PNEUMATIC DOOR APPARATUS

"National Pneumatic" System
(Patented)

TRAMWAYS

C. D. PETERS & Co LTD
Caxton House, Westminster,
LONDON. S.W.1.

G. D. PETERS & CO., LIMITED

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TRAMWAYS.

"NATIONAL PNEUMATIC SYSTEM."

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LONDON & SLOUGH.

FOREWORD.

TRAMWAYS SECTION.

One of the most difficult problems connected with modern and improved Passenger Transport facilities lies in the successful handling of Passenger Traffic with a minimum of inconvenience to the passenger combined with a maximum of safety and rapidity of passenger interchange.

The "National Pneumatic" System of Door Operation and Control affords the best and most direct means to this end, whether the Passenger Service be operated by a Railway, Tramway or Omnibus Undertaking.

A Catalogue dealing with the apparatus for Pneumatic Door Operation and Control on the "National Pneumatic" System suitable for application to Railway Coaches, Tramcars and Omnibuses is available, but this section deals particularly with Pneumatic Door Operation for Tramcars.

We shall always be glad to put forward, on request, considered schemes and proposals for any application dealing with Passenger Traffic.

The Pneumatic Operation of doors contributes, more than any other single item of equipment, effectively and in many different ways towards making every Tramcar a safer Car, a more comfortable Car, and a faster Car.

INTRODUCTION.

PNEUMATIC DOOR APPARATUS FOR TRAMWAYS.

The problem ever present in the minds of those responsible for the operation of Tramway Undertakings is how to convey the largest possible number of passengers with a maximum amount of **SPEED, ECONOMY and SAFETY.**

Much has been effected by providing more powerful Electrical Equipment and Brakes to obtain more rapid acceleration and deceleration in running; but little or nothing has been done to eliminate one great source of wastage, namely, time lost unnecessarily at stopping places, largely due to the confusion caused by passengers being required to board and leave a car by the same entrance.

The importance of this factor may be gauged from a statement made by the Manager of one of the large Undertakings at a Conference of Tramways Officials and Engineers held recently, to the effect that on his system a reduction of **one second**—on the average—in time lost at each stopping place would represent a **saving** in operating expenses of an amount approaching **£20,000 per annum.**

PNEUMATIC DOOR APPARATUS provides the solution to this part of the problem, and renders possible a substantial increase in the three important factors mentioned, viz., **SPEED, ECONOMY and SAFETY;** at the same time adding materially to the **COMFORT** of the passengers, thus increasing the popularity of the Service and consequently its revenues.

1. **SPEED.** The use of power operating and controlling apparatus, makes it possible to equip the car with extra side Entrance Doors, or with Two-Stream, Three-Stream or Four-Stream Entrance and Exit Doors on the front and rear Platforms. Such door arrangements enable passengers to enter and alight simultaneously without congestion on the street around the doors, or inside the car.

It takes less time to open and close doors by simply pushing an electric switch button, or turning a pneumatic valve handle, than it takes to open and close the same doors by hand. Passengers can therefore begin to board and alight in less time after the car has stopped, and the doors can be closed again more promptly, when the interchange of passengers has been completed. If, moreover, the Motorman's Signal System is used, the Motorman is given a starting signal simultaneously with the closing of the doors, and does not have to wait for the slower bell cord signal.

Many valuable seconds, therefore, are saved at every stopping place, "standing time" is reduced, and the operating speed increased accordingly.

2. **ECONOMY** is effected by the use of Pneumatic Door Apparatus in four different ways:—

(*a*) By reducing the proportion of unprofitable standing time as already explained.

(*b*) By enabling the vehicle staff to be reduced to the minimum, thus reducing the wages bill.

(*c*) By minimising the possibility of accidents to passengers with corresponding reductions in Insurance Premiums.

(*d*) By eliminating the banging and slamming of doors, and resultant wear and tear on the vehicles and their fittings.

3. **SAFETY.** Where an extra Exit Door is provided it is essential, to ensure *absolute safety*, that such a door is so arranged that it does not open until the car stops; and the only satisfactory method of accomplishing this is by the adoption of Pneumatically-operated Door Equipment.

Where "One-Man" Cars can be employed, safety for passengers is ensured by the complete enclosure of car platforms. All doors are closed and all steps folded in before the car starts. No one, therefore, will attempt to board a car in motion, as the doors are closed against him and he cannot cling to folded steps. Similarly, no one can fall from, or attempt to alight from, a moving car, as the doors are not open until after the car has stopped.

At the same time provision is made so that in case of accident or emergency, such as failure of the line current, collisions, etc., all doors and steps can be readily operated by hand, so as to enable passengers to leave the vehicle.

4. **COMFORT** for the passengers is ensured, as they are less crowded and less hurried when boarding and alighting from a car which has separate entrances and exits. They are also protected while so doing, for the car cannot start while a passenger's foot is on the step. The door cannot hurt them if it strikes them in closing, as there is a moulded rubber Safety Door Edging running the whole length of the door. Also there is no slamming or banging to jar their nerves or arouse their tempers. The doors open and close with a well regulated smooth and "cushioned" action which is always the same.

* * *

"THE CIRCULATING LOAD."

1. TWO-MEN" CARS WITH EXTRA EXITS.

A "FLOW" OF PASSENGERS FROM REAR TO FRONT.

Assuming that the car is of the usual "Two-Men" Type (it may be with an upper deck), the Extra Exit Door is situated at the front of the car, either at the left-hand side of the driver, or underneath the staircase leading from the upper deck. Such a door is preferably Treadle Controlled, and may be arranged so that it is automatically freed for operation simply by passengers desiring to alight stepping on to the Treadle Plate. Alternatively, it can be arranged that the driver must first free the door for Treadle Control, by means of a Control Valve or Switch, or he may actually open and close the door positively by means of such a Valve or Switch. For Treadle Control, the **Folding Door** provides the most satisfactory results; but if it is for any reason desirable to fit a sliding door, this may be arranged, provided the construction of the car permits.

Where the question of initial cost is a serious consideration, it is not essential to control such a door automatically, although it will be readily appreciated that the extra safety features incorporated with the Automatic Control System render such control an extremely desirable feature.

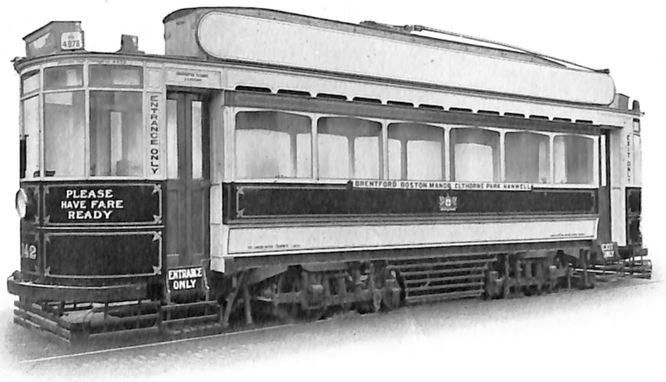
Whatever the system of control, the advantages obtained by providing this Extra Exit, and the circulating flow of passengers from rear to front of the car, will be apparent.

2. **THE "ONE-MAN" CAR.**

A "FLOW" OF PASSENGERS FROM FRONT TO REAR.

With this type of car control, only one man—the motorman—is required to operate the vehicle. On each side of the car an Entrance and an Exit Door is provided—the Entrance Door being at the front and the Exit Door at the rear. Passengers having paid their fares to the Motorman, and received their tickets, are free to enter the passenger saloon. Passengers who wish to alight, walk to the rear of the car, and stepping on to the Treadle Plate, let themselves out through the Exit Door. Immediately these passengers have alighted, the Exit Door closes and the Step folds up, thus preventing the ingress of passengers at this point.

* * *



Outside View of "One-Man" Tramcar, which we have equipped with Automatic Electro-Pneumatic Door Controlling and Operating Mechanism for the London United Tramways.

TECHNICAL DETAILS.

Numerous systems are available for such door operation and control, as hereafter described, and from a study of the actual conditions under which each vehicle, or set of vehicles, has to operate, a suitable system can be built up to meet these operating conditions. If desired, the equipment may be built up from **several** systems of control and thus combine **all** of the available safety features in each vehicle.

DOOR OPERATION AND DOOR CONTROL.

It is essential to clearly distinguish between **Door Operation** and **Door Control.** Doors should always be **operated pneumatically** since it is absolutely essential to ensure that their movement is well regulated and "cushioned," and for the purpose of operation many types of pneumatic door engines are available (see following sections).

Door Control is an entirely separate matter from that of operation, and the dividing line is drawn at the Rotary Valve* on the Pneumatic Door Engine. Control of this Rotary Valve may be effected by either :—

(*a*) **Manual Control,** in which the Rotary Valve is operated by rods actually moved by the driver or conductor so as to rotate the Valve Trip. (This type of control must be located fairly close to the engine.)

(*b*) **Pneumatic Control,** in which the Rotary Valve is operated by means of a Pneumatic Valve Puller, which is charged and discharged of air through a Rotary Valve operated by the driver or conductor. (This type of control should not be employed where the distance between the control point and the Valve Puller exceeds 25-ft., as the operation will be delayed perceptibly if this is increased.)

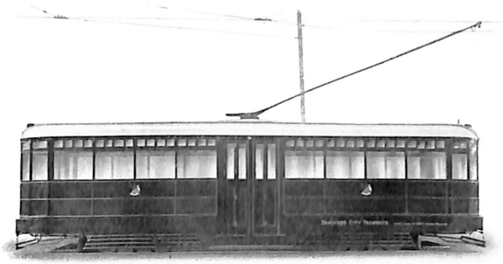
(*c*) **Automatic Pneumatic Control,** in which the **whole** of the gear functions automatically. For the operation of this control it is essential that air brakes are fitted to the car. The motorman retains his grip on the "Deadman" handle of the brake, until he desires to pick up or set down passengers. When the car is at rest, the release of the "Deadman" handle causes a system of relay valves to permit the passage of air to, or its exhaust from, the Valve Pullers. While the car is running, however, it is impossible for passengers to operate the doors, and the Electro-Magnetic Air Lock prevents the car doors being opened even by an emergency release of the "Deadman" handle, until the speed of the car has been reduced to approximately two miles per hour. The motorman has only one handle to operate—the Change-Over Valve—**and this only at the termination of each trip.**

(*d*) **Automatic Electro-Pneumatic Control,** in which the **whole** of the gear functions automatically. It is not absolutely essential for the operation of this control that air brakes are fitted to the car, but it is more simple to provide the necessary safety features, if such brakes are used. The principle of this system is that the main items of the gear are electrical rather than pneumatic, but the equipment functions in exactly the same way as that described under (*c*) above. An additional safety feature is incorporated in this system—the "No-Volt" Relay Valve, which ensures that a failure of line current will result in the automatic freeing of all doors, ready for hand operation. If air brakes are not fitted, the "Deadman" handle may be fitted to the Traction Controller if desired. The motorman has only one handle to operate—the Change-Over Switch—**and this only at the termination of each trip.**

Alternatively, this system may be used for **non-automatic** working, by using a Rotary Drum Switch, having selective positions for the door operations required. This provides an electro-pneumatic equivalent of system (*b*).

