" have been followed, what should be done?

A. 37. The motorman should assure himself that power is on the line—this can be determined by noting whether the dynamotor-compressors are running.

Q. 38. If power is on the line what should be done?

A. 38. The master controller handle should be moved to the first point, then the master controller switch should be opened to ascertain if the control circuit is complete; this will be indicated by an arc at the switch.

Q. 39. What will cause the failure of the master control or the train cable circuit, as indicated by the absence of an arc at this switch?

A. 39. (1st) A defective main control fuse.
(2nd) Imperfect contact of the master controller fingers.
(3rd) Imperfect contact of master controller switch.

Q. 40. Is there any other defect that would cause an open control circuit?

A. 40. Yes, a defective fuse in dynamotor-compressor or bus line circuit.

Q. 41. What should be done to detect a defective main control fuse?

A. 41. Open the main control switch on the switchboard and test the fuse.

Q. 42. If two main control fuses blow in succession, what should be done?

A. 42. This may indicate that the train cable is grounded and it should be divided by removing a train cable jumper in the middle of the train. The train must then be operated in accordance with "Rules for Moving Trains Under Abnormal Conditions."

Q. 43. What should be done to detect imperfect contact in the master controller?

A. 43. Open the master controller switch, remove the controller cover, turn the handle on the controller slowly and see that all fingers make good contact with the cylinder contact segments. If the fingers cannot be adjusted, operate from another controller.

Q. 44. What master control troubles will render a train inoperative?

A. 44. Defects in the dynamotor-compressor circuit, a defective main control fuse, imperfect contact of the master controller fingers, loose train cable jumpers, or imperfect contact in a master controller switch.

Q. 45. What should be done in the event of train failure?

A. 45. Test the fuses in the circuits that control the movement of the train.

Q. 46. What defect tends to reduce the speed of a train?

A. 46. One or more disabled motor cars due to any one of the following causes—a circuit breaker, a control cutout or a main switch open, a main fuse, or one or more 3-amp. fuses, (numbering from 1 to 7, in the control circuit), blown on individual cars, or a loose train cable jumper.

Q. 47. How can a defective No. 1 control fuse be detected?

A. 47. The motor rheostats on that car will become overheated and the train will operate sluggishly.

Q. 48. If a motor car fails to operate and it is found that the dynamotor circuit, main fuse, circuit breaker, and reverser are O. K., also that the main and control cutout switches are closed, what should be done?

A. 48. Test all fuses in the master control circuit.

Q. 49. Describe a train cable jumper and explain its function.

A. 49. The jumper contains seven wires enclosed in a cable terminating in plugs. When the jumper is in place

it provides for the continuity of the train cable throughout the train.

Q. 50. How would you proceed to remove a train cable jumper?

A. 50. Grasp the plug (not the cable) firmly, and work it out gradually.

Q. 51. Is there any danger in removing a train cable jumper?

A. 51. No, because the train cable carries current only when the master controller is operated.

Q. 52. How should the jumper be removed when there is a defect in the train cable?

A. 52. The jumper must be removed from both coupler sockets and placed in the vestibule.

Q. 53. If a train is standing under an insulated section and fails to operate, what does it indicate?

A. 53. That the collector is in contact with the insulated section.

Q. 54. How does this affect the train operation?

A. 54. It renders the dynamotor inoperative and therefore the master control current is not available.

Q. 55. How would you proceed to move a train off of an insulated section?

A. 55. If the train consists of two or more motor cars, the dynamotor circuit should be transferred; open switch No. 8; close switch No. 6, on the car that is making contact with the insulated section. The dynamotor-compressor on the car making contact on the trolley wire should then be started, which will supply available control current for operating the train. If trouble occurs on a single car the contact pole should be used, as referred to in General Directions.

Q. 56. Why must switch No. 8 be opened?

A. 56. To prevent trouble in the dynamotor circuit when the collector again makes contact with the energized trolley wire.

Q. 57. Should dynamotors be operated with this combination of switches for any length of time?

A. 57. No, the switches should be placed in their normal positions as soon as the train is moved off the insulated section.

Q. 58. If an unusual noise is noticed during the operation of a train, what should be done?

A. 58. The motorman should instruct trainmen to stand near the track to locate the noise while he moves the train slowly.

Q. 59. If the noise is located within the motors what should be done?

A. 59. Open the main switch and the control cutout switch on the car affected.

Q. 60. Describe the valve switch.

A. 60. The valve switch is a hand operated switch with air valve attachments.

Q. 61. What are its functions?

A. 61. It is provided for operating the commutating switch, both pneumatically and electro-pneumatically.

Q. 62. What precaution should be used when it is desired to operate the commutating switches?

A. 62. The valve switch should never be operated until after the controller has been placed in the "off" position and locked.

Q. 63. Describe the operation of two or more commutating switches in a train.

A. 63. Upon operating the valve switch, air is first admitted direct to the cylinder on a car on which the valve is operated, which operates the commutating switch to its respective position. The succeeding commutating switches are then operated electro-pneumatically as the succeeding cars pass over the insulated sections in the trolley wire.

Q. 64. How can it be detected if the commutating switch fails to operate?

A. 64. By the sluggish action of the train or car.

Q. 65. In case a commutating switch fails to operate when operating the valve switch, how can the commutating switch be operated?

A. 65. By throwing the switch manually, for which a handle is provided on the end of the switch.

Q. 66. How should the valve switch be manipulated in trains of two or more cars?

A. 66. The controller handle should first be placed in the "off" position and locked; the valve switch then placed to the 600 or 1500 volt position as desired. Hold in this position until the entire train has passed from 1500 to 600 volts or vice versa.

Q. 67. In operating from a control car who should operate the valve switch on the motor car?

A. 67. The trainmen.

Q. 68. Under whose direction?

A. 68. The motorman's.

Q. 69. How shall the trainmen be governed in operating this switch?

A. 69. By the prescribed signal from the alarm whistle.

Q. 70. What is the prescribed signal?

A. 70. One long and one short blast, thus ——— —.

Q. 71. Before signalling the trainmen to operate the valve switch, what precaution should the motorman take?

A. 71. Place the controller handle in the "off" position and lock it.

Q. 72. Why is it necessary to have the controller handle in the "off" position when operating the valve switch?

A. 72. Because the commutating switch is operated by air directly on the car upon which the valve switch is operated and if the commutating switch is operated with the motors taking current, trouble is apt to be the result.

Q. 73. Why is the valve switch placed to the left of the controller?

A. 73. To prevent it being conveniently operated with the controller handle in the "on" position.

Q. 74. Can the controller handle be placed in the "on" position after the car upon which the valve switch is operated has passed under the insulated section?

A. 74. Yes, as the commutating switches on the succeeding cars are operated electrically and so interlocked that the electric circuits for operating the electromagnets are not closed until the car is passing under the insulated section.

Q. 75. In case the commutating switch should fail to operate automatically, how can it be operated?

A. 75. A handle is provided for hand operation.

PART III.

ELECTRIC LOCOMOTIVES

GENERAL

The electric equipment, as applied to the electric locomotives, differs from that used on multiple unit cars, inasmuch as the master control circuit is semi-automatic and the contactors are operated electro-pneumatically. However, the electric equipment in the same way as on the multiple unit cars, comprises two distinct sets of circuits, viz.: the motor circuit, and the master control circuit, the former being governed by the latter. Each locomotive has four motors, the control being arranged to operate the motors at full speed on either 600 or 1500 volts.

DESCRIPTION OF THE MOTOR CONTROL APPARATUS

THE MOTOR CONTROL CIRCUIT is the path for the current from the trolley through the motor control apparatus and motors to the track rails, and includes the following:

1 Roller Type Pantograph Collector
1 Main Fuse
1 Main Switch
1 Circuit Breaker
1 Set Motor Rheostats
2 Changeover Switches for motor resistance and dynamotor compressor connections.
2 Contactor Boxes, containing nine contactors each
2 Motor Cutout Switches
1 Series Parallel Switch
4 250 hp. Motors (forced ventilation)
2 Reversers.

COLLECTOR: See description, pages 82 and 83, Part II.

MAIN FUSE BOX: The main fuse box is located on the roof near the collector and contains a copper ribbon fuse, which protects the main motor circuit. In case it is necessary to make repairs or renewal of fuse in this box, the collector shall first be lowered and locked.

