 P.W.—K.4.

Post Office Engineering Department

TECHNICAL PAMPHLETS FOR WORKMEN

Subject

Pneumatic Tube Systems

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4. Test Boards.
5. Protective Fittings.
6. Measuring and Testing Instruments.
7. Sensitivity of Apparatus.
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CORRECTION SLIP TABLE.

The month and year of issue is printed at the end of each amendment in the Correction Slips, and the number of the slip in which any particular amendment is issued can, therefore, be traced from the date. In the case of short corrections made in manuscript, the date of issue of the slip should be noted against the correction.

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PNEUMATIC TUBE SYSTEMS

INTRODUCTORY

Pneumatic tubes are used by the Department for the transmission of messages such as telegraph forms, fault dockets, etc., in carriers, from one position to another in the same building, when they are known as **House Tubes**; or from one building to another, when they are known as **Street Tubes.** Tubes in which telephone trunk call record tickets are transmitted, without being first enclosed in a carrier, are known as **Ticket Tubes.**

In all pneumatic tubes the same principle is employed, *i.e.*, the production of a moving column of air, which propels the carrier or ticket along the tube. This column of air is produced by a pump or blower which delivers air under pressure, or creates a vacuum at one end of the tube, the other end being open to atmosphere.

PART I.—HOUSE TUBES

1—GENERAL

House-tube systems in which the tubes are used for transmitting telegraph forms, fault dockets, etc., from one part of a building to another are sometimes known as Docket Tubes. They are worked either by hand-operated pumps or, more generally, by electrically-driven rotary blowers or centrifugal fans.

In the case of tubes worked by *hand power*, a manually-operated reciprocating air pump is used, the pressure or delivery side of the pump being connected to the tube for sending in the "down" direction. For sending in the "up" direction, the vacuum or suction side of the pump is connected to the tube; this rarefies the air or creates a vacuum at the pump end of the tube, and the carrier is then propelled from the open or far end of the tube by the air flowing in to fill up the vacuum thus created.

In the case of *power-worked* house tubes, a flow of air is maintained by means of a motor-driven rotary blower or centrifugal fan, which is connected to the end of the tube or tubes. The blower or fan creates the flow of air by maintaining a low vacuum of about 10″ to 16″ water gauge (about

½ lb. per sq. in.), from which the system is known as the Low Vacuum system. The current of air is not reversed in the tubes, up and down traffic is provided for by connecting two tubes at the far end, thus forming a Loop, one end of which is connected to the blower and the other open to atmosphere.

2—Tubes

Cylindrical brass tubes 1½″ and 2¼″ internal diameter are used. These are fixed by clips and hangers to walls and ceilings. For tubes operated by hand pumps, the lengths of tubing are generally connected by split couplings, but for power-worked tubes, a close-fitting sleeve is used; this is sweated on to the two ends of the tubes, which are carefully butted together. Where the run of the tubes is easy, the joints may be made with a mixture of red lead and gold size instead of being sweated.

Standard brass bends must always be used and *under no circumstances should locally-made bends or sets be used.* The bend for general use is 3 ft. radius, but a limited number of 18-inch radius bends may be used on a run of 1½″ tubing.

The use of 10½-inch radius bends for 1½″ tubes, and 2-ft. radius bends for 2¼″ tubes, is strictly limited to the connecting up of terminals in confined spaces, such as under the counter of a public office.

3—Carriers

The carriers used for house-tube installations consist of vulcanized fibre cylinders of slightly smaller diameter than the tube. One end is closed and fitted with a felt buffer; the other end is open for the insertion of messages, which are held by a spring clip. Messages should not be allowed to project beyond the end of the carrier. The 1½″ carrier can be made to take 5 plain forms; the 2¼″ carrier takes 25 plain forms.

4—Tube Fittings

Various fittings are provided for inserting the carriers or removing them from the tubes. These fittings are briefly described as follows:—

Installations worked by Hand Pumps.—A Cage, Carrier (Fig. 1) is used at the open end of the tubes. This consists of a square wire cage with a wooden top, through which the carrier is discharged from the tube. A swinging wire door is provided at the bottom of one of the sides, to enable carriers to be inserted or removed.