(*e*) **Automatic Electrical Control,** in which the **whole** of the gear functions automatically. It is not essential for the operation of this control that air brakes are fitted to the car, and indeed the system has been designed for use **without air brakes.** System (*d*) above requires considerably less piping than system (*c*), and similarly system (*e*) requires considerably less piping than system (*d*). Only **one** pipe for air supply to the door engines is required, and all control of the door-operating mechanism is accomplished electrically through the medium of the Interlocking Drum Switch which is situated below the Traction Controller, and driven by same. On the Motorman bringing the car to rest, and returning his Traction Controller handle to the " off position," the doors are caused to operate automatically. This, however, does not prevent unlimited " coasting " with the Controller in the " off position "—it is only after the **Magnetic Brakes** have been applied, the Controller Handle brought into the " off position," and a slight pause made in that position, that the automatic operation of the door equipment occurs.

* **Note.** Where operating conditions necessitate the use of the **Ball Checked Valve** (instead of the **Rotary Valve**) on the Door Engine, this may be readily fitted to systems (*b*), (*d*), and (*e*) above, by employing duplex Rotary Valves or Electro-Pneumatic Valves, respectively, for control purposes.



Outside View of Tramcar, which we have equipped with Double Folding Doors and Safety Interlocking Door Control System for the Bradford Corporation Tramways.

FOLDING STEPS.

The height of Tramcar platforms above the street level renders it essential to provide steps, and these should always be of the " Folding " type and coupled to the doors so as to ensure that it is impossible for passengers to ride on these steps when the doors are closed. See Section T.4. for description of step-operating mechanism.

FOLDING DOOR GEAR.

Folding doors provide the neatest construction for power operation on a Tramcar, and they have the added advantage that a door pocket is not required. The Door Engines (see Section T.2.) are generally located above the doorway in a header box. It should be understood, however, that the design of the engine is such that it is not essential to fit it in a header box—it may be conveniently slung underneath the car platform on bearers, or may be located under a longitudinal or cross seat near the door which it is required to operate. In any type of mounting, the Folding

Door Engine is connected to the door shaft by ball-jointed connecting rods which allow free movement of the rods in any desired plane without rattle due to vibration of the vehicle. The movement of the Folding Door Engine is transmitted to the door shaft by means of plain or geared adjustable terminals, situated at the top or bottom of the door shaft. The movement of the door shaft is communicated directly to the primary leaf of the door, by the door straps, and by means of the door roller brackets and guides, to the secondary leaf of the door.

For convenience in selection, it should be noted that the following combinations of door operations are possible :—

(1) **SINGLE FOLDING DOORS,** with equal or unequal leaves and to fold either inwards or outwards.

(2) **DOUBLE FOLDING DOORS,** with equal or unequal leaves and to fold either inwards or outwards.

(3) **COMBINED SWING AND SINGLE FOLDING DOORS,** with equal or unequal folding leaves, and doors swinging and folding either inwards or outwards.

Where Single Folding Doors are used, the Door Engine can be fitted either in a Header Box or underneath the car ; but with Double Folding Doors or Combined Swing and Single Folding Doors the Door Engine cannot as a rule be fitted otherwise than in a Header Box, without introducing mechanical difficulties.

With any of the above combinations, folding steps of either two-arm, three-arm, or even four-arm type may be operated without increasing the engine-power required.

For further particulars and diagrams, see Section T.3.

SLIDING DOOR GEAR.

Where it is essential to fit Sliding Doors on a Tramcar, the engines may either be located under longitudinal or cross seats, in header boxes, or on the platform of the car. Door pockets must be provided, either in the interior of the car or inside the enclosed platform end. It is possible to fit sliding doors to the Exits of the car, but if Treadle Plates are to be employed, it is not advisable to use sliding doors unless the car construction lends itself readily to such fitting.

Double Sliding Doors may be operated, and if desired, folding steps may be incorporated to work with the doors.

TREADLE PLATES.

The ideal control for exit doors on Tramcars is the Treadle Plate Mechanism. Briefly, this consists of a flat chequered plate made to replace a portion of the car platform, and built up with its various component parts, and the step hanger mechanism, to form a complete unit, the dimensions of which are in every case made to conform to the car construction. The whole unit is preferably slung from the opposite platform angle of the car so as to give an almost vertical movement to the plate. The total amount of downward travel of the plate against the action of the balance springs is $\frac{3}{8}$-in., of which the first $\frac{1}{16}$-in. movement has no effect on the operating valve or switch.

Where the car construction prohibits the employment of the standard Treadle Plate, a pivoted plate working on a bearing at its inside edge, can be supplied. This type of plate necessitates a

larger area, to ensure that a person standing near to the pivotal point is capable of operating the Valve or Switch situated underneath.

INTER-CONNECTED BRAKES AND PNEUMATIC DOOR APPARATUS.

It is not essential to fit Air Brakes on a Tramcar in order to be able to operate the doors pneumatically (as already described under Sections (*d*) and (*e*) dealing with methods of control). However, where Air Brakes are already fitted, or where it is proposed to fit a combined system of Air Brakes and Pneumatic Door Operating Gear, the cost of installation of the latter is very considerably lessened.

Where Air Brakes are not fitted, the air supply is obtained from a small motor-driven Compressor. The capacity of the Compressor is arranged to give an ample supply of air for operating the doors, according to the service upon which the vehicle is operating, and under normal circumstances such a Compressor would **not** be large enough to provide sufficient air for operating **Air Brakes.** In the case of vehicles fitted with Air Brakes, a Compressor sufficiently large to adequately provide for all braking conditions will be found quite capable of coping with the additional load imposed by the Door Operating Mechanism. It may, of course, be necessary or desirable to add another Reservoir or Water Trap, but this would only occur in certain isolated cases.

In all cases, the Motor-Compressor units are arranged in conjunction with an Air-operated Switch, which is constructed so as to close the contacts (and so start up the Compressor Motor) at the required air pressure minima, and open these contacts at the required air pressure maxima. It will thus be seen that the operation of supplying air to the Pneumatic Door Equipment, or the Air Brakes, or both, is carried on automatically, and needs no attention on the part of the driver.

EMERGENCY OPERATION OF DOORS.

In order to cope with the conditions which may arise in Depôt use, and in the event of a necessity either to free or to lock a certain door in cases of emergency, a Release Valve is fitted to each Door Engine, and this enables an independent operation of **each** door (through the medium of the release valve attached to the appropriate engine) to be effected, without reference to the system of Control employed.

COMBINED SETS OF AIR BRAKES AND PNEUMATIC DOOR APPARATUS.

We are in a position to supply complete sets of Air Brakes and Pneumatic Door Apparatus, so designed and constructed as to give the best co-ordinated results, and, by reason of the economies which can be effected in the manufacture of such combined sets, we are able to offer equipment at an extremely attractive price. Further, by placing the full responsibility for the operation in our hands, we are able to **guarantee the satisfactory working of the entire equipment.**

AUTOMATIC CHANGE-GIVING MACHINES.

For " One-Man " Tramcars the use of an Automatic Change-giving Machine is advisable, so that the passengers are enabled to pay their fares, and receive their tickets and change **as they enter the car, and while they are passing the motorman,** without the slightest delay.

LONDON & SLOUGH.

Tillotsons (Bolton), Ltd., Art Printers, Bolton and London.

SYSTEMS OF PNEUMATIC DOOR OPERATION AND CONTROL

"NATIONAL PNEUMATIC SYSTEM" (PATENTED).

The selection of the most suitable system of Pneumatic Door Operation and Control for a Tramcar, depends to a large extent upon the service which the vehicle is required to operate, the size and design of the vehicle, and the local conditions which are met with on the routes served, such as exceptionally high peak loads at certain times of the day, competing transport services, Police Regulations, etc.

Generally, it is necessary for us to receive certain information before a recommendation can be made as to the system and set of equipment which will provide the best results. These requirements are tabulated below, for the guidance of purchasers when enquiring for sets of Pneumatic Door Equipment :—

(i). Dimensioned Drawings showing **outside elevation** of vehicle and **floor plans** of upper and lower decks, with indications as to position of doors and seats.

(ii.) Dimensioned Drawing of underframe, showing plan and side elevation.

(iii.) The type of Service Operation (*i.e.*, " One-Man," " Two-Men," or " One-Man "-" Two-Men ") should be stated.

(iv.) Particulars as to the number of doors, and whether Single-stream or Two-stream Doorways are required, with Front Entrance and Rear Treadle Exit, or vice versa. If single doors only are required, the location should be indicated on the drawings.

(v.) The clear height of the doorways, minimum clear openings, thickness of doors, and height of door sill plate above rail level, will be needed for the preparation of General Arrangement Drawings.

(vi.) If Folding Steps are required, the height from rail level to top of step board, and from top of step board to door sill plate, together with the minimum length of step board, should be stated. Local Regulations regarding step clearances and dimensions (folded and unfolded) should be quoted. A Transverse Sectional Drawing of the platform end will be required.

(vii.) If Treadle Plate Equipment is required, the information given in (vi.) above will be sufficient.

(viii.) If Air Brakes are fitted to the car, full particulars of these will be required, including the Air Compressor output (in cubic feet of compressed air per minute at the maximum working pressure), the dimensions of the Air Reservoir, the total volume of air used in the Brake Cylinders per brake application (in cubic feet of compressed air at the maximum working pressure), the number of service stops and average time per trip, and the sizes of air pipes used in the Air Brake Equipment. If it is required to interlock the air brakes with the Pneumatic Door System, this should be stated.

(ix.) The voltage of supply should be stated, giving average variation from normal.

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If desired, we shall be glad to arrange for our Representative to obtain all the particulars enumerated on the preceding page, provided that the necessary facilities can be given.

There are five main types of Pneumatic Door Control for Tramcars, namely :—(a) Manual, (b) Pneumatic (non-automatic), (c) Automatic Pneumatic, (d) Electro-Pneumatic, (e) Automatic Electric (see Section T.). Any one of these five main types may be further sub-divided into separate and distinct systems, according to the conditions of operation and the apparatus employed, etc.

It is impossible to present complete schematic diagrams for all available systems, incorporating the various combinations of apparatus, but in order to give some idea of the scope of the different schemes, four arrangements are illustrated, together with a diagram of Signal Wiring (see Figs. 1, 2, 3, 4, and 5).

Referring to Fig. 1 on page 4, this shows a schematic arrangement of piping and wiring for a Tramcar having Front Entrance and Rear Treadle Plate Controlled Exit Doors, similar door arrangements being provided for both sides of the car at appropriate ends. The doorways are of the " Single Stream " type.

The control system is of the Automatic Electro-Pneumatic type, governed by means of the Electric Door Lock and the " Deadman's Handle " on the air brake equipment. Only a certain portion of the air brake equipment is illustrated.