MAIN SWITCH: The main switch is a knife blade, hook operated switch, enclosed in a box lined with fire proof insulation, and located overhead on No. 1 end of locomotive. The main switch should never be opened when the motors are taking current, but is provided for opening the main motor circuit when inspection or repairs are to be made to equipment. The hook provided shall be used for operating this switch.

CIRCUIT BREAKER: The circuit breakers, or line switches, located between the changeover switches in the apparatus compartment on the No. 1 end of locomotive, are provided for protecting the motors from excessive currents. The circuit breaker is equipped with a powerful magnetic blow-out and an overload trip which will open the motor circuit whenever a predetermined current has been exceeded.

MOTOR RHEOSTATS: Motor rheostats are similar to those described on page 90. They are located in a special compartment and are ventilated through globe type ventilators located in the roof.

CHANGEOVER SWITCHES: Two in number, located in the apparatus compartment on the No. 1 end of the locomotive, are provided for readjustments of the divisions of the motor rheostats and dynamotor connections from 600 to 1500 volts and vice versa, and in addition lock the series parallel switch in the series position. These switches are operated by a lever which connects the two together and is provided with a handle projecting outside of the apparatus compartment. They should never be operated when the motors are taking current. Only the motorman shall operate the change-over switches, thereby insuring that the controller is "off" and the motors are not taking current.

CONTACTORS: Contactors are electro-pneumatically operated switches, eighteen in number, and are enclosed in two boxes known as the contactor boxes located in the apparatus compartment. The contactors are supported by insulated bolts from channel iron supports within the boxes. The inside of the boxes are heavily lined with fire proof insulating material to prevent short circuits that might otherwise be caused by the arcing of the contactors when opening the motor circuit. The contactors are numbered progressively, the numbers being stenciled on the frame which supports the pneumatic valve. The principle of their operation is that a solenoid coil is energized which operates an air valve admitting air to a small cylinder that contains a piston and piston rod which connects to a hinged arm of the contactor. This arm carries a contact tip and when closed completes an electric circuit through the contactor.

In series with the contactor circuit there is connected a powerful magnetic blow-out coil for extinguishing the arc when the contactor opens, breaking the circuit.

MOTOR CUTOUT SWITCHES: Two in number, located one on each side of and near the center of the apparatus compartment, are provided for cutting-out individual motors in case of defects which render them inoperative. Switch No. 1 when open cuts out numbers 1 and 3 motors. Switch No. 2 cuts out numbers 2 and 4 motors. Each switch has a small auxiliary cutout switch attached for opening the control circuit of the series contactors. These switches are normally closed, except in case of individual motor trouble. It should be noted that the switch is fully closed and that the small auxiliary switches make good contact. With either one of these switches open, the locomotive will not move until the controller handle reaches the series parallel position.

SERIES PARALLEL SWITCH: The series parallel switch, located in the apparatus compartment between the reversers on the No. 2 end of locomotives, is an electro-pneumatically operated switch, and is provided for

changing the motor connections so as to operate the motors in either series or parallel with each other at the will of the motorman. The control circuit to this switch is so interlocked that it is not possible to operate the switch when the circuit to the main motors is closed. The series parallel operating switch, located at each end of the locomotive, is provided for operating the series parallel switch.

MOTORS: Each of the two locomotive trucks is equipped with two motors independently geared to the axles. The motor weight is carried partly on the axle bearings and the remainder supported by a nose which rests directly on the truck transom. The motors are the interpole type designed especially for slow speed locomotive service and are rated with natural ventilation at 225 h. p., and with forced ventilation at 250 h. p. each. They are geared to the axle with a gear ratio of 16:57 and due to the slow speed characteristics of the motor, the locomotive can start and haul heavy loads with relatively low current. Forced ventilation is supplied to the motors through two air ducts carried under the frame of the locomotive by means of centrifugal blowers mounted on the shafts of the dynamotor compressors. When operating a locomotive using forced ventilation, the locomotive can exert continuously a tractive effort of 11,500 pounds and with forced ventilation it can exert for one hour a tractive effort of 21,600 pounds. With a clean, dry rail a locomotive will be able to exert momentarily a tractive effort of 30,000 pounds.

REVERSER: Two in number, one located at each end of the apparatus compartment. Each reverser has the armature and field leads of two respective motors connected to the studs of its contacts. The connections of the armature and field leads for producing forward and backward movements of the locomotive are established by means of copper bars pressed against the spring contacts. The reversers are electro-pneumatically operated by two pneumatic cylinders to which air is admitted and released by means of electrically operated magnet valves attached to the cylinders to which electrical connections are established by means of the master controller.

LOCOMOTIVE OPERATION

General

Before attempting to start a locomotive, the motorman should first close the dynamotor switch, then the main switch, and see that the main control switch and all cut-out switches are closed; also, that the series parallel operating switch is in the position corresponding to the voltage to be operated on.

After the reservoir and brake pipe have been charged, the master controller switch on the operating end of the locomotive should be closed; the reverser handle placed in position, in the direction of the desired movement of the locomotive. The controller should then be placed on the first point, noting that the reversers throw and that the locomotive moves in the desired direction. The brakes should then be applied and the locomotive stopped, and the reverser handle thrown in the opposite direction; the controller placed on the first point, noting that the locomotive moves in the desired direction. These tests having been made satisfactorily, the locomotive is then ready for service.

To operate the controller, it is necessary to release the latch of the controller handle, moving the controller handle to the first notch, then to the second notch, and so on, until the desired speed is obtained. For coupling the locomotive, when switching, the first or second notches will ordinarily be sufficient. If it is desired to get up speed as soon as possible, the handle may be moved, notch by notch, allowing the latch of the controller handle to engage the quadrant, so as to make each notch positive until the last notch is reached. When notching up the controller, notch by notch, the ammeters

should be closely watched, and it should be noted that the current does not exceed the predetermined limit. Each notch on the controller should invariably be taken when moving the controller handle, whether in accelerating or in throwing the controller on with the motors already up to speed. In notching off, the notches need not be observed. The "off" notch of the controller may be called the zero notch; the first closed position of the controller is the first notch, and so on, the tenth notch being the full series position, and indicated by a slot in the quadrant. The 19th notch is the "parallel" and "series parallel" position, according to the position of the series parallel switch.

The intermediate points, the positions of which are not indicated by notches in the quadrant, are resistance points which should ordinarily be used only for accelerating and switching. The transition from the 10th to the 11th notches should be made steadily without pausing. When the controller is in the "on" position, the current passes from the master controller switch through the master controller to the train cable of the one or more locomotives and thence to the electro-magnet coils of the reversers and the contactors, causing them to close in the order as shown on the following table. This table gives the number of the contactors which are closed at each step on the master controller.

If the reversers are not already thrown to the position corresponding to the position of the reverser handle, and the controller is at the first notch, current will first pass through the proper operating coil to ground, and after the reversers are thus thrown to their correct positions, interlocking contacts on each reverser cut off the current to ground and establish a circuit through the series contactor coils.

Moving the reverser handle does not operate the reverser, but simply prepares the circuit so that when the controller is turned to the first position, the circuit is energized and the reversers will be thrown in the proper direction. The operating coils for one direction on one