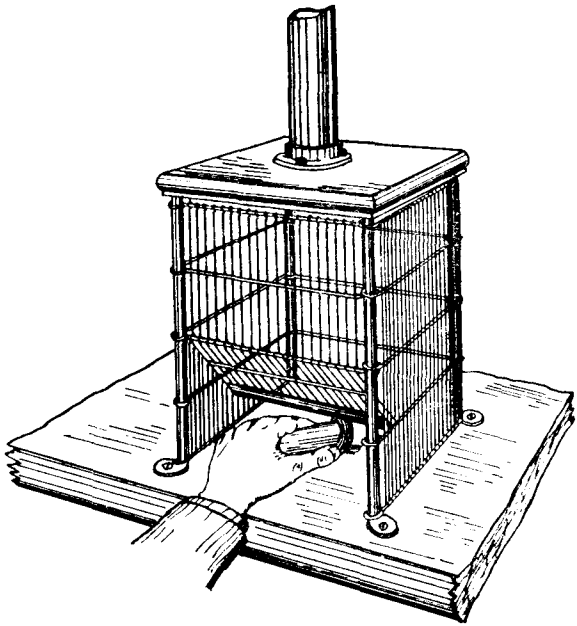


Fig. 1.—Cage, Carrier

At the pump end of the tube, a " Slide, feed," which can be fixed vertically or horizontally is used (Fig. 2). This consists of a short length of tube with an opening cut in it, to enable carriers to be inserted or removed. The opening is covered by a sliding sleeve which can be moved up to insert the carrier, and, when replaced, closes the opening so that pressure or vacuum may be applied to the tube.

Installations worked by Power.—A funnel terminal (Terminal Nos. 1 or 2) is used for despatching carriers at the open end of the tube and a terminal with a hinged door (Terminals Nos. 3 or 4), Fig. 3, at the centre of the loop. For receiving the carriers Flap Terminals (Terminals Nos. 5 or 6), Fig. 4, are used. This is provided with a hinged flap and an internal deflecting grid. The flap is knocked open by the carrier, which then drops into the basket provided (Basket, carrier).

5—Control Cocks and Fittings

The air supply to the tubes is controlled by means of cocks or orifice discs.

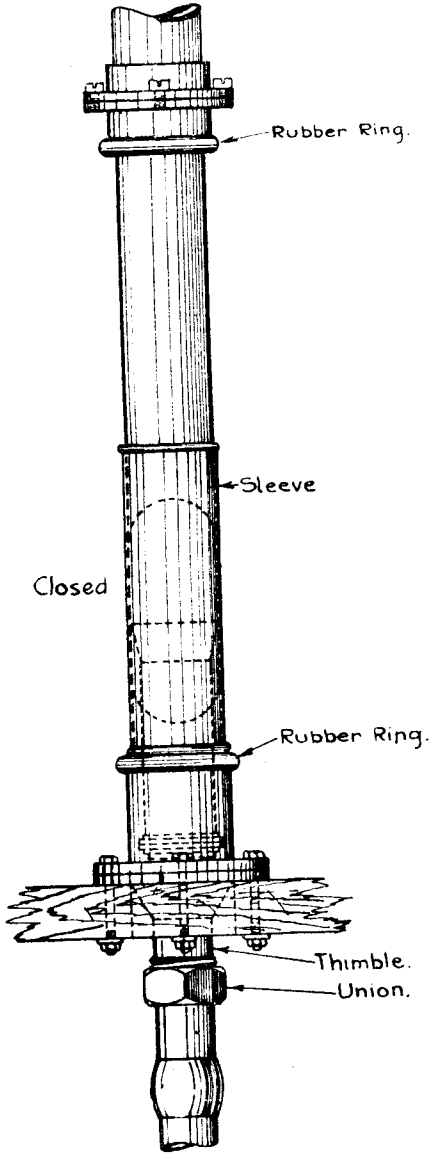


Fig. 2.—Slide, feed

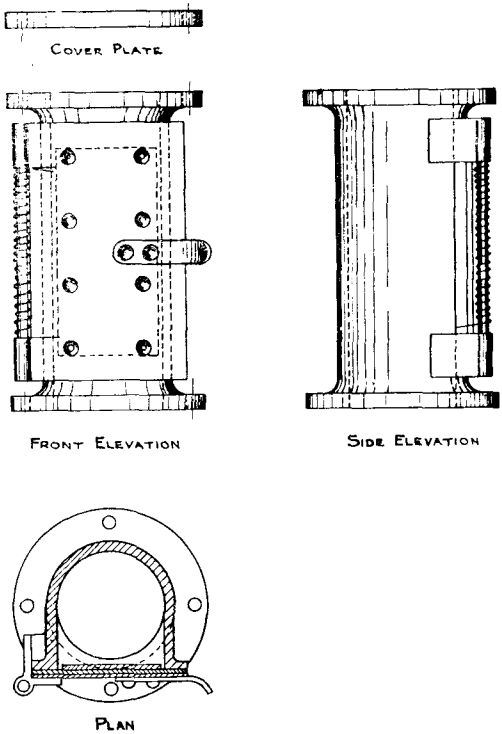


Fig. 3.—Door Despatch Terminal

For installations worked by hand pumps, the control cock is fitted to the pump itself. It is a two-position cock with four connexions so arranged that, with the lever in the Receiving Position, the pump suction or inlet valves are connected to the tube, and the delivery or outlet valves to the outside air. With the lever in the Sending position, these conditions are reversed. When two tubes are to be operated from one hand pump, a "Switch, Pneumatic No. 2" is provided. This switch has a bottom opening which is fixed to the usual tube connexion of the pump, the feed slides of the respective tubes being connected to the top of the switch.