On the pneumatic side of the door equipment, the following apparatus is employed :—

From the Air Compressor, air is led into two Water Traps and from thence to the No-Volt Relay Valve. With the coil of the No-Volt Electro-Pneumatic Valve energised, air flows directly into the single pipe which feeds the door system and which runs from end to end of the car. Under these circumstances the exhaust valve of the No-Volt Relay Valve is closed ; this valve communicates with the valve chamber pipe of the " Deadman's " apparatus, when the coil mentioned above is de-energised.

The air supply for the four Type " E " Door Engines passes in each case through an Emergency Release Valve and $\frac{1}{4}$-in. Air Strainer to the Rotary Valve (see Section T.2), a parallel feed being taken to the top of each Electro-Pneumatic Valve, for control of the Valve Puller connected thereto.

On the electrical side of the door equipment, the following apparatus is employed :—

From the trolley or plough gear a feed wire is taken through a Fuse and an Isolating Switch (of the Tumbler or Snap type) to the coil of the No-Volt Electro-Pneumatic Valve, the other end of the coil being earthed. A parallel feed is also taken to the door system across the interlocking Switch of the Electric Door Lock (see Section T.6), and thence across an Air-operated Switch of the " Compressor Governor " Type. From this switch, the supply branches out into two parallel paths, one path leading to each side of the car equipment. Each parallel path crosses the contacts of a Single Pole Key-operated Change-over Switch (if in the "On" position), and from thence a further branch in parallel is made, one path leading to the coil of the Entrance Door Electro-Pneumatic Valve, the other path leading across the Treadle-operated Switch and the coil of the Exit Door Electro-Pneumatic Valve, to earth.

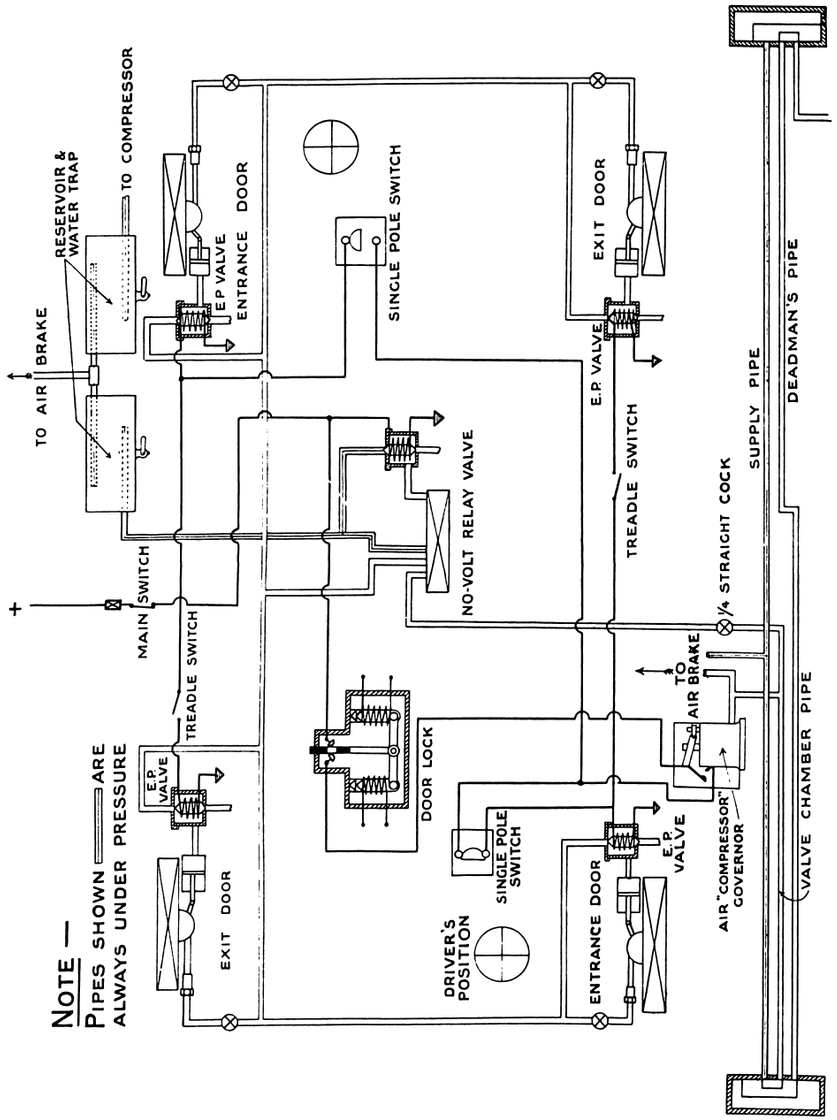


Fig. 1. Schematic Arrangement of Piping and Wiring for a Tramcar fitted with Automatic Electro-Pneumatic Door Control System, and Air Brakes with Slide Valve Type "Deadman's Handle."

Patent No. 262.854.

The Driver has no duties to perform in order to effect operation of the Pneumatic Door Equipment, except to place the Isolating Switch in the " On " position before leaving the Depôt, remove and replace the Operating Key on the appropriate Change-over Switch at the termination of each trip, and, if a trolley changing loop is not installed at the terminus, to close and open the Exhaust Valve, before and after changing the trolley position.

The operation of this system of equipment is as follows :—

At each stopping place the Driver brings the car to rest by applying the air brakes, and when the speed of the car has dropped below two miles per hour, the Electric Door Lock completes the circuit across the Interlocking Switch. As soon as the Driver is ready to permit of the interchange of passengers, he releases his grip of the " Deadman's Handle," thereby exhausting the operating diaphragm of the Air-operated Switch. Current then flows directly to the Entrance Door Electro-Pneumatic Valve, thereby opening the Entrance Door. Simultaneously, current flows to the Treadle-operated Switch, and if passengers wish to alight, a circuit is made through the Exit Door Electro-Pneumatic Valve, thereby opening the Exit Door. As soon as these passengers have alighted, the Exit Door and Step closes again.

To start the car, the Driver again grips the " Deadman's Handle," thereby breaking the circuit at the Air-operated Switch, and closing all doors.

For traffic stops, the Driver does not release his grip of the " Deadman's Handle," hence the doors do not open under these circumstances.

In the event of a serious collision, involving derailment of the car, in which it may turn over on either side, the action of detaching the vehicle from a source of current supply de-energises the No-Volt Electro-Pneumatic Valve, which thereby causes the Relay Valve to place the whole of the Pneumatic Door Apparatus to exhaust.

Should the Driver become incapacitated, the car is automatically brought to a standstill by the emergency application of the brakes, and on the car reaching a standstill, the doors are opened as described above.

It will be readily understood that by replacing the Electrical and Electro-Pneumatic Apparatus by Pneumatic Fittings, the Automatic Pneumatically-controlled System will result, giving the same safety features as those described above.

The apparatus is described in detail in Sections R.3, R.4, R.5, T.2, T.5, T.6, and O.4.

The equipment illustrated schematically in Fig. 2 on the following page is designed for an Automatic Electrical Control of the doors on a Tramcar of similar design to that assumed in connection with Fig. 1.

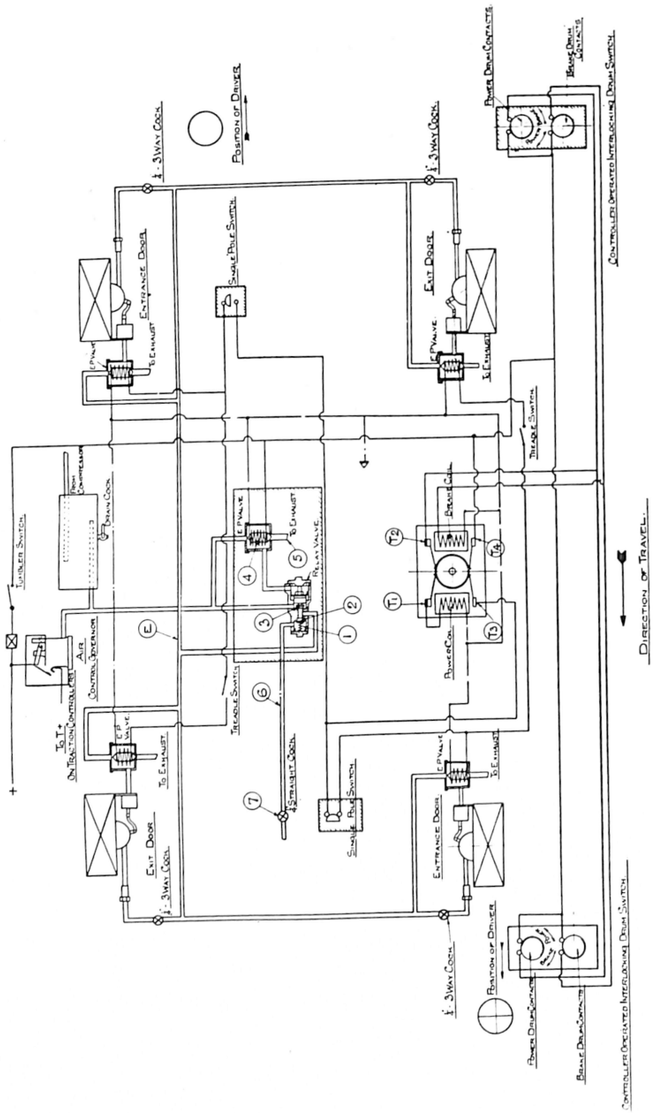


Fig. 2. Schematic Arrangement of Piping and Wiring for a Tramcar fitted with Automatic Electric Door Control System, without Air Brakes.
Prov. App.: No. 22152/26.

In this case, no governing means are provided beyond the movements of the traction controller handle.

On the pneumatic side of the door equipment, the following apparatus is employed :—

From the Air Compressor, air is led into a Water Trap and from thence to the No-Volt Relay Valve. With the coil of the No-Volt Electro-Pneumatic Valve energised, air flows directly into the single pipe which feeds the door system, and which runs from end to end of the car. Under these circumstances, the exhaust valve of the No-Volt Relay Valve is closed ; this valve communicates with the atmosphere, via the Exhaust Valve (7) when the coil mentioned above is de-energised.

The air supply for the four Type " E " Door Engines, passes through Emergency Release Valves and $\frac{1}{4}$-in. Air Strainers, to the Rotary Valves (See Section T.2), parallel feeds being taken to the tops of each Electro-Pneumatic Valve for control of the Valve Puller connected thereto.

On the electrical side of the door equipment, the following apparatus is employed :—

From the trolley or plough gear a feed wire is taken through a Fuse and an Isolating Switch (of the Tumbler or Snap Type) directly to the coil of the No-Volt Electro-Pneumatic Valve, the other end of the coil being earthed. From the positive side of the coil, a further lead is connected to a line wire running from end to end of the car and connected to the positive poles of the Double Contact Controller-operated Drum Switches (see Section T.6). From the " Power " contacts of each switch, a connection is made to the corresponding contacts on the Drum Switch at the other end of the car, and a parallel connection across contacts T2 and T1 to the " Power " coil of the Controller-operated Interlocking Switch, and thence to earth.