CONTACTORS CLOSED

Controller Points	Series Running	Parallel
1	LS'-LS'1-LS'2-M-M'-M'1-JR-JR'	
2	LS'-LS'1-LS'2-M-M'-M'1-JR-JR'-*LS2*	
3	LS'-LS'1-LS'2-M-M'-M'1-JR-JR'-*LS2-R1*	
4	LS'-LS'1-LS'2-M-M'-M'1-JR-JR'-LS2-R1-*RR1*	
5	LS'-LS'1-LS'2-M-M'-M'1-JR-JR'-LS2-R1-RR1-*R2*	
6	LS'-LS'1-LS'2-M-M'-M'1-JR-JR'-LS2-R1-RR1-R2-*RR2*	
7	LS'-LS'1-LS'2-M-M'-M'1-JR-JR'-LS2-R1-RR1-R2-RR2-*R3*	
8	LS'-LS'1-LS'2-M-M'-M'1-JR-JR'-LS2-R1-RR1-R2-RR2-R3-*RR3*	
9	LS'-LS'1-LS'2-M-M'-M'1-JR-JR'-LS2-R1-RR1-R2-RR2-R3-RR3-*R4*	
10	LS'-LS'1-LS'2-M-M'-M'1-JR-JR'-LS2-R1-RR1-R2-RR2-R3-RR3-R4-*J-J'*	
Bridge	LS'-LS'1-LS'2-LS'2-M-M-M'1-J-J'	
11		LS'-LS'1-LS2-LS'2-M-M'-M'1-J-J'-*M2-M'2-G*
12		LS'-LS'1-LS2-LS'2-M-M'-M'1-J-J'-M2-M'2-G-*R1*
13		LS'-LS'1-LS2-LS'2-M-M'-M'1-J-J'-M2-M'2-G-R1-*RR1*
14		LS'-LS'1-LS2-LS'2-M-M'-M'1-J-J'-M2-M'2-G-R1-RR1-*R2*
15		LS'-LS'1-LS2-LS'2-M-M'-M'1-J-J'-M2-M'2-G-R1-RR1-R2-*RR2*
16		LS'-LS'1-LS2-LS'2-M-M'-M'1-J-J'-M2-M'2-G-R1-RR1-R2-RR2-*R3*
17		LS'-LS'1-LS2-LS'2-M-M'-M'1-J-J'-M2-M'2-G-R1-RR1-R2-RR2-R3-*RR3*
18		LS'-LS'1-LS2-LS'2-M-M'-M'1-J-J'-M2-M'2-G-R1-RR1-R2-RR2-R3-RR3-*R4*
19		LS'-LS'1-LS2-LS'2-M-M'-M'1-J-J'-M2-M'2-G-R1-RR1-R2-RR2-R3-RR3-R4-*RR4*

reverser are in multiple with the corresponding coils on the other reverser, these two coils being controlled by one wire from the master controller. On the first notch the main, or motor, current flows from the contact on the overhead trolley, through the main fuse, main switch, through line switches, contactors, reversers, motors, motor rheostats, to ground.

When it is necessary to reverse the direction of the locomotive movement, place the controller handle in the "off" position, throw the reverser handle in the opposite direction and operate the controller handle in the usual way. The position of the reverser handle indicates the direction in which the locomotive will move. The motors should not be reversed while the locomotive is moving except in extreme cases of emergency. If it is necessary to reverse while moving, do not throw the controller handle beyond the first notch if all the motors are cut in, or beyond the 11th notch if one or more motors are cut out.

In case of electric trouble within the master controller, train cable, couplers or connection boxes, the single fuse in the main master control switch will protect the circuit.

DESCRIPTION OF MASTER CONTROL APPARATUS

The master control apparatus comprises the following:

2 Master Controllers
2 Sets of Control Resistance
1 Main Control Switch
2 Master Control Switches
1 Train Cable
4 12-point Train Cable Coupler Sockets
2 12-point Train Cable Jumpers
2 12-point Train Cable Connection Boxes
2 Series Parallel Operating Switches
1 Section Break Relay
1 Open Circuit Signal Relay
1 Over-speed Relay

THE MASTER CONTROLLER: Two in number, one located at each end of the locomotive, the functions of which are to supply current at the will of the motorman to the train cable for operating the reversers and contactors. The primary or slow speed is obtained when operating the controller in the series position. The second or parallel position will produce motor combinations for operating the locomotive at higher speed. The controller is equipped with a separate reverse handle. The reverse handle can be thrown only when the controller handle is in the "off" position. The "off" position of the controller is indicated and is the extreme forward position of the handle. Eleven notches are provided on the master controller for operating the motors in full series, nine notches with the motors operating in parallel and nine notches with the motors in full parallel. The resistance notches are not indicated on the dial of the controller, but are used for switching and accelerating purposes only. The notches indicated on the dial show the positions of the controller for continuous running. The latch on the handle engages the notches on the dial ring and has to be released in moving the controller from one position to the next.

CONTROL RESISTANCE: Two sets of control resistance are provided for reducing the voltage for operating the electro-pneumatic valves.

MAIN CONTROL SWITCH: The main control switch, (located on the No. 1 end of the locomotive), is used for supplying current to the master control circuit. It must be closed to operate from either master controller.

MASTER CONTROLLER SWITCHES: Two in number, one located at each end of the locomotive above and to the left of the master controller. These switches are used for supplying or cutting off current from the individual master controller. The switch should only be closed when it is desired to operate from its respective controller.

TRAIN CABLE: The train cable is composed of twelve conductors which run from end to end of the locomotive

and are attached to numbered studs in the coupler sockets. The train cable is similar to the train cable described on page 96.

TRAIN CABLE COUPLER SOCKETS: Contain twelve contact studs. (For description see page 97.)

TRAIN CABLE JUMPERS: Are equipped with twelve contacts to agree with the coupler socket. (See description, page 97.)

TRAIN CABLE CONNECTION BOXES: Are used for making connections from the master controller and coupler socket to the train cable. (See description, page 97.)

SERIES PARALLEL OPERATING SWITCHES: One located at each end of the locomotive, are provided for operating the series parallel switch, and must be operated when passing from 1500 to 600 volts or vice versa. This switch when placed in its respective position for corresponding voltages will operate the series paralleling switch upon operating the controller.

TIME LIMIT POTENTIAL RELAY: This relay is located in the apparatus compartment and is inserted in the master control circuit so that when approaching insulated sections in the trolley wire, the master control circuit will be opened irrespective of any movement of the master controller handle, thereby shutting off the power to the motors. In order to again close the control circuit, it is necessary to first place the master controller in the "off" position, and again notch up.

POTENTIAL OR SIGNAL RELAY: Located inside the locomotive, is similar in construction to the potential relay described on page 98, and is provided for automatically opening the master control circuit if for any reason the main current supply to the locomotive is interrupted. This relay is also provided with a second contact which closes a dry battery circuit that operates a signal bell warning the motorman that there is an open circuit due either to the action of the circuit breaker opening, blowing of the main fuse, pantograph trolley off the wire, or failure of power. The battery circuit is controlled

by a small switch located on the end of the apparatus compartment and in case of power failure or lowering of the pantograph trolley, this switch must be opened. thereby preventing the unnecessary discharging of the batteries.

OVER-SPEED RELAY: The over-speed relay is located in the apparatus compartment and is provided for opening the control circuit at a predetermined speed of the locomotive. This relay is normally set to operate at a speed of approximately 40 miles per hour with motors using current; it is not effective when drifting.

QUESTIONS AND ANSWERS

Q. 1. For reference in reporting work on the locomotive how should it be designated?

A. 1. No. 1 end; No. 2 end.

Q. 2. Which is the right side of the locomotive?

A. 2. Right side looking forward from No. 1 end.

Q. 3. How many motors per locomotive, and horsepower each?

A. 3. Four 250 h. p. (forced ventilation)—two on each truck.

Q. 4. How are they electrically connected when operating at full speed?

A. 4. In pairs in parallel—two pairs in series when operating on 1500 volts; and two pairs in parallel when operating on 600 volts.

Q. 5. How are they numbered?

A. 5. 1 to 4 from No. 1 end; No. 1 and 3, and 2 and 4 in pairs.

Q. 6. Explain briefly the course of the current from the collector through the motors to ground.

A. 6. From the collector through the main fuse, the main switch, the circuit breaker, motor resistance, change-over switch, contactors, motor cut-out switch, series parallel switch, motors, reversers to ground.

Q. 7. Name the apparatus located on the roof?

A. 7. The collector and main fuse.

Q. 8. Where is the motor control apparatus located?

A. 8. In special compartments in the main cab.

Q. 9. What is the function of the main fuse?

A. 9. To protect the motor circuit.

Q. 10. Describe the main fuse.

A. 10. The main fuse is a copper ribbon fuse of 1000 ampere capacity.

Q. 11. How would you proceed to renew the main fuse?

A. 11. First, lower and lock the pantograph collector, loosen the thumb screws of the main fuse box and renew the fuse.

Q. 12. What is the function of the main switch?

A. 12. To open the motor circuit when necessary to inspect or repair the motor control apparatus.

Q. 13. What precaution should be taken before going on the roof to make repairs?

A. 13. Note the clearance between the overhead wire and the roof and avoid coming into contact with the wires. Lower and lock the collector.

Q. 14. Describe the circuit breaker and explain its function.

A. 14. It is composed of a set of automatically operated switches provided to protect the motor circuit from an overload of current.

Q. 15. How would you proceed to reset a circuit breaker after it has blown?

A. 15. Place the controller in the "off" position, and then move the control switch to the reset position. If the circuit breaker does not respond to this, the breaker can be set by pulling out on the overload trip on the side of the circuit breaker.