For Power-worked systems with more than one tube or loop, Cocks are used and should be placed at the junction of the

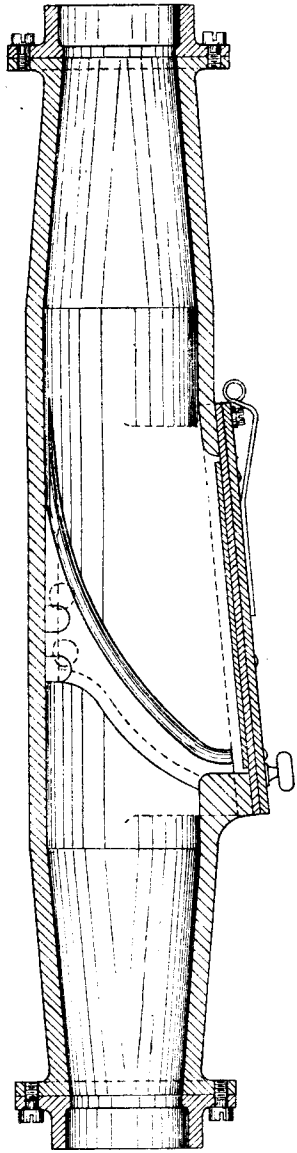


Fig. 4.—Flap Terminal

tubes with the common service pipe or header, to enable stoppages to be cleared or tubes shut off as required.

Tubes of various lengths require different degrees of vacuum to operate them, and orifice discs of different sizes as needed are inserted in the tube accordingly to balance them.

Size of Orifice.—In choosing the right size of orifice, it has to be borne in mind that the maximum vacuum at the receiving terminal nearest the blower should not exceed 10″ water gauge for satisfactory working, while the velocity of the carrier in the tube should not exceed 30 ft./sec., otherwise unnecessary wear of the carriers and fittings will result.

6—Signalling Apparatus

For hand-worked installations, trembler bells (type 13A or 24A) or buzzers, with press buttons, usually suffice.

For power-worked installations it is not usual to install any signalling apparatus, unless arrangements can be made to stop the blower or fan during periods of no traffic. When this is controlled from one point, it is necessary to install a bell or buzzer, so that a signal may be given from the other stations when air is required.

7—Air Pumps, Rotary Blowers and Centrifugal Fans

The standard pump for hand-worked tubes is the *Pump, Pneumatic, Hand,* which is made in two sizes. The smaller one can be supplied with the handle arranged to work vertically or horizontally; the larger size has the vertical motion only. In both cases, the pump is of the reciprocating double-acting type, and a sketch showing a section of the cylinder is given in Fig. 5.

The control cock, described in Section 5, fits over the passages marked "Pressure Connexion" and "Vacuum Connexion." The piston is shown moving in an upward direction, and if the control cock is set at "Send" the air above the piston is being compressed and driven through the *delivery valve* and control cock to the tube. At the same time, by the upward motion of the piston, air is being drawn into the lower portion of the cylinder from atmosphere through the suction valve and control cock. When the piston descends, the two valves shown open in Fig. 5 at once close, and two other valves (not shown in the sketch) are opened. One of these is connected to the space above the piston and is a *suction* valve; the other is connected to the space below the piston, and is a *delivery* valve. It will therefore be seen that

the air, which has been drawn from atmosphere into the space below the piston on the upward stroke, is compressed and driven out into the house tube on the downward stroke. Pumps arranged to work in this manner are called "*double acting*" reciprocating pumps.