From the " Brake " contacts of each Drum Switch a connection is made to the corresponding contacts on the Drum Switch at the other end of the car, and a parallel connection across the " Brake " coil of the Controller-operated Interlocking Switch, and thence to earth.

A further feed is taken directly from the Isolating Switch line across contacts T4 and T3 of the Controller-operated Interlocking Switch, to each Single Pole Key-operated Change-over Switch, in parallel, tappings being taken off for the Entrance Door Electro-Pneumatic Valve, the Treadle-operated Switch, and the Exit Door Electro-Pneumatic Valve, as described for Fig. 1.

The Driver's duties are identical with those described in connection with Fig. 1.

The operation of the equipment is as follows :—

At each stopping place, the Driver brings the car to rest by applying the magnetic brakes, and when the car is at rest, the traction controller handle is brought from a magnetic brake position to the " Off " position. This results in de-energising the " Brake " coil mentioned above, and thereby completing the Door Circuit across contacts T4 and T3, through the movements of the Controller-operated Drum Switch.

As soon as the interchange of passengers is completed, the Driver moves the traction controller handle **towards** the power notches, thereby moving the Drum Switch so as to make contact and complete the circuit at contacts T_2 and T_1. The " Power " coil is thereby energised, but the arrangement of the mechanism is such that the action of this coil results in **breaking its own circuit,** preventing a repetition of the coil plunger movements by subsequent movements of the Drum Switch. Hence, unlimited coasting of the car does not affect this apparatus, and on applying the magnetic brake, the doors will still remain closed. It is only after an application of the brakes has been made, the traction controller handle brought into the " Off " position, and a slight pause made in that position, that the automatic operation of the doors takes place. For ordinary traffic stops, the handle may be moved from magnetic brake and into power positions, and vice versa, without affecting the door equipment, provided that a pause is not made in the " Off " position, **after** applying the brakes. It should be understood, however, that the controller handle need only be moved 2 degs. from the " Off " position towards the first notch of the power positions, to retain the doors in their closed position.

The safety equipment provided in this system is similar to that already described in connection with Fig. 1.

Air Brakes are not required for this equipment.

Referring to Fig. 3, this shows a schematic arrangement of piping and wiring built up from the Electro-Pneumatic and Electric Systems, but without the Controller-operated Interlocking Switch.

From the foregoing descriptions, the general principles will be clear, but an additional safeguard is provided in the form of an Air-operated Switch of the " Control Governor " Type. The Electric Door Lock is placed in series with the whole of the Door Control Equipment. From this apparatus three parallel circuits are made ; one circuit passes through one pair of poles of one of the Double Pole Change-over Switches (see Section T.6) and thence across one of the Single Pole Controller-operated Drum Switches (if the traction controller handle is in the " Off " position, or in any magnetic brake position), and thence to the fixed contact of an Air-operated Switch of the " Compressor Governor " type. Another parallel path is taken to the moving contact of this switch, while the third path is made across the other Change-over and Drum Switches. Both Change-over Switches cannot be " On " together.

From the fixed contact of the " Compressor Governor " Switch mentioned above, the circuit is continued across an Air-operated Switch of the " Control Governor " Type, and thence branches out into two parallel paths on each side of the car.

The functioning of the equipment is as follows :—

The Electric Door Lock prevents the flow of current into the equipment until the speed has been reduced to two miles per hour. At that speed, current then flows across one pair of poles of

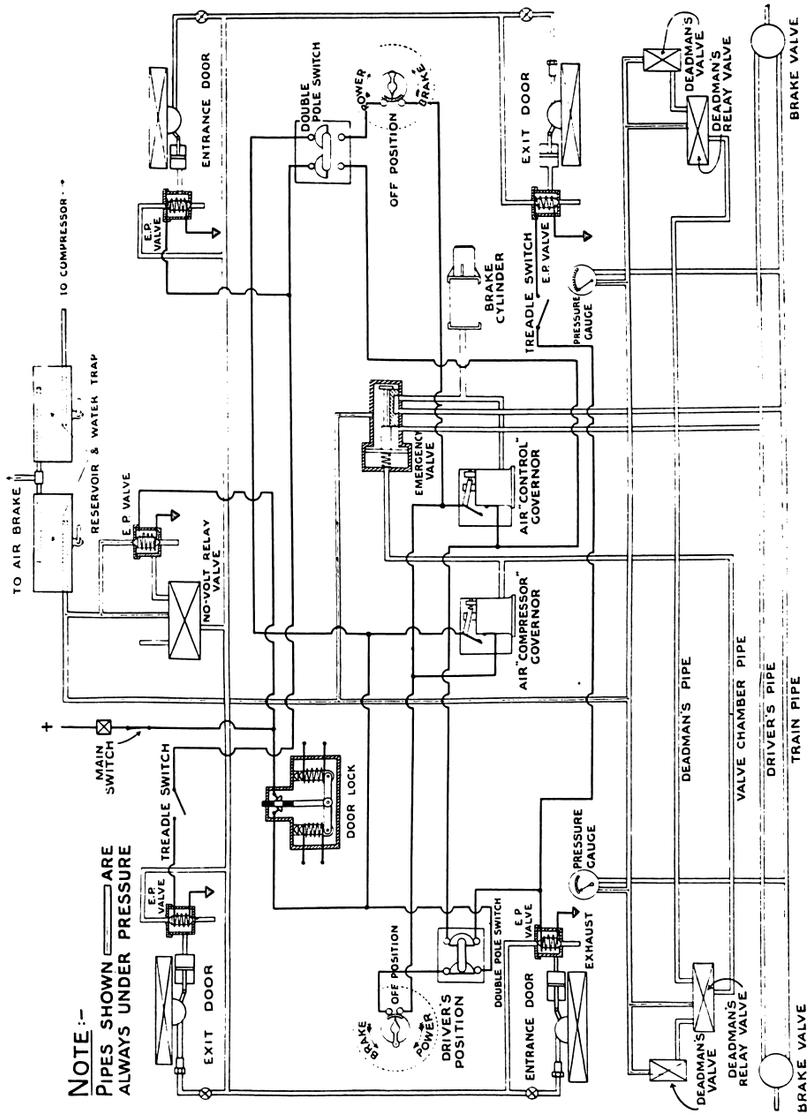
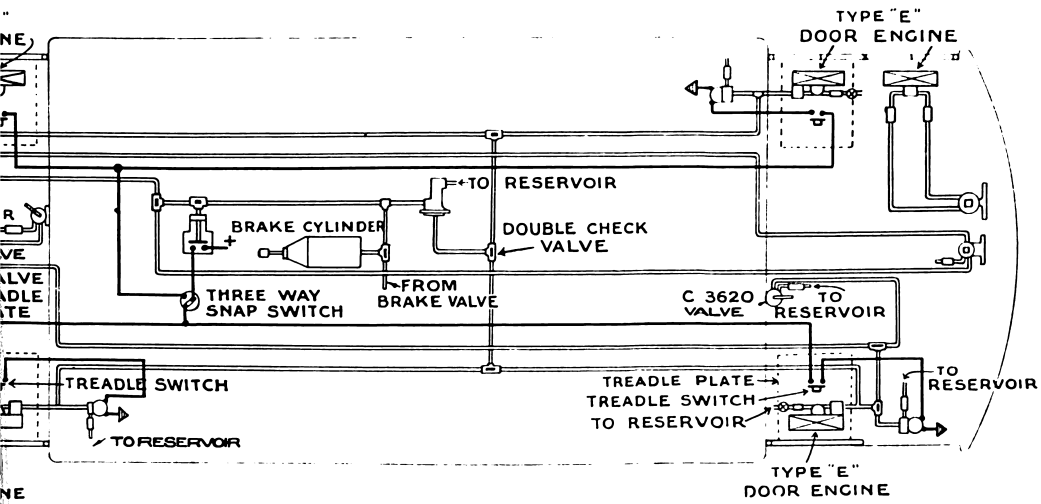


Fig. 3. Schematic Arrangement of Piping and Wiring for a Tramcar fitted with Combined Electro-Pneumatic Door Control System, and Air Brakes with Relay Type " Deadman's Handle."



ematic Arrangement of Piping and Wiring for a Tramcar fitted with Pneumatically Controlled Two-Stream Entrance and Exit Doors, and Air Brakes.

The Type C.6060 Control Valve (see Section O.3) is connected so as to charge the Air-operated Switch when the handle is moved to the right, thus seating the Check Valves shown in the enlarged Tee Pieces. When the handle is moved to the left, the air is caused to flow to the opposite end of the car, seating two Check Valves, and returning along the lower pipe in the diagram, thereby seating the Check Valve shown in the centre of that pipe, and also the Check Valve in the short branch pipe leading to the Relay Valve, of Type C.8550. The Relay Valve is connected directly to the Reservoir, and when air pressure is admitted to the top of the valve it causes air at reservoir pressure to flow into the short pipe connected to the Brake Cylinder, by way of a Check Valve.

Hence, when the Rear Exit Electro-Pneumatic Valve is energised, and the Rear Exit Door is open (due to a passenger standing on the Treadle Plate, the Relay Valve is in a position to charge the Brake Cylinder, even if the Air Brakes have been released through the Driver's Brake Valve. A connection is also made between the Relay Valve and the Air-operated Switch, so that the release of air in the pipe from the Driver's Brake Valve will not cause the Switch to open while there is pressure on the Relay Valve.

If the brakes have been applied, and the Type C.6060 Control Valve set for Treadle Plate control of the Rear Exit Door, and a passenger is on the Treadle Plate or Step, the brakes cannot be released until the passenger has stepped off the Treadle Plate or Step.

The left-hand position of the Type C.6060 Control Valve is an " Emergency " position, and enables the Driver to open the Rear Exit Door whether a passenger is standing on the treadle plate or not, but this action can only take place **after** the brakes have been applied.

The Type C.3620 Valve, placed at each end of the car, is provided in case a Conductor is required to operate the Rear Exit Door at the rush hours, or to permit passengers to enter by this door. The Valve is connected directly to the Valve Puller on the Door Engine. When the C.3620 Valve is operated, an application of the brakes is made simultaneously, if they have not already been applied, and the brake application is maintained until the door is closed.

With this system of control it is necessary for the Driver to operate the Type C.6060 Valve at each stopping place. The Valve will, however, **reset itself** after the brakes have been released.

For descriptions of the various parts of the apparatus, see Sections R.3, R.4, R.5, T.2, T.5, T.6, O.3, and O.4.

The Driver's Signal Light System illustrated in Fig. 5 on the opposite page, although designed for Tramcars is equally suitable for Railway use, when adapted to meet the special conditions required for the latter.

Referring to Figs. 3, 4, and 5 of Section R.4, these show the various types of Interlocking Switches which are employed on the Door Engines, to make contact only when the door is closed.