Q. 16. Describe the contactor and its functions.

A. 16. It is an electro-pneumatically operated switch provided to operate and close the motor circuit.

Q. 17. How many contactors are there on the locomotive?

A. 17. Eighteen.

Q. 18. Describe and locate the motor cutout switches.

A. 18. The motor cutout switch is a 3-blade, double throw, knife switch in the motor circuit to permit cutting out of either pair of motors, without interfering with the operation of the other pair. They are located at the end of the contactor boxes in the apparatus compartment.

Q. 19. What are the normal positions of the cutout switches?

A. 19. Closed in upper positions.

Q. 20. What is the function of the series parallel switch and how is it operated?

A. 20. Series parallel switch is provided for changing the motor connections from 600 to 1500 volts and vice versa.

Q. 21. How is it operated?

A. 21. By the series parallel operating switch located near the master controller, or by hand operation, using the handle provided on the end of the switch.

Q. 22. In what position should the series parallel switch be set?

A. 22. The series parallel switch should be set for the corresponding operating voltage.

Q. 23. How is the overhead collector operated?

A. 23. In two ways, by hand pump and hand valve.

Q. 24. In case the main fuse blows a second time what does this indicate?

A. 24. That trouble existed in one or more motors.

Q. 25. How would you proceed in a case of this kind?

A. 25. First cut out No. 1 and No. 3 motor, and if this does not correct the trouble, cut No. 1 and No. 3 in again and cut out No. 2 and No. 4.

Q. 26. How many fuses constitute the locomotive equipment?

A. 26. One main fuse, 1000 ampere capacity (ribbon).
Two dynamotor fuses, 30 ampere capacity (enclosed).
Two master control fuses, 10 ampere (enclosed).
Two light fuses, 3 ampere (enclosed).
One headlight fuse, 10 ampere (enclosed).

Q. 27. Name the fuses that if defective would prevent the locomotive from moving.

A. 27. The main fuse, dynamotor fuse or control fuse.

Q. 28. In case of mechanical defects in the controller that would not permit throwing it "off" how would you stop the locomotive?

A. 28. Open the master controller switch or lower the collector and apply the brakes.

Q. 29. What are the functions of the change-over switches?

A. 29. Two change-over switches are provided for readjustment of the rheostats when operating on either 600 or 1500 volts.

Q. 30. How are these switches operated?

A. 30. By hand.

Q. 31. Who is responsible for the operation of these switches?

A. 31. The motorman.

Q. 32. How would you proceed to get a locomotive ready for service?

A. 32. First see that the change-over switches are in their proper position to correspond with the line voltage, then see that all switches are open except the motor cut-out switches, and that the master controller is in the "off" position; second, raise the collector; third, close the dynamotor switch; fourth, close the main switch; fifth, close the small knife blade bell switch; sixth, set the circuit breaker, and place the master controller switch in the "on" position; seventh, close the series parallel switch for the corresponding voltage to be operated on; eighth, see that sufficient air is accumulated for operating the contactors, (70 lbs.); ninth, open the cut-out cock and test the brake; tenth, try the locomotive for moving in either direction.

Q. 33. In changing from one end of the locomotive to the other for operating what procedure is necessary?

A. 33. Set the brakes and remove the brake valve handle; close the cutout cock in the brake pipe and remove the reverser handle.

Q. 34. What is the function of the dyanmotor?

A. 34. To furnish current at 600 volts for master control and lighting circuits, also for operating the air compressors and fans for cooling the motors.

Q. 35. How many dynamotor switches and where located?

A. 35. One for each dynamotor located at the No. 1 end of the locomotive.

Q. 36. In the event of dynamotor failure, where would you look for the trouble?

A. 36. First, in the fuses.

Q. 37. In case of failure in one dynamotor what is the procedure?

A. 37. Cut the defective dynamotor out and operate the good dynamotor.

Q. 38. Prior to laying up a locomotive what are the final duties of the motorman?

A. 38. To open all switches and lower the collector.

Q. 39. If the locomotive fails to move after instructions have been followed, what should be done?

A. 39. See if the power is on the line, by trying the reset switch for an arc.

Q. 40. If this reset switch arcs what fuses do you know are good?

A. 40. Dynamotor and main control fuses.

Q. 41. If no arc what would this indicate?

A. 41. That the master control fuse had blown or the dynamotor fuse had blown.

Q. 42. How can you detect whether it is the master control fuse or dynamotor fuse?

A. 42. If the dynamotor fuse is blown the dynamotor would stop.

Q. 43. After assuring yourself that the master control and dynamotor fuses are good how would you proceed to remedy the trouble?

A. 43. By placing the master controller on the first point and noting the contactors that close.

Q. 44. What contactors should close on the first point?

A. 44. LS′, LS′1, LS′2, M, M′, M′1, JR, JR′.

Q. 45. If none of the contactors operate what should be done?

A. 45. Ascertain if the air pressure is available. Turn on the light circuit switch to ascertain if there is power in the overhead line, or try the reset switch for an arc.

Q. 46. With current on the locomotive and available air pressure, what would cause the failure of the locomotive to operate?

A. 46. First—Imperfect main control fuse.
Second—Imperfect contact in the master controller.
Third—Circuit Breaker open.
Fourth—One or both reversers not operating.

Q. 47. Before inspecting the contact in the master controller what should be done?

A. 47. Open the master controller switch.

Q. 48. How can a defective master control fuse be detected?

A. 48. By testing the fuse.

Q. 49. In case the locomotive fails to move and some of the contactors close, what would this indicate?

A. 49. That the control circuit is perfect but one or more of the contactor operating air valves is defective.

Q. 50. How can you detect a defective air valve?

A. 50. By placing the controller handle on the first point, and inspect the valves for air leaks.

Q. 51. Before inspecting contactors, reversers or change-over switches, what precaution should be taken?

A. 51. Open the main switch.

Q. 52. If the locomotive will move in one direction and not in the other what should this indicate?

A. 52. That one of the reversers is not operating.

Q. 53. What would cause the reverser not to operate?

A. 53. Imperfect contact with the reversing switch in the controller.

Q. 54. With either pair of the motors cut out, on what point of the controller would the locomotive move?

A. 54. Tenth, or series position.

Q. 55. In operating with a pair of motors cut out, how should the controller be handled?

A. 55. The locomotive will not move until the controller is placed on the 10th or series position. More time should be taken in accelerating, the operator closely observing the ammeter.

Q. 56. For what purpose is the ammeter intended?

A. 56. For the motorman's guidance in accelerating the locomotive.

PART IV.

PARTS OF THE ELECTRIC LOCOMOTIVE AIR BRAKE EQUIPMENT

The following is a list of the operating parts which make up the equipment, with a short description of each:

1. Dynamotor Compressor.—Each locomotive is equipped with two dynamotor air compressors similar to those installed on electric motor coaches, but in addition have attached thereto one fan blower that furnishes air for the purpose of forced ventilation to the motors. Each dynamotor is controlled by a separate switch (Type 544-A), located on No. 1 end of the locomotive. The supply circuit is protected by a fuse located in a special box on the floor in the apparatus compartment at No. 1 end of the locomotive.

2. Electric Compressor Governor (1)—In conjunction with the electro-pneumatic compressor switch and electrical details constitutes the Governor Synchronizing System for insuring uniform compressor labor.

3. Main Reservoirs (4)—To which the compressed air is delivered from the air compressors where it is cooled and stored for use in charging the brake system.

4. Safety Valves (2)—One connected to the first main reservoir of each set, which protect against excessive main reservoir pressure in case the Governor Synchronizing system (or the governors) for any reason fail to stop the compressors.

5. Feed Valve (1)—Which automatically maintains a predetermined normal pressure in the brake system.

6. Reducing Valve (1)—Which reduces main reservoir pressure for straight air operation and for the air signal system, when used.

7. Two Illuminated Duplex Air Gauges (2)—Located near each brake valve, the larger of which indicates equalizing reservoir and main reservoir pressures and the smaller, brake pipe and locomotive brake cylinder pressures.