When the control cock is changed over to the "Receive" position, the vacuum connexion is joined to the house tube, and the pressure connexion to atmosphere. The pump then draws in air from the house tube, from the end open to

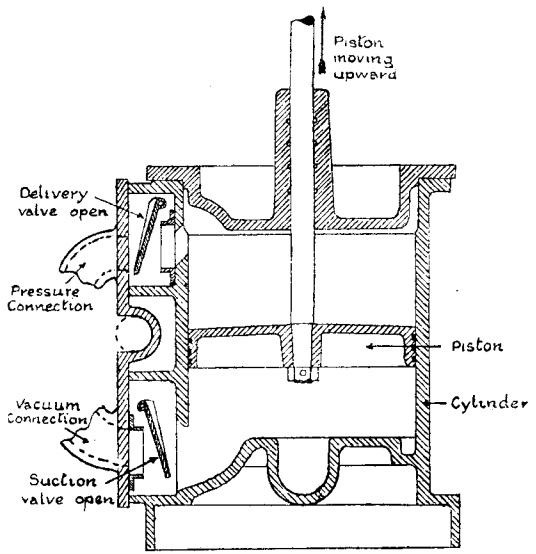


Fig. 5.—Hand-Pump Cylinder

atmosphere to the end attached to the pump, and so propels the carrier towards the station nearest the pump.

If it is intended to work only one tube, the feed slide is usually bolted direct to the pump. If two tubes have to be dealt with, a *Switch, Pneumatic, No.* 2, described in Section 5, is also provided. The small pump can be fixed on a table if necessary, but it is usual to mount the larger one on a base for pneumatic pumps.

Spare parts supplied for hand-pumps are as follows :—

Clack (valves) ;
Springs (for valves) ;
Washers, leather (for fixing on piston rods).

Power-worked installations.—In small offices, a centrifugal fan (Fan, Centrifugal, compound type) is used, this being suitable for one or two $1\frac{1}{2}''$ tubes or loops or one $2\frac{1}{4}''$ tube, the vacuum maintained being $1\frac{1}{2}''$ water gauge. If the tubes are so long that the 10″ water gauge is required to maintain the movement of the air in the tube itself (*i.e.*, 300 feet $1\frac{1}{2}''$ tube) a Roots' Blower 08 or 07 should be used, giving 16″ water gauge.

Roots' Blowers 06 and 05 are standard for larger installations, while special "Fans, centrifugal" are installed when the number of tubes is outside the capacity of these machines.

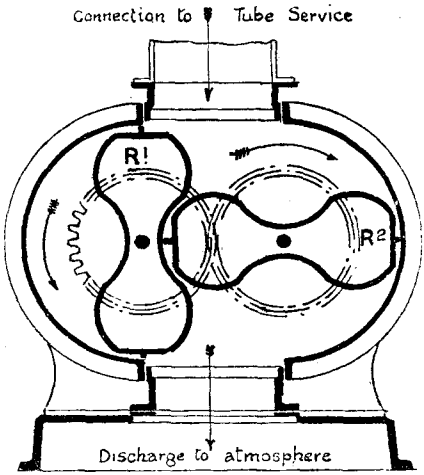


Fig. 6.—Rotary or Roots' Blower

The Rotary or Roots' Blower (Fig. 6) consists of a casing inside which are two rollers of special shape, mounted on spindles and so geared together that when one is vertical in position the other is horizontal, with its top fitting closely into the "waist" of the vertical one. These two rollers R1 and R2 may be said to scoop the air through the blower as they revolve and, as they fit closely together and to the casing, a flow of air is maintained from the suction to the delivery outlet. This flow of air depends on the speed of rotation and is maintained practically constant at any vacuum or pressure up to about 1 lb. per sq. in. If, however, the outlet becomes blocked, the pressure tends to rise abnormally;

the vacuum is to a certain extent self-regulating, owing to air slip between the rollers and casing.

As the Department's installations are worked by applying a low vacuum to the ends of the tubes, the suction side of the blower is connected to the tubes or common service main.

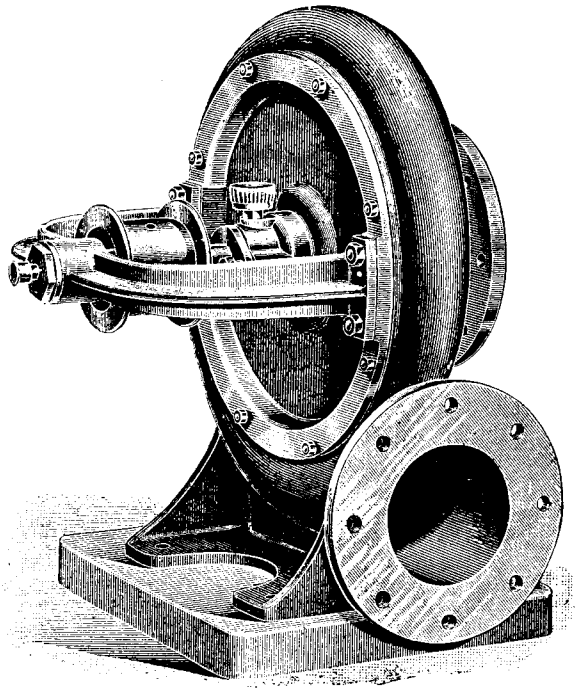


Fig. 7.—Single-stage Centrifugal Fan

These blowers are belt-driven from electric motors and, to ensure quiet running, the speed should not exceed about 220 r.p.m.