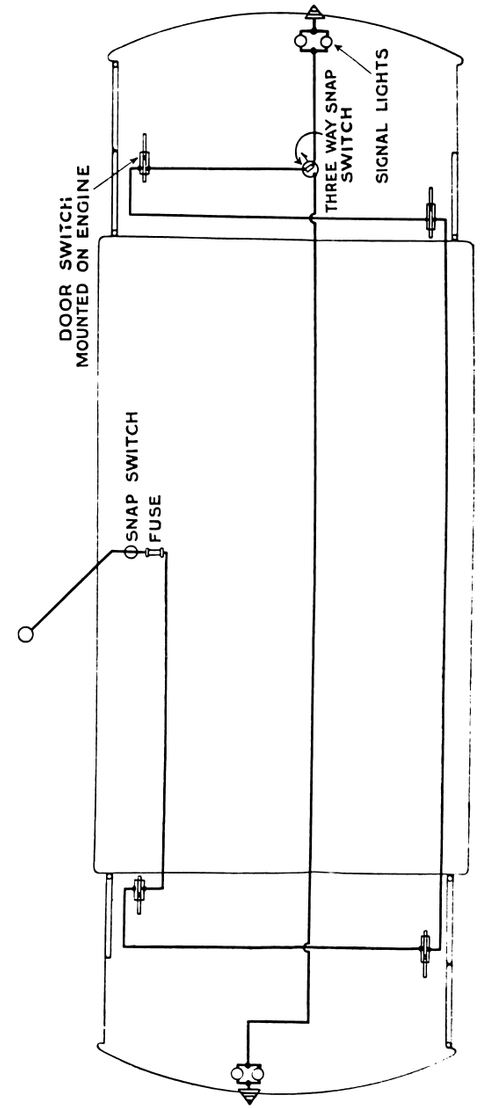


Fig. 5. Schematic Arrangement of Wiring for Driver's Signal System.

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A feed is taken from the trolley or other source of supply, through an Isolating Switch and Fuse, across the Door Engine Interlocking Switches, and, by way of a Signal Direction Switch, a suitable Resistance, and the Driver's Lamp Signal Box, to earth.

Two lamps are employed in parallel, each lamp being of such a voltage that when connected in circuit, it burns with approximately half the normal candlepower. Should one lamp burn out, the other lamp will glow with normal brilliance and thus indicate the defect. An external resistance for the lamps is necessary and lamps may be employed for this purpose ; alternatively, see Section R.5 for illustrations of suitable Resistance Boxes.

All doors on the car must be closed before the Driver can receive the signal to proceed, and hence it is quite impossible for passengers to become trapped in any pneumatically-operated door fitted with this equipment, and for the Driver to start before they have freed themselves.

See Drawing No. W.L.2898 for details of construction of the Driver's Lamp Signal Box.

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PNEUMATIC DOOR ENGINES

"NATIONAL PNEUMATIC SYSTEM"
(PATENTED).

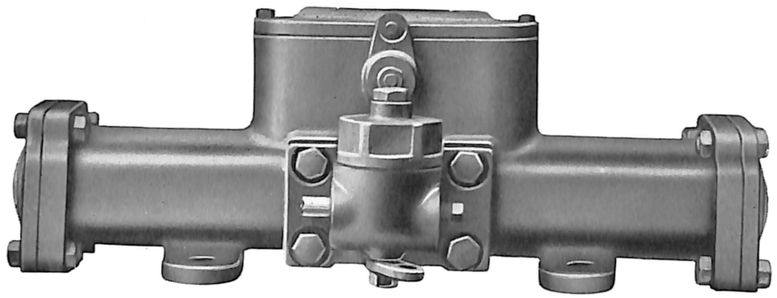

Fig. 1. Type "E" Folding Door Engine, with Rotary Valve.

The above illustration shows a front view of the Standard Folding Door Engine—Type "E," fitted with the Rotary Valve movement. See also Figs. 3 and 4, Section R.2.

The engine has a stroke of 4½-in., and a cylinder bore diameter of 2⅝-in., and is capable of working at any air pressure between 50-lbs. per square inch and 90-lbs. per square inch, according to the size and weight of the doors, and steps (if the latter are fitted).

The volume of air required per stroke, **at the working pressure,** is .014 cubic ft. per door-opening or door-closing stroke. Hence the total quantity of air **at the working pressure** required per complete duty cycle (or vehicle stop) is .028 cubic ft.

The Type "E" Folding Door Engine has a feature which is entirely independent of the type of valve movement (Rotary or Ball Checked) or of the control system employed. This feature is common to all engines of this design, and concerns the point at which the Door Engine "cushions" during its stroke. One of the most important functions of a Door Engine is to operate the door as "courteously" as possible, in order that when the door is closing there is no prospect of a passenger receiving the slightest blow from the door.

A properly cushioned engine functions in the following manner :—

During the first portion of its movement, the door travels fairly rapidly, the speed being of the order of 15 to 18-in. per second. When the door has travelled to within 6-in. of its closed position, the movement of the Door Engine is positively checked, and the completion of the stroke is carried

out at the relatively low velocity of 10-in. per second. The rapid portion of the door closing stroke warns a passenger that the door is about to close, the check in the movement gives him time to remove any portion of his body or clothing which may be in the way, and the rate of travel of the door during its final movement is such as to give every reasonable facility for the removal of such obstructions, even up to the point of contact between the Safety Door Edging and the door pillar.

During the door opening stroke there is, of course, no possibility whatever of the door coming into contact with the passengers. It is, however, equally important to protect the vehicle body from strains and other damage due to an imperfectly moved door, and the cushioning of the engine during the door opening stroke ensures perfect freedom from such troubles.

The points in the strokes at which this check or cushion takes place, are unalterable, and hence there is no possibility that the varying ideas of maintenance staffs may result in an unsatisfactory operation due to their having attempted to alter the designed conditions. It is quite unnecessary to alter these cushion points—the exact compression ratios have been determined as the result of lengthy experience in the manufacture and operation of such engines.

The methods by which the cushioning of the engine is obtained are fully described on pages 6 and 12.

One Type "E" Engine will satisfactorily operate Double Folding Doors of a width up to 5-ft. between centres of door shafts, and having a three or four-arm step attached. It will be readily understood that where it is required to operate light single folding doors, the cushioning arrangements of the engine must be suitably adjusted to account for the smaller load. All engines are tested at our Works with reference to the doors which they are required to operate, and the adjustment of the cushioning plugs should not subsequently be altered, unless absolutely essential.

In new installations, it is occasionally found that the door movement is somewhat slower than was anticipated. This is due to the doors and tracks, etc., being a little stiff. No adjustment whatever should be made to the engine or the door gear until both have been in full service operation for at least a week. This will give the entire mechanism an opportunity to "run in," and it should then be found that the door movements are considerably accelerated. Should this not be the case, however, the door engine should be disconnected from the doors at the Engine Arm Connecting Rod Jaw, and the doors tested thoroughly by hand for binding. As the car structure settles down it is sometimes found that door binds occur.

Before going into service the door engines should be lubricated with "Paragon" Grease. About ½ pint should be placed in each gear chamber, and no further attention should be required for at least 12 months, when the engines should be thoroughly lubricated.

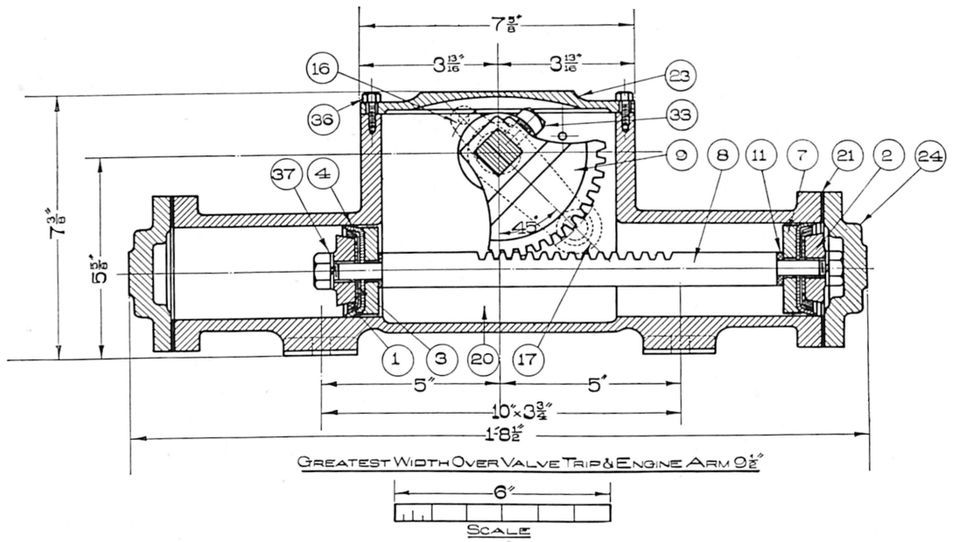

Fig. 2. Sectional View of Type "E" Folding Door Engine, showing principal parts.

PARTS LIST.

(Abridged.)

Part No.	Description.	Part No.	Description.
1.	Piston Cup Expander.	17.	Gear Shaft.
2.	,, Follower.	20.	Cylinder.
3.	,, Washer.	21.	Gasket for Cylinder End.
4.	,, Cup Leather.	23.	Gear Chamber Cap.
7.	,, Centre.	24.	End for Cylinder (Right Hand).
8.	Rack.	33.	Setscrew (Square Head).
9.	Gear.	36.	Setscrews for Part 23.
11.	Piston Centre Gasket.	37.	Piston Nut.
16.	Switch Connector Lever.		

For complete List of Parts, see Drawing No. W.L.2746.

When ordering Spare Parts for Type "E" Door Engines, please quote Part Nos. as above, or from Parts List on Drawing No. W.L.2746.*

Fig. 3, on page 5 shows a front view of the Rotary Valve for attaching to Door Engines of Types "E," "F," "K," and "L." This Valve is capable of operation in a number of ways :—

(*a*) **Manually,** by means of rods actually moved by the driver or conductor, so as to rotate the Valve Trip. (This type of control must be located fairly close to the engine.) Connecting Rods, Forks, Control Rods, Control Stands, Brackets, and Handles are supplied to suit the car construction and system of operation.

(*b*) **Pneumatically,** by means of the Pneumatic Valve Puller, as described on pages 8 and 9. (See Figs. 6 and 7.)

(*c*) **Electro-Pneumatically,** by means of the Pneumatic Valve Puller coupled with the Electro-Pneumatic Valve, as described on page 10. (See Fig. 8.)

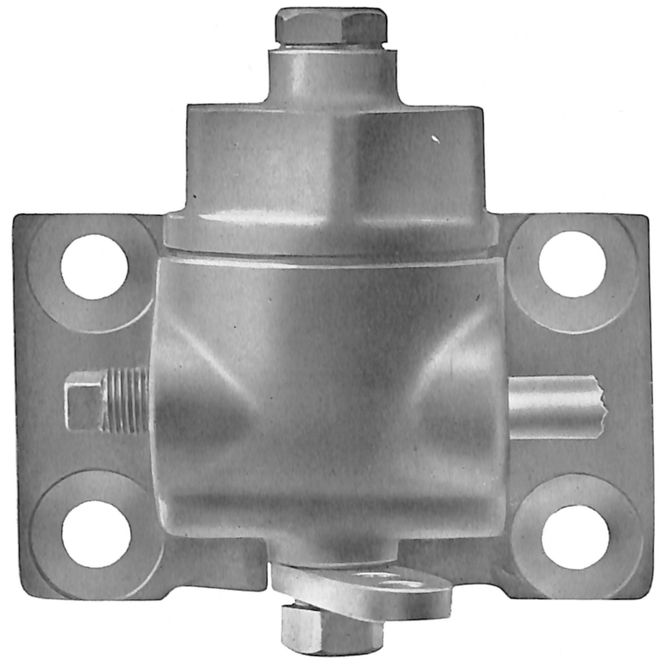

Fig. 3. Rotary Valve for Engines of Types "E," "F," "K" and "L."