8. Two Brake Valves (2)—One at each end of the locomotive, consisting of an Automatic and an Independent portion. The Automatic portion controls the operation of the locomotive and train brakes; the Independent portion controls the operation of the locomotive brakes only. By proper movements of the automatic brake valve handle (the lower and larger one), the motorman is able to charge the entire system on the locomotive and train, apply the brakes and hold them applied, release the brakes on the locomotive and train, or hold the locomotive brakes applied while releasing the train brakes and recharging the entire system. By proper movement of the independent brake valve handle, (the upper and smaller one), the locomotive brakes can be operated independently of the train brakes at any and all times.

9. An Equalizing Reservoir (1)—Which adds volume to the space above the equalizing piston in the brake valve so that reductions in brake pipe pressure may be properly made during service application of the brakes.

10. A Distributing Valve (1)—Which automatically controls the flow of air from the main reservoirs to the locomotive brake cylinders when applying the brakes, and from these brake cylinders to the atmosphere when releasing the brakes; and which automatically maintains locomotive brake cylinder pressure against leakage, keeping it constant when holding the brakes applied. The distributing valve therefore bears a similar relation to the brakes on the locomotive as the triple valve bears to those on the car, besides performing additional functions.

11. One Brake Cylinder (1)—With pistons and rods so connected through the brake levers to the brake shoes

that when the pistons are forced outward by air pressure this force is transmitted through said rods and levers to the brake shoes and applies them to the wheels.

12. A Centrifugal Dirt Collector (1)—Which is connected in the branch pipe between the brake pipe and distributing valve as near the distributing valve as circumstances will permit. The dirt collector is for the purpose of preventing pipe scale, cinders or foreign particles of any kind from reaching the distributing valve.

13. A Combined Strainer and Check Valve (1)—Which, together with a Cut-out Cock, constitutes the dead engine fixtures, enabling the brakes on a locomotive being hauled dead in a train to be operated like those of any car on the train.

14. Various Cut-out Cocks, Hose, Couplings, Dummy Couplings, Etc., the location and uses of which will be readily understood from the diagram of the equipment, Fig. 69, and the descriptions which follow.

15. Two Air Alarm Whistles (2)—One at each end of the locomotive, to be used as a warning of approach, with the necessary *whistle valves and cut-out cocks.*

16. The Train Signal System provides a means whereby signals may be transmitted from any part of the train to the motorman.

The brake system requires two lines of *pipe,—Main Reservoir Pipe* and *Brake Pipe*, the latter being continuous throughout the train.

The Main Reservoir Pipe has branches leading as follows: To the *compressor governor* and to the *electro-pneumatic compressor switch* through *cut-out cocks;* to the *distributing valve;* to the *feed valve;* to the *reducing valve;* to the large *duplex air gauge;* and to the *brake valves.*

The Brake Pipe leads from the brake valves throughout the length of the locomotive and train, having branches connecting to the *distributing valve* on the locomotive and to the *triple valve* on each car. It forms the means of communication by which the motorman, by

proper manipulation of the brake valve handle, can operate the brakes on the entire train. A branch from the brake pipe just below the brake valve cut-out cock, leads to the small *duplex air gauge*.

CONTROL RESERVOIR, located underneath the floor on the left side looking toward the No. 1 end of the locomotive, is provided for storage of air to operate the contactors, reversers, circuit breaker and series parallel switch.

The control reservoir is supplied with air from the main reservoir through a cutout cock and reducing valve. The cutout cock and reducing valve are located on the left side in the center of the cab looking toward the No. 1 end. The purpose of this control reservoir is two-fold; viz:

1st.—It provides a supply of air at reduced pressure (70 lbs).

2nd.—It provides a supply of air in case of accident to the air system whereby the locomotive may be operated regardless of main reservoir pressure.

The capacity of this reservoir is limited and in order that the locomotive may be moved off the line in case of defects in the air system, the controller should not be operated beyond the series position. No time should be lost in clearing the main line, as the air pressure will gradually reduce below 50 pounds at which pressure the contactors and reverser will not operate.

INSTRUCTIONS FOR OPERATING THE ELECTRIC LOCOMOTIVE AIR BRAKE EQUIPMENT

Charging

Before starting the air compressor (the locomotive not being coupled to the train), *close* the drain cocks in the reservoirs, the brake pipe angle cocks, the main reservoir pipe cut-out cocks and the signal pipe cut-out cocks at each end of the locomotive, the cut-out cock

under the alarm whistle not to be used and the double heading cock under the brake valve not to be operated, also the cut-out cock in the branch pipe connecting the main reservoir pipe to the brake pipe and containing the dead engine fixtures. See that all the following cocks are *open:* governor cut-out cock, compressor switch cut-out cock (if the governor synchronizing system is installed), main reservoir cut-out cock, brake cylinder cut-out cocks on the locomotive, cut-out cock under alarm whistle to be operated, cut-out cocks in pipes leading to car discharge valve and signal whistle, brake pipe cut-out cock under the brake valve to be operated, distributing valve cut-out cock, all brake pipe angle cocks and signal pipe cut-out cocks between cars and locomotive.

See that all hand brakes are fully released.

Place the handles on the brake valve to be operated, (the cut-out cock underneath it being open), and move them to *Running* position. Then start the compressor by closing the two switches in the compressor circuit.

Do not attempt to move the train, (or locomotive), until the brake pipe gauge hand shows full brake pipe pressure.

The instructions for manipulating the air brake equipment on electric locomotive are practically the same as those given for the combined automatic and straight air brake used on steam locomotives known as the No. 6 ET Equipment, which is standard for use on steam locomotives; therefore, no radical departure from present methods of brake manipulation is required to get the desired results.

Running

Keep both the independent and automatic brake valve handles in *Running* position when not being used.

In event of sudden danger move the automatic brake valve handle quickly to *Emergency* position, at the extreme right, and leave it there until the train stops and the danger is past.

After an emergency application of the brakes, while running over the road, due to any cause other than by the operating motorman himself, he shall be governed as follows:

(1) IN PASSENGER SERVICE move the automatic brake valve handle to *Emergency* position at once and leave it there until the train stops.

(2) IN FREIGHT SERVICE move the automatic brake valve handle to *Lap* position and let it remain there until the train stops. After the train stops the handle should be moved to *Emergency* position and left there to insure the brakes remaining applied until released by the motorman in charge of the train or until hand brakes can be set to hold the train, if a stop for any length of time is required.

This is to prevent loss of main reservoir pressure and insure the brakes remaining applied until released by the motorman in charge of the train. After the train stops the cause of the application should be located and remedied before proceeding.

LOCOMOTIVE AND TRAIN BRAKES

Service Application

To apply the brakes for an ordinary stop, move the automatic brake valve handle to *Service* position until the desired reduction has been made, as indicated by the equalizing reservoir pressure hand of the large duplex air gauge, then return to *Lap* position, which is the position for holding all brakes applied. The handle should remain in this position until it is desired to release the brakes or to apply them with greater force.

How much the brake pipe reduction should be and whether a full reduction should be made at once or the brakes graduated on, depends upon the conditions existing in each particular case, such as the speed and weight of the train, condition of rail, grade, kind of stop desired, and so on. It should be especially borne in mind, however, that the retarding effect of any given reduction is relatively greater at low than at high speeds, other conditions being equal. When making a service application the brake pipe pressure should never be reduced below the "Equalizing Point," at which the brake cylinder and auxiliary reservoir pressures become equal. Under normal operating conditions this corresponds to a reduction of 20 lbs. from 70 lbs. brake pipe pressure. Beyond this point further reduction will not cause any increase in brake cylinder pressure, is a needless waste of air and interferes with the release of the brakes.

The best possible stop will be made when the brakes are applied as hard, *at the very start*, as the conditions of speed, rail and comfort of passengers will permit, and then releasing as the speed of the train is reduced, so that at the end of the stop little or no pressure remains in the brake cylinders. When the rail or train conditions are unfavorable it may be desirable to divide the initial application into two reductions, the first, say, an 8- or 10-lb. reduction to allow the train slack to adjust itself gradually, then followed after three or four seconds by the remaining amount of brake pipe reduction necessary to obtain the total application desired.

Because the retarding effect of any given reduction is greater at low than at high speed, a heavy brake pipe reduction at low speeds will result in an abrupt stop, with perhaps discomfort to passengers or slid wheels. At *high* speeds a heavy initial reduction should be made in order to obtain the most effective retardation possible when the momentum of the train is greatest. If the brake cylinder pressure is very light at first and is increased as the speed of the train diminishes, so that the highest pressure is obtained at the end of the stop, it not only makes a longer stop but the high cylinder pressure at the end will be liable to produce a rough stop, perhaps slide the wheels and result in loss of time because of the necessity for waiting until this high cylinder pressure can exhaust before the train can proceed.