The supply air for the engine is fed through the Rotary Valve by means of a pipe as shown broken at the right-hand side on Fig. 3 above. The supply port is drilled through the body, thus allowing an alternative feed from the opposite side of the valve ; this port being shown plugged at the left-hand side on Fig. 3 above. The position of the supply pipe is governed entirely by the arrangements of the Control Rods (in the case of Manual Control), or the position of the Valve Puller (in the case of Pneumatic or Electro-Pneumatic Control). The Valve Puller is located on the side of the engine appropriate to the system of control, *i.e.*, so as to permit of the charging or discharging of the Valve Puller for closing the door.

The Valve Body consists of a gun-metal casting, drilled for the various ports, to connect with the engine cylinder, and provided with a Rotary Valve element, which is moved through the necessary angle by means of the Valve Trip shown at the lower end of the valve body. Air, at the working pressure, is constantly applied to the upper surface of the valve, and ensures that no cross-connection of the ports is possible. The valve cap is readily removable for the purpose of cleaning, lubricating, and lapping in the valve. Specially grease-dressed leather gaskets are provided for all joints to ensure perfect air-tightness.

The satisfactory "cushioning" of the movement of a Door Engine is one of its most essential characteristics, and in engines of Types "E," "F," "K," and "L," fitted with the Rotary Valve, this cushioning effect is accomplished through the medium of restricted exhaust ports. Referring to Fig. 4 on next page, this shows the location of the Rotary Valve with reference to the engine cylinder. A brief description of the valve construction is given above.

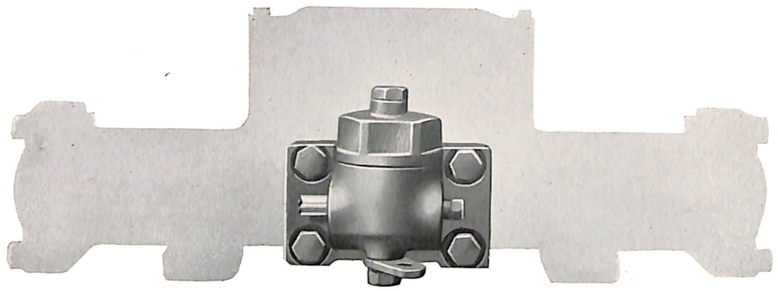

Fig. 4. Type "E" Folding Door Engine, showing location of Rotary Valve.

The passage of air through the various ports in the engine and Rotary Valve is shown in Fig. 5 on the opposite page, the air at working pressure being shown in **red,** the free and the "cushioned" exhausts being shown in **blue.**

Referring to the upper diagram, and assuming that the piston is at the extreme left-hand end of the cylinder, the Rotary Valve allows pressure air to flow unrestrictedly into the left-hand end of the cylinder. Simultaneously, the right-hand end of the cylinder is placed to free exhaust through the Rotary Valve. This exhaust air is allowed to discharge into the gear chamber, and thus eliminate noise.

During the period of free exhaust, air is also flowing out through the cushion port, as indicated in the lower right-hand passage of the upper diagram. As soon, however, as the piston has travelled past the free exhaust port, as shown in the lower diagram, the only remaining exhaust is through the lower right-hand passage, and thence through a restricted port in the Rotary Valve.

This change in the size of the exhaust ports, made during the travel of the engine pistons (and consequently of the door), results in a definite check or "cushion" taking place in the velocity of the door at the points where the pistons cut off the free exhaust passages. Hence, the door always cushions at the same definite point in each stroke, irrespective of all other conditions, since it is not possible to change this cushion point after the engines have been built.

By removing the Rotary Valve from the engine cylinder, and reversing same, it will be found that five holes are provided in the rear face. The centre port is the common exhaust to atmosphere for both ends of the cylinder. The top **right-hand** port is the free exhaust for the **left-hand** end of the cylinder, and the top **left-hand** port is the free exhaust for the **right-hand** end of the cylinder. The bottom **right-hand** port is the feed and cushion exhaust port for the **left-hand** end of the cylinder, and the bottom **left-hand** port is the feed and cushion exhaust port for the **right-hand** end of the cylinder. The speed of the engine can generally be adjusted by placing cushion plugs in the two upper ports only. Plugs placed in the lower ports have little effect in restricting the exhaust, and act only upon the admission of air into the ends of the cylinder. An obstruction at this point is seldom required, and it is better to allow the compressed air to flow freely into the engine, and determine the speed of the engine by the rate of exhaust.

If a satisfactory regulation of the engine cannot be secured by changing the plugs to give smaller or larger openings in the free exhaust passages, a further reduction in engine speed may be obtained by placing plugs in the lower ports. This will regulate the velocity of flow of compressed air into the engine.

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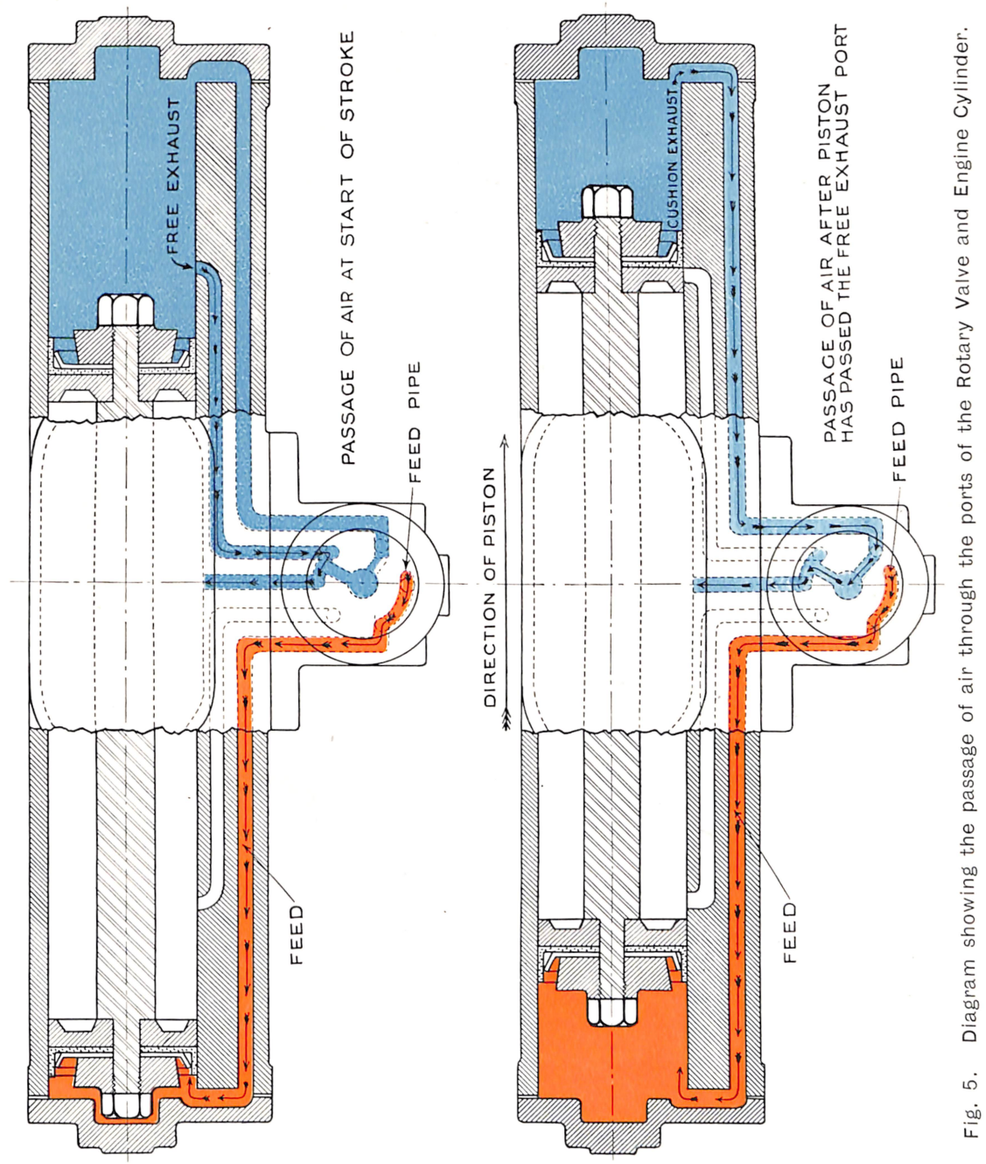

Fig. 5. Diagram showing the passage of air through the ports of the Rotary Valve and Engine Cylinder.

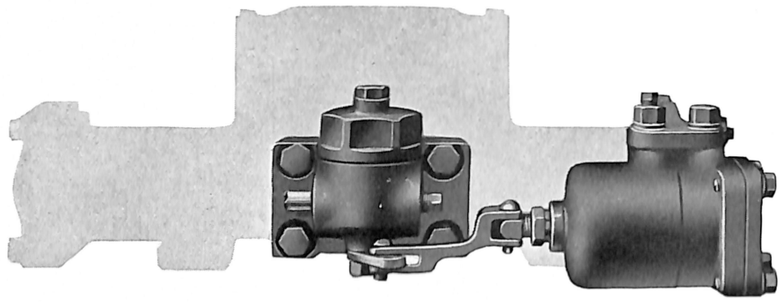

Fig. 6. Type "E" Folding Door Engine, showing location of Pneumatic Valve Puller control for Rotary Valve.

Fig. 6 above shows the Pneumatic Valve Puller attached to the Type "E" Folding Door Engine. In the position shown, the Valve Puller is connected so as to cause the engine to **close** the door when the Valve Puller is **charged,** and to **open** the door when the Valve Puller is **exhausted.**

The position of the Valve Puller, and the range of Door Shaft Terminals available, renders possible any desired combination of door movements to suit various systems of control, and car constructions.

Referring to Fig. 7, which shows the general arrangement of the Valve Puller, the Cylinder, which is of close-grained cast iron, is secured to the Door Engine Cylinder by means of a Bracket (part 3), which permits of a small amount of angular movement of the cylinder to suit the position of the Rotary Valve Trip Pin.

The Piston, which is packed with a specially grease-dressed Cup Leather and a Phosphor-bronze Expander, is free to travel $\frac{13}{16}$-in. under the action of the control air pressure, against the action of the Return Spring (part 7). The distance of travel is definitely checked by the Distance Piece (part 6). The End Cover of the Valve Puller is provided with Gaskets which have a Gauze Strainer inserted between them, thus ensuring that no grit or other foreign substance may enter the Cylinder, and so score the walls, or the Cup Leather.