To make a smooth and accurate *two-application passenger stop*, make the first application sufficiently heavy to bring the speed of train down to about 15 miles per hour at a convenient distance from the stopping point, then release as explained later and re-apply as required to make the desired stop, the final release being made as explained below.

To properly weigh all these varying factors in every stop becomes, after a little practice, an act of unconscious judgment. Careful attention to cause and effect at the very start and real desire to improve are the most necessary qualifications in order to become expert in handling this or any other form of brake equipment.

Holding Brakes Applied

When the handle of the automatic brake valve is left in *Lap* position after an application, the brakes on the locomotive and the entire train will remain applied. This position should therefore be used to hold all the brakes applied between successive reductions when graduating the brakes on, and during the stop until it is desired to release the brakes.

Never allow the brake valve handle to remain in Lap Position except while bringing the train to a stop, and it should not be allowed to remain in this position a sufficient length of time to permit brake cylinder leakage to materially diminish the braking power on the cars.

Release

Passenger Service.—In making the first release of a two-application stop the brake valve handle should be moved to *Release* position and then quickly back to *Running* position, where it should be allowed to remain for an instant, (1st, to permit the pressure in the equalizing reservoir and brake pipe to equalize and 2nd, to release part of the driver brake cylinder pressure), then

moved to *Lap* position and from there to *Service* position as required. In passenger service the time the handle is in *Release* position should be only momentary but the time in *Running* position should be governed by the conditions existing for each particular case, such as the length of train, kind of reduction made, time available, and so on.

In making the final release of a two-application stop, with short trains, release shortly before coming to a standstill by moving the handle to *Release* position and immediately back to *Running* position, and leave it there. With long trains, the brakes should, as a rule, be held applied until the train stops.

The release after a one-application stop should be made in the same manner as the *final* release of a two-application stop.

Freight Service.—Under normal conditions the train should come to a stop before releasing the brakes on a freight train, especially a long one, rather than attempt to release at low speed.

Train Brakes Only.—While releasing the brakes on the cars and recharging the system the locomotive brakes may be held applied if necessary, (as for example, when stopping at a station on a grade), by means of the automatic brake valve. The usual method of making such a release is as follows: Move the automatic brake valve handle to *Release* position for the time necessary to start all train brakes releasing, then to *Holding* position. In this position of the brake valve handle, the train brakes will continue to release but the locomotive brakes *will not release* The locomotive brakes can then be fully released by placing the automatic brake valve handle in *Running* position and leaving it there, or they may be graduated off by short successive movements of the handle between *Running* and *Holding* positions. If the independent brake valve handle is in *Lap* position, the locomotive brakes cannot be released with the automatic brake valve.

Care must be exercised in holding the locomotive brakes applied when releasing the train brakes that too high a pressure is not held in the locomotive brake cylinders, which might produce a rough stop, or that the train brakes are not released too soon, which would lengthen the stop and perhaps cause the locomotive driving wheels to slide.

It will be noted that when handling the automatic brake valve there is but one position, viz.: *Running* position, in which the locomotive brakes will release; and that they cannot be released with the automatic brake valve even in this position, unless the independent brake valve handle is in *Running* position.

If the cars are equipped with graduated release brakes having this feature cut in, *to graduate or partially release both the locomotive and train brakes after an automatic application*, move the automatic brake valve handle to *Running* position for a moment, then back to *Lap* position, repeating this operation as may be necessary until the train is brought to rest with only enough pressure retained in the brake cylinders to prevent it from rolling.

Emergency

Should it become imperative to stop in the shortest possible time and distance to save life or avoid accident, move the automatic brake valve handle quickly from whatever position it may be in to *Emergency* position, which is at the extreme right, and leave it there until the train stops.

LOCOMOTIVE BRAKES ONLY

Service Application

When using *the independent brake only*, the handle of the automatic brake valve should be carried in *Running* position.

To apply locomotive brakes independently of the train brakes, use the independent brake valve. For a gradual application of the locomotive brakes, place the independent brake valve handle in *Slow Application* position until the brakes are sufficiently applied then return it to *Lap* position.

For a quick application of the locomotive brakes, place the independent brake valve handle in *Quick Application* position until the brakes are sufficiently applied, then return it to *Lap* position.

In either of these cases, if a full application is desired, or if the locomotive brakes are to be held applied for any length of time, as when holding the train at a station on a grade, leave the independent brake valve handle in *Slow Application position.* The handle is automatically returned from *Quick* to *Slow Application* position by a spring.

The independent brake valve should always be used to operate the brakes in service applications on a locomotive when running alone. When an emergency application of the brakes is necessary, always use the automatic brake valve.

Holding Brakes Applied

When the handle of the independent brake valve is left in *Lap* position, after an independent application, the locomotive brakes will remain applied. The locomotive brakes cannot be released by means of the automatic brake valve when the independent brake valve handle is in *Lap* position, and this position should therefore be used *only when operating the locomotive brakes with the independent brake valve.*

When handling a train and desiring to hold the locomotive brakes applied while releasing the train, use the automatic brake valve as explained under *Release.*

Release

The locomotive brakes can always be released by placing the handle of the independent brake valve in *Release* position. If the automatic brake valve handle is in *Running* position, as would be the case when using the independent brake valve to apply the locomotive brakes only, the locomotive brakes can be released by placing the independent brake valve handle in *Running* position. But if the automatic brake valve handle is *not* in *Running* position, as when holding the brakes on the entire train applied during a stop, and it becomes necessary to release the locomotive brakes on account of overheating the tires, sliding of wheels, etc., the independent brake valve handle should be placed in *Release* position.

Changing Ends

In changing from one end of the locomotive to the other when not on a grade, close the double heading cock in the brake pipe underneath the brake valve, remove the brake valve handles and after placing them on the b.ake valve at the other end, open the double heading cock underneath the brake valve to be operated. Always close the double heading cock before removing the brake valve handles and place the handles on the brake valve before opening this cock.

If it is desired to change ends while on a grade, first apply the brakes, as may be required, by the automatic brake valve and then move to *Lap* position, after which close the double heading cock in the brake pipe underneath the brake valve, remove the handles, place them on the brake valve at the other end and open that double heading cock as before.

Double Heading

When two locomotives are coupled together the brake pipe, main reservoir and signal pipe hose must be coupled up between the two locomotives and their cut-out cocks open.

Where there are two or more locomotives in a train, the instructions already given remain unchanged so far as the leading locomotive, or the locomotive from which the brakes are being operated, is concerned. On all other locomotives in the train, however, the double-heading cock under the automatic brake valve must be closed and the automatic and independent brake valve handles carried in *Running* position.

On the second locomotive close the double heading cock under each brake valve and place the handle of one automatic brake valve in *Running* position. The brakes of the second locomotive can then be operated from the first locomotive the same as those in the train. But if the motorman on the second locomotive finds it necessary, he can prevent the application of the brakes on the second locomotive by placing the independent brake valve handle in *Release* position. Also, if the brakes on the second locomotive are applied and there is danger of overheating the tires, or the drivers should slide, the brakes can be released by moving the independent brake valve handle to *Release* position, reapplying later, if necessary, by using the independent brake valve handle in the usual way, provided the handles of the independent and automatic brake valve on the second locomotive are, as before, left in *Running* position after the operation. This does not in any way interfere with the brakes on the second locomotive being afterwards released from the first locomotive in the usual way. The pressure in the brake cylinders on the second locomotive should never be thus reduced, however, except where absolutely necessary.

Dead Heading

When the locomotive is to be hauled dead in the train, place the handle of one automatic brake valve in *Running* position, close the double heading cock under each brake valve, and open the dead engine cock in the connection from the brake pipe to the main reservoir pipe. The locomotive brakes will then operate like those of a car in the train.

General

While handling long trains of cars, in road or switching service, the independent brake should be operated with care, to prevent damage to cars and lading, caused by running the slack in or out too hard. In cases of emergency arising while the independent brake is applied, apply the automatic brake instantly. The safety valve will restrict the brake cylinder pressure to the proper maximum.

The brakes on the locomotive and on the train may be alternated in heavy grade service where conditions, (such as short, steep grades or where grade is heavy and straight for short distance), require, to prevent overheating of driving wheel tires and to assist the pressure retaining valves in holding the train while the auxiliary reservoirs are being recharged. This is done by keeping the locomotive brakes released by use of the independent brake valve when the train brakes are applied, and applying the locomotive brakes just before the train brakes are released, and then releasing the locomotive brakes after the train brakes are re-applied.

Care and judgment should always be exercised in the use of driver brakes on grades to prevent overheating of tires.

When all brakes are applied automatically, to graduate off or entirely release the *locomotive brakes only,* use *Release* position of the independent brake valve.

The red hand of the gauge will show at all times the pressure in the locomotive brake cylinders and this hand should be watched in brake manipulation.

Release Position of the Independent Brake Valve will release the locomotive brakes under any and all conditions.

The train brakes should invariably be released before detaching the locomotive, holding with hand brakes where necessary. This is especially important on a grade, as there is otherwise no assurance that the car, cars, or train so detached will not start when the air brakes leak off, as they may in a short time where there is considerable leakage.

The automatic brakes should never be used to hold a locomotive or a train while standing even where the locomotive is not detached, for longer than ten minutes, and not for such time if the grade is very steep or the condition of the brakes is not good. The safest method is to hold with hand brakes only and keep the auxiliary reservoirs fully charged, so as to guard against a start from brakes leaking off and to be ready to obtain any part of full braking power immediately on starting.

The independent brake is a very important safety feature in this connection, as it will hold a locomotive or quite a heavy train on a fairly steep grade if, as the automatic brakes are released, the slack is prevented from running in or out, (depending on the tendency of the grade), and giving the locomotive a start. To illustrate: The best method to make a stop on a descending grade is to apply the independent brake heavily as the stop is being completed, thus bunching the train solidly; then, when stopped, place and *leave* the handle of the independent brake valve in *Application* position; then release the automatic brakes and keep them charged. Should the independent brake be unable to prevent the train from starting, the automatic brakes will become sufficiently recharged to make an immediate stop; in such an event enough hand brakes should at once be applied as are necessary to assist the independent brake

to hold the train. *Many runaways and some serious wrecks have resulted through failure to comply with the foregoing instructions.*

When leaving the locomotive, while doing work about it, always leave the independent brake valve handle in *Application* position.

If the locomotive brake must be cut out for any reason, close the distributing valve cut-out cock in the branch from the main reservoir pipe to the distributing valve.

TESTING LOCOMOTIVE BRAKES

In preparing the locomotive for service and before making the following tests, follow carefully the rules given under the heading "Charging," page 156.

TEST No. 1.—When the system is charged and the governor stops the compressor, note whether a leak occurs at the service exhaust port of the automatic portion of the brake valve when the handle is in *Release, Running, Holding* or *Lap* positions. Leakage at this point indicates that the equalizing piston valve is leaking. If this leakage is due to foreign matter on the valve seat, it can usually be displaced by closing the cut-out cock underneath the brake valve, then making a heavy service application and returning the handle to *Release* position. The heavy blow caused at the exhaust fitting usually removes the obstacle and allows the equalizing piston valve to seat.

TEST No. 2.—Place the handle of the automatic portion of the brake valve in *Service* application and allow it to remain there until brake pipe pressure is entirely exhausted as indicated by the gauge hand, after which place the handle in *Lap* position and note if there is leakage at the rotary valve, which will be indicated as follows: Increase of brake pipe pressure will cause a blow at the service exhaust fitting; increase of equalizing reservoir pressure will cause the equalizing reservoir gauge to so

register; increase of pressure in the application chamber of the distributing valve will cause an increase in brake cylinder pressure or an intermittent blow at the safety valve.

TEST No. 3.—Make a partial *Service* application with the independent portion of the brake valve, then *lap* the valve. If brake cylinder pressure increases up to the amount for which the reducing valve is adjusted, it indicates leakage of the independent rotary valve.

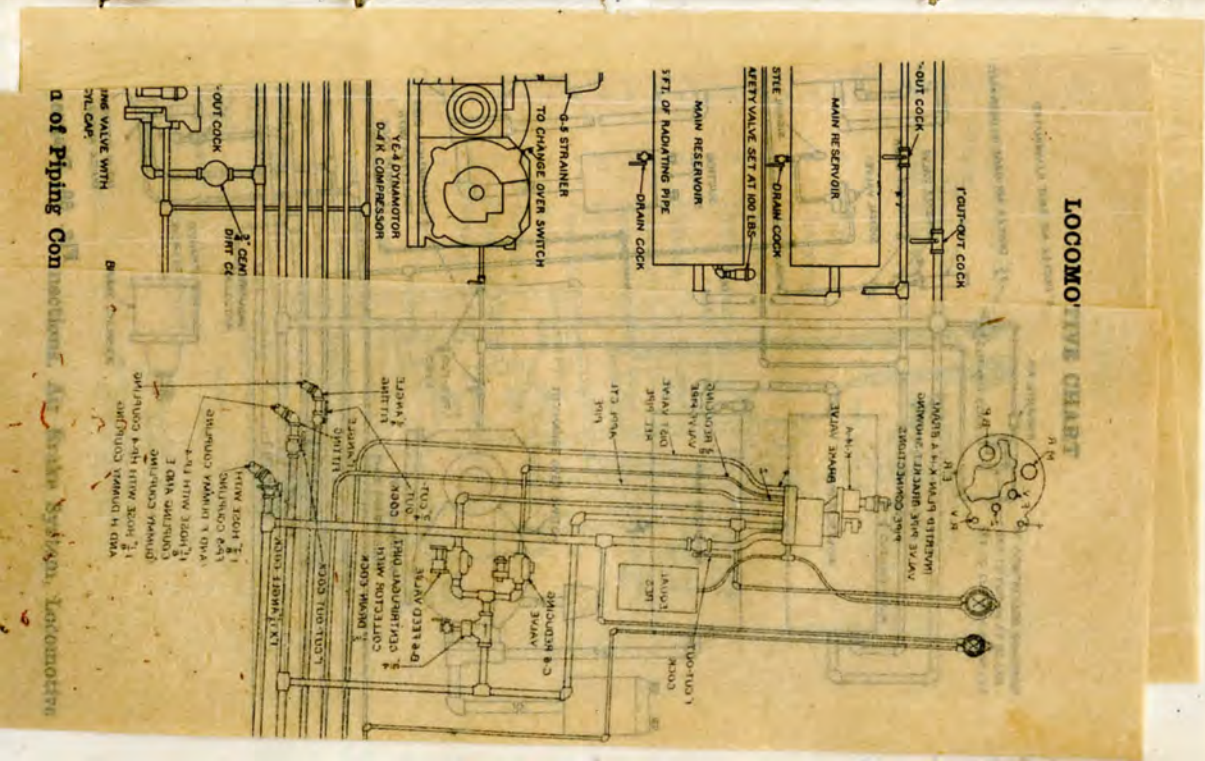
TEST No. 4.—If after a Service application, the locomotive brakes release, air is leaking from the application cylinder or the application cylinder pipe. Leakage at the brake cylinder exhaust port of the distributing valve when the locomotive brakes are applied indicates a leaky exhaust valve, while an increase of pressure above that put into the brake cylinder at the time of an application or blowing of a safety valve indicates that the application valve is leaking. Should there be a blow at the exhaust port of the automatic portion of the brake valve when both handles are in *Running* position, it indicates leakage past the equalizing valve.

A leaky graduating valve may be detected by increase in brake pipe pressure when the handle of the automatic portion of the brake valve is in *Lap* position after an ordinary service application.