A Connector (part 4) of length suitable for the type of Door Engine, is provided for transmitting the movement of the Piston Rod to the Valve Trip.

Two alternative inlets to the Valve Puller Cylinder are provided in the end cover, one of which is plugged. Both inlets are tapped $\frac{1}{4}$-in. gas.

The Valve Puller is capable of operating at any air pressure between 40-lbs. per square inch and 90-lbs. per square inch.

Before going into service the Valve Puller should be lubricated with "Paragon" Grease. The interior of the Cylinder should be well covered with this grease, and no further attention should be required for at least 12 months, when the Valve Puller should be thoroughly lubricated.

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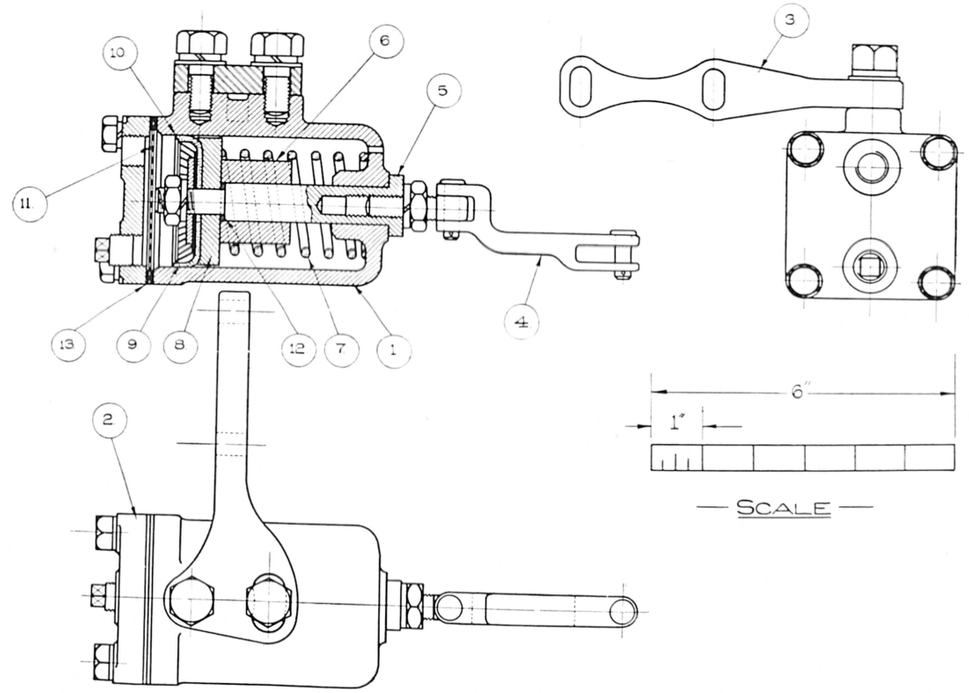

Fig. 7. General Arrangement of Pneumatic Valve Puller for use on Engines of Types "E," "F," "K," and "L."

PARTS LIST.

(Abridged.)

Part No.	Description.	Part No.	Description.
1.	Cylinder.	8.	Piston Centre.
2.	,, Cover.	9.	,, Cup Leather.
3.	Bracket.	10.	,, Cup Expander.
4.	Connector.	11.	Copper Gauze.
5.	Piston Rod.	12.	Piston Centre Gasket.
6.	Distance Piece.	13.	Cylinder Cover Gaskets.
7.	Return Spring.		

For complete List of Parts, see Drawing No. W.L.2761.

When ordering Spare Parts for Pneumatic Valve Pullers, please quote Part Nos. as above, or from Parts List on Drawing No. W.L.2761.

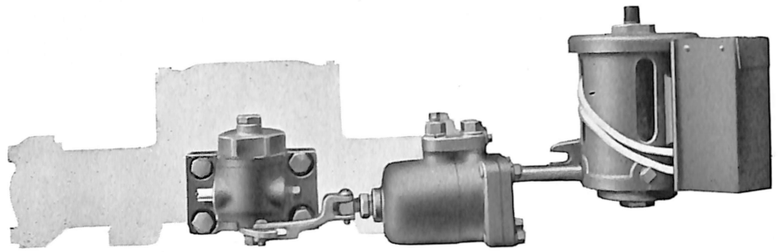

Fig. 8. Type "E" Folding Door Engine, showing location of Electrical Valve Puller control for Rotary Valve, by means of a ⅜-in. Electro-Pneumatic Valve.

The above illustration shows the location of one form of mechanism for electro-pneumatic control of Door Engines of Types " E," " F," " K," and " L." Referring to Fig. 8, the Type " E " Folding Door Engine is shown with the Valve Puller in such a position that **charging** the cylinder will result in **closing** the door. (See page 8.)

The ⅜-in. Electro-Pneumatic Valve, shown connected to the Valve Puller by means of a short length of pipe, is fully described elsewhere. (See Section R.5, Fig. 5.) An alternative size of valve (¼-in.) is also described in Section O.4.

Both sizes of Electro-Pneumatic Valves of the " Exhaust " type mentioned above, function in the same manner ; when the coil is energised a plunger is raised and a ball caused to seat on the fixed core so as to cut off the supply air and place the lower seating to atmosphere. This results in discharging the Valve Puller Cylinder, via the lower seating of the Electro-Pneumatic Valve, thereby causing an instantaneous operation of the Door Engine.

Should it be necessary to employ the " pressure " type of Electro-Pneumatic Valve (such as the C.4070), arranged so that when de-energised it places the Valve Puller Cylinder to exhaust, this can readily be accommodated. Care should be taken in piping such valves, since the ports are reversed with respect to the "exhaust" type of valve, and this feature presents a further set of alternative operations of the door, with various Door Shaft Terminals and Valve Puller positions.

The coils of all Electro-Pneumatic Valves supplied for electrical valve puller control are wound for intermittent rating, and to suit the line voltage, with or without external resistance. Coils can be supplied from stock to suit voltages from 300 to 600 D.C. without added resistance. The resistances are of the type shown in Fig. 2, Section R.5, and are contained in a ventilated box with appropriate terminals to permit of ready connection to the control circuits.

Suitable brackets can be supplied for carrying the ⅜-in. Electro-Pneumatic Valve, but the ¼-in. size of Valve is provided with feet, and hence needs no fixing bracket. A wooden packing block should, however, be employed, in order to permit of a free exhaust from the lower seating. Fan-tailed exhaust pipes should be attached to both sizes of Valve in order to eliminate the noise of exhaust, and at the same time ensure an unrestricted flow of air, unless the Valve is situated in such a position that it can exhaust below the car floor. The maintenance of Electro-Pneumatic Valves is an extremely small item ; it should only be necessary to examine and grease the seatings occasionally to ensure that no leakage of air takes place.

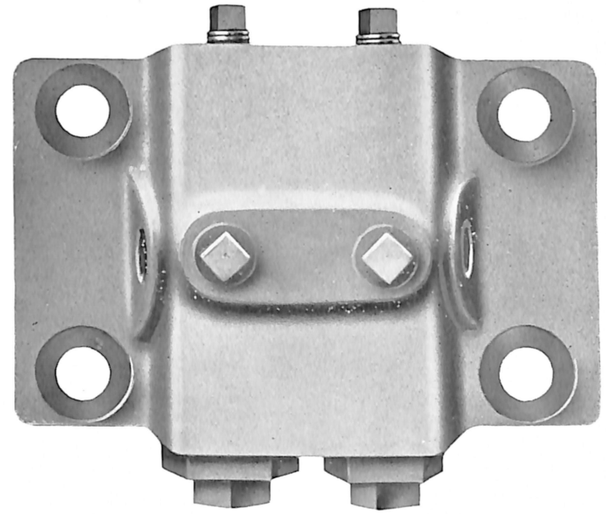

Fig. 9. Ball Checked Valve for Engines of Types "E," "F," "K," and "L."

The above illustration shows a front view of the Ball Checked Valve for attaching to Door Engines of Types " E," " F," " K," and " L." This Valve is capable of operation in two ways :—

(*a*) **Pneumatically,** by means of a Door Control Valve of the C.3620 Type, (see Fig. 3, Section O.3).

(*b*) **Electro-Pneumatically,** by means of an Electro-Pneumatic Valve coupled to a Pneumatic Relay Valve.

The supply air for the engine is fed into the Ball Checked Valve from both sides, the pipe openings being clearly shown on the horizontal centre line. For each engine movement, one of these pipes is charged with air at supply pressure, while the other pipe is exhausted, the reverse stroke of the engine being obtained by exhausting the pipe which was previously charged, and charging the pipe which was previously exhausted. By referring to Fig. 3, Section O.3, it will be seen that the Type C.3620 Valve forms a very simple method of control for the Ball Checked Valve, by using both control pipes on the C.3620 Valve.

Alternatively, electrical control for the Ball Checked Valve is provided. This consists of an Electro-Pneumatic Valve coupled with a Pneumatic Relay Valve, of which several types are available. The piping of such control equipment must be arranged to suit the operating conditions of the vehicle, and the door shaft terminals. The simplest method is to couple up the apparatus so that one pipe line from the door engine is exhausted and charged directly from the Electro-Pneumatic Valve, a pipe line being carried in parallel to the operating cylinder of the Pneumatic Relay Valve. Thus, each cycle of operations at the coil of the Electro-Pneumatic Valve, results in opening and closing the ports of the Relay Valve, by means of the spring-pressed piston in the operating Cylinder. These ports are connected directly to the remaining port on the Ball Checked Valve, and it will thus be seen that the charging and discharging of the appropriate pipes is carried out automatically on energising and de-energising the coil of the Electro-Pneumatic Valve.

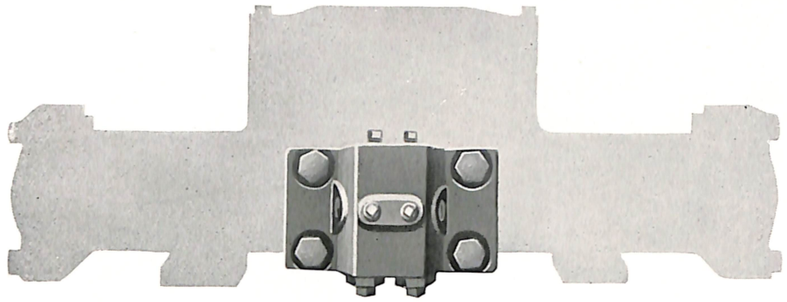

Fig. 10. Type "E" Folding Door Engine, showing location of Ball Checked Valve.

The Valve Body is of gun-metal, drilled for the various ports. (See Fig. 12.) The two openings at the top of the Valve Block (shown plugged) are provided for inspection of the $\frac{5}{16}$-in. free exhaust ball valves. On the horizontal centre line of the valve block, two further plugs are shown. These permit of the ready inspection of the cushioning plugs shown in Fig. 12. At the lower end of the valve block, two caps are shown. These are the heads of the cushion exhaust ball valve cages, which carry the $\frac{7}{16}$-in. ball valves at their upper ends.

The Ball Checked Valve should require little maintenance, other than to ensure that the balls are seating satisfactorily. No lapping in of any description is required, all that is necessary being to tap a steel ball of the appropriate size on to the seat, afterwards replacing with the bronze ball. **Only one blow should be given to the steel ball.**

A specially grease-dressed leather gasket is provided for the rear joint face, to ensure perfect air-tightness.

The remarks in the last paragraph on page 5, referring to the Rotary Valve movement for controlling Engines of Types "E," "F," "K," and "L," apply equally to the Ball Checked Valve movement.

Fig. 10 above shows the location of the Ball Checked Valve with reference to the engine cylinder. A brief description of the Valve is given on page 11.

The passage of air through the various ports of the engine and Ball Checked Valve is shown in Fig. 11 on the opposite page, the air at working pressure being shown in **red,** the free and the "cushioned" exhausts being shown in **blue.**

Referring to the upper diagram, and assuming that the piston is at the extreme left-hand end of the cylinder, the Ball Checked Valve allows pressure air to flow unrestrictedly into the left-hand end of the cylinder, by forcing up the left-hand $\frac{7}{16}$-in. ball from its seat and causing the left-hand $\frac{5}{16}$-in. ball to close the exhaust seat. This operation is shown in red on the top right-hand portion of Fig. 11.

Simultaneously, the air contained in the right-hand portion of the cylinder is placed to exhaust through the appropriate control pipe. A free exhaust is provided by the right-hand $\frac{5}{16}$-in. ball rising from its seat, and a restricted exhaust by the equilibrated position of the right-hand $\frac{7}{16}$-in. ball. This operation is shown in blue on the top right-hand portion of Fig. 11.

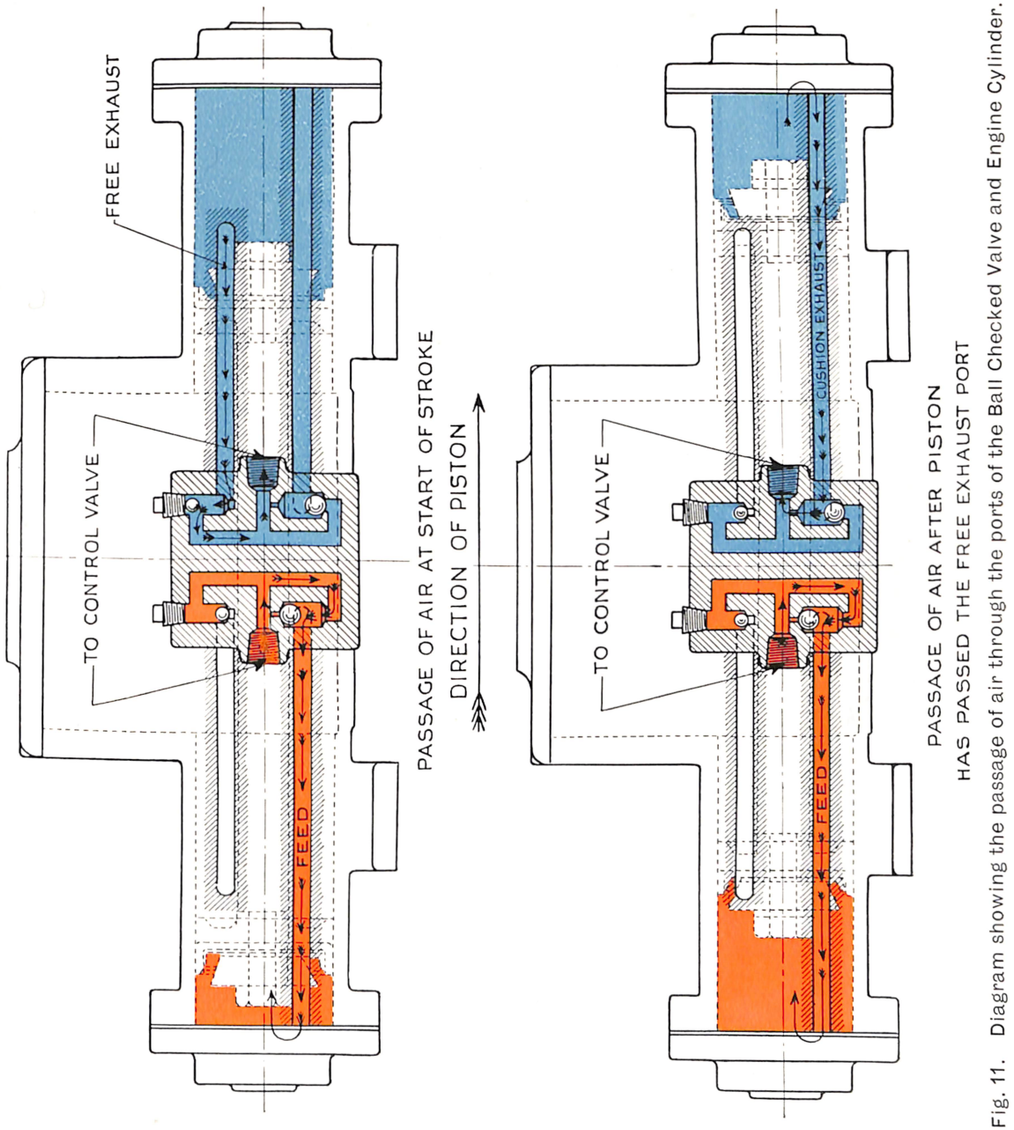

Fig. 11. Diagram showing the passage of air through the ports of the Ball Checked Valve and Engine Cylinder.

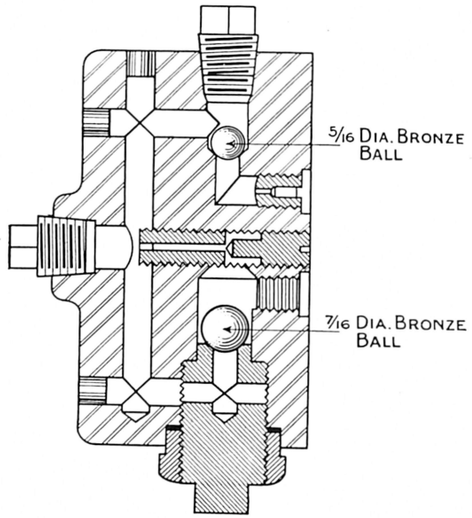

Fig. 12. Sectional View of Ball Checked Valve.

As soon, however, as the piston has travelled past the free exhaust port, as shown in the lower diagram, the right-hand $\frac{5}{16}$-in. free exhaust ball seats, and the remaining air in the right-hand portion of the cylinder flows into the appropriate control pipe through the restricted passage shown in Fig. 12.

This change in the size of the exhaust ports, made during the travel of the engine pistons (and consequently of the door) results in a definite check or " cushion " taking place in the velocity of the door at the points where the pistons cut off the free exhaust passages. Hence, the door always cushions at the same definite point in each stroke, irrespective of all other conditions, since it is not possible to change this cushion point after the engines have been built.

By removing the Ball Checked Valve from the engine cylinder, and reversing same, it will be found that four holes are provided in the rear face. The top **right-hand** port is the free exhaust for the **left-hand** end of the cylinder, and the top **left-hand** port is the free exhaust for the **right-hand** end of the cylinder. The bottom **right-hand** port is the feed and cushion exhaust port for the **left-hand** end of the cylinder, and the bottom **left-hand** port is the feed and cushion exhaust port for the **right-hand** end of the cylinder. The speed of the engine can generally be adjusted by placing cushion plugs in the two upper ports only. Plugs placed in the lower ports have little effect in restricting the exhaust, and act only upon the admission of air into the ends of the cylinder. An obstruction at this point is seldom required, and it is better to allow the compressed air to flow freely into the engine and determine the speed of the engine by the rate of exhaust.

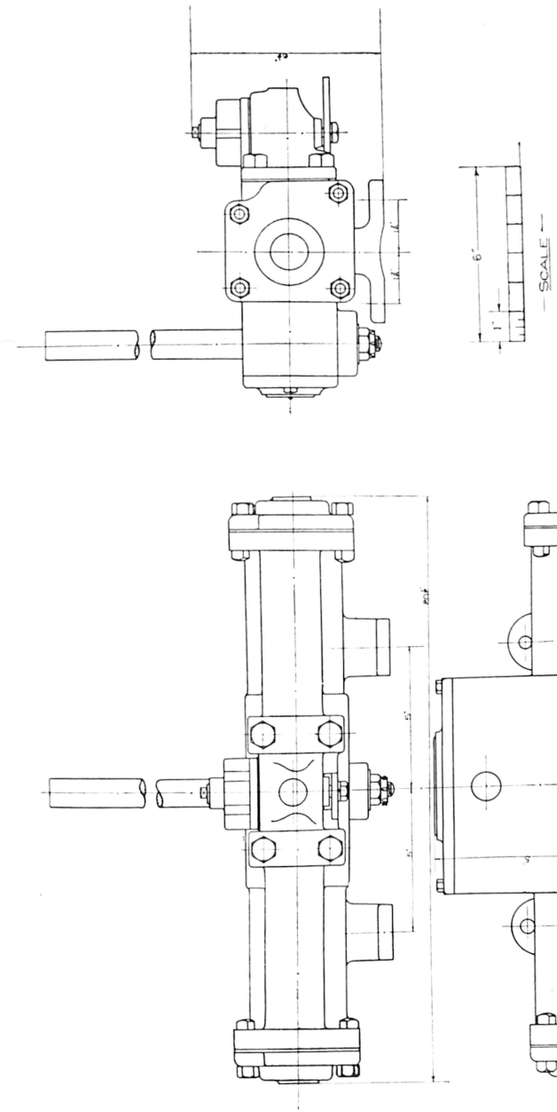

Fig. 13. General Arrangement of Type "K" Folding Door Engine, fitted with Rotary Valve.

If a satisfactory regulation of the engine cannot be secured by changing the plugs to give smaller or larger openings in the free exhaust passages, a further reduction in engine speed may be obtained by placing plugs in the lower ports. This will regulate the velocity of flow of compressed air into the engine.

Referring to Fig. 13 on page 15, this shows the general arrangement of the Type " K " Folding Door Engine. In operation and control this engine is identical with the Type " E " Engine already described. In construction, the only difference lies in the disposition of the gear chamber on the engine, with reference to the feet. The gear chamber is arranged so that the quadrant shaft is at right angles to the feet, and this shaft may be extended above or below the engine as desired.

Fig. 7, Section T.7, shows one application of the Type " K " Door Engine.

An alternative application is to place this engine immediately over the top of the folding door shaft, and so dispense with connecting rods and terminals.

The controlling equipment is identical in all respects with that of the Type " E " Door Engine.

For dimensioned drawing of the Type " K " Door Engine, see Drawing No. W.L.2875.

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FOLDING DOOR EQUIPMENT

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