WEIGHTS AND DIMENSIONS OF SUBURBAN AND INTERURBAN ELECTRIC PASSENGER TRAIN CARS

ITEM	Comb. Coach	Motor Coach	Control Coach	Baggage and Express Car	Baggage Express and Mail	Elec. Loco.
Weight of carbody complete without elec. equipment and air brake equipment	40,800	41,650	37,600	37,550	.....	.....
Weight of trucks complete without elec. equipment	29,500	29,500	23,600	29,500	.....	.....
Weight of car complete without elec. equipment and air brake equipment	70,300	71,150	61,200	67,050	.....	.....
Weight of carbody complete	56,300	58,100	43,400	55,100	.....	.....
Weight of trucks complete, with motors	43,900	43,900	23,600	43,900	.....	.....
Weight of car completely equipped	100,200	102,000	67,000	99,000	.....	.....
No. of two-passenger seats	26	30	30	.....	.....	.....
Seating capacity	52	60	60	.....	.....	.....
Length of body over end sills	49′ 5⅜″	46′ 10″	46′ 10″	52′ 0¼″	.....	.....
Length of vestibule	5′ 0″	5′ 0″	5′ 0″	.....	.....	.....
Length of baggage compartment	10′ 0¾″	.....	.....	54′ 4″	.....	.....
Length over buffers (coupled)	56′ 10″	56′ 10″	56′ 10″	56′ 10″	.....	.....
Width of cars over eaves	9′ 5 3/16″	9′ 5 3/16″	9′ 5 3/16″	9′ 5 3/16″	.....	.....
Width of cars over sills	9′ 2″	9′ 2″	9′ 2″	9′ 2″	.....	.....
Height of car body from running rail to top of roof	13′ 0½″	13′ 0½″	13′ 0½″	13′ 0½″	.....	.....
Distance from running rail to underside of sills	3′ 8¼″	3′ 8¼″	3′ 8¼″	3′ 8¼″	.....	.....
Seat centers	2′ 10″	2′ 10″	2′ 10″	.....	.....	.....
Window centers	2′ 10″	2′ 10″	2′ 10″	.....	.....	.....
Truck centers	35′ 0″	35′ 0″	35′ 0″	35′ 0″	.....	.....
Wheel base of car	42′ 0″	42′ 0″	42′ 0″	42′ 0″	.....	.....
Wheel base of truck	7′ 0″	7′ 0″	7′ 0″	7′ 0″	.....	.....

The normal height of trolley wire above top of rail is 22 feet.



LOCOMOTIVE CHART

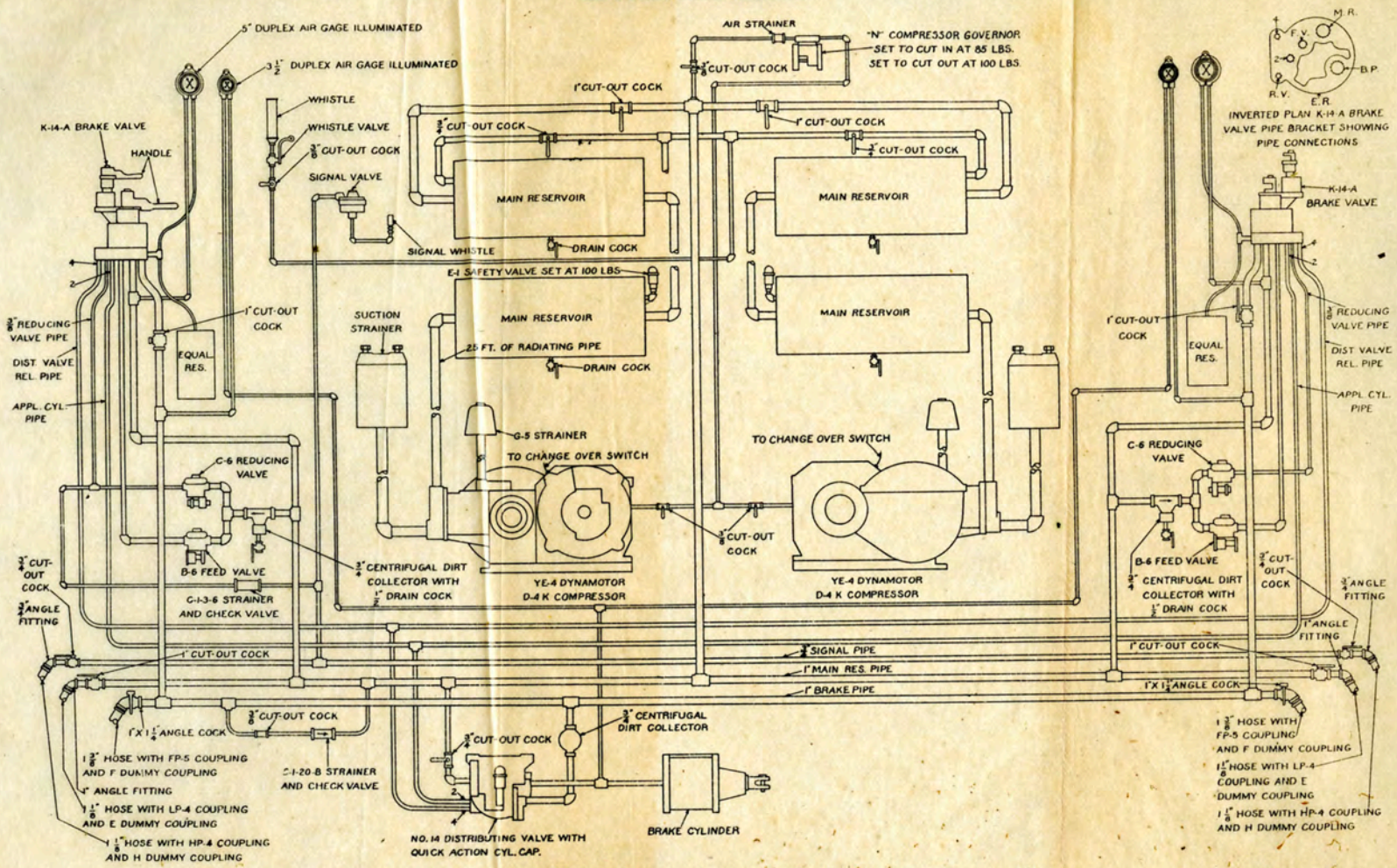


Fig. 69, Diagram of Piping Connections, Air Brake System, Locomotive

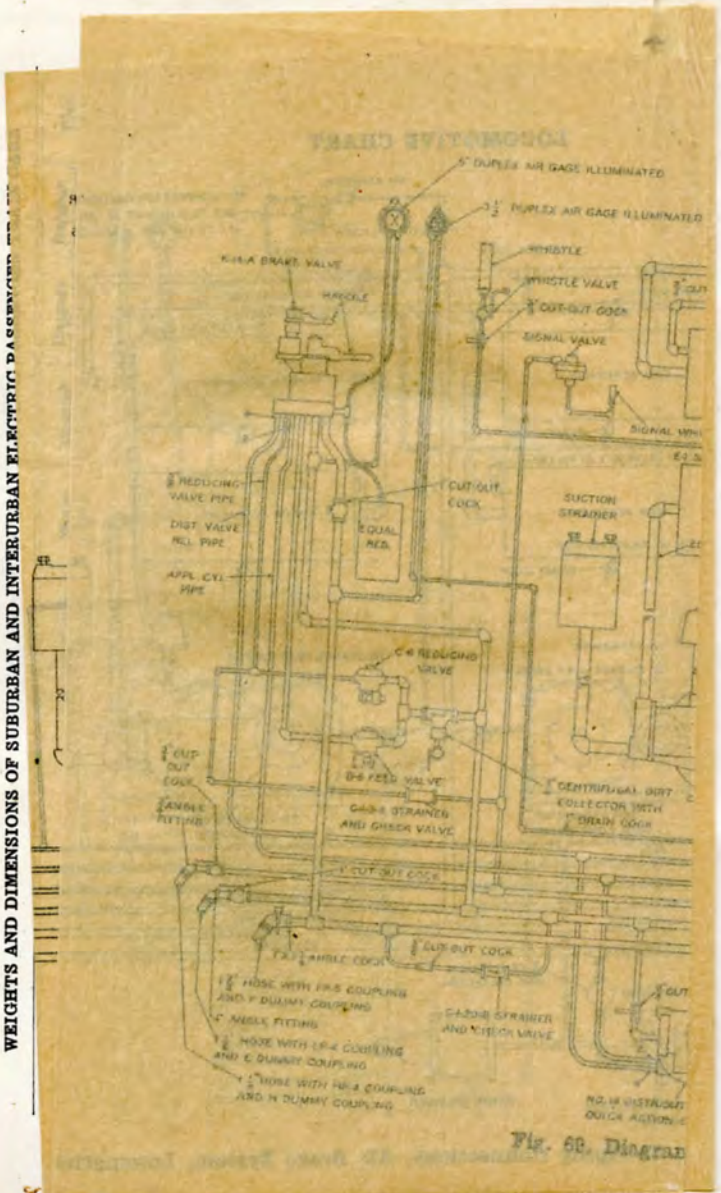


Fig. 68. Diagram

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