Single-stage centrifugal fan (Fig. 7).—In the small standard "Fan, centrifugal, compound type," two similar fans are connected in series, forming a two-stage fan. In these fans, the air is drawn in at the centre of the casing in which an impeller revolves from which the air is thrown off by centrifugal action at the tips of the blades, collected and discharged

from the circumferential spiral. With these fans, the pressure or vacuum developed remains practically constant at all loads from no load to full load. These fans are usually coupled directly to electric motors running at 2,000 to 3,000 r.p.m.

8—Systems

The system operated by hand pumps scarcely needs further description. The pump is fixed in a convenient position behind the counter, or elsewhere. The feed slide, by means of which the carrier is inserted in the tube, is bolted direct to the pump outlet (or pneumatic switch if two tubes are operated from the same pump) and from it the brass tube is run to the Instrument Room and terminated in a carrier cage.

The **Low-Vacuum System** is the most economical and satisfactory of the purely house-tube systems worked by power, and is the standard system installed by the Post Office. The various fittings used have been described in Section 4.

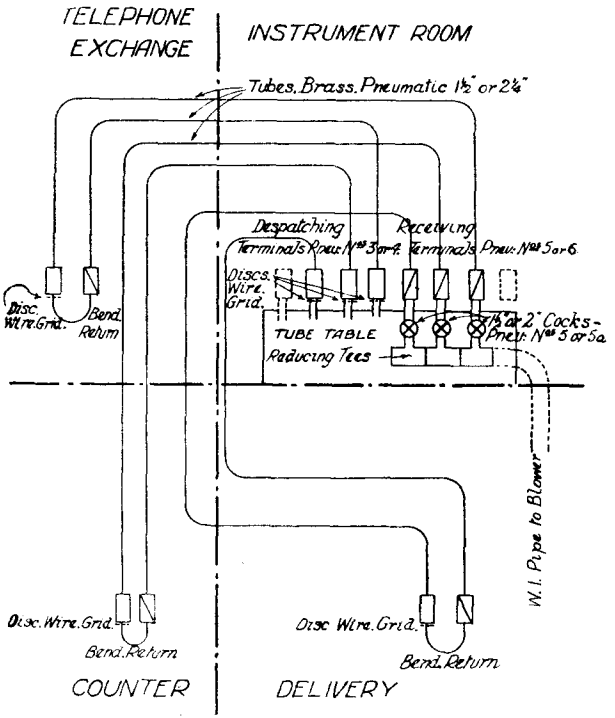
In this system, the tubes are joined up in " parallel " or " multiple." The various stations are generally connected by separate looped tubes—one leg of which is used for " up " traffic and the other for " down " traffic—to the central distributing point, usually the Instrument Room, and each loop is then joined to a common service pipe and thence to the blower or centrifugal fan. Such a system is shown in Fig. 8.

The air current in each branch is maintained at a velocity of 25 to 30 ft./sec. by the blower or fan, and the total length of any tube (complete length of loop) should not exceed 300 ft. for $1\frac{1}{2}''$ tubes, or 400 ft. for $2\frac{1}{4}''$ tubes.

If these lengths were exceeded, it would be necessary to use more than 10″ water gauge vacuum on the tubes and the operation of the discharge terminals would become unsatisfactory. If the total length of the tube is greater than the limits stated above, it is necessary to split the tube into two independent tubes, each with its own service pipe from the blower.

A loop may also be run to connect, say, the Counter and Instrument Room, and the Instrument Room and Delivery Room, instead of forming an " up " and " down " tube between two points only, but, generally, in any run there should not be more than two despatch terminals and two receiving terminals on the tube.

Tubes should always be arranged so that a carrier is despatched in an upward direction.

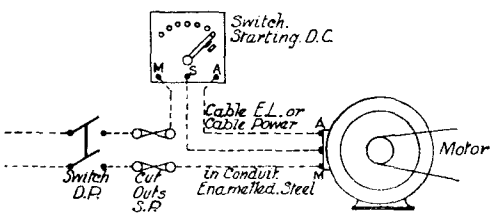


Reference:-

- ▯ = Terminals. Pneumatic. Nos 5 or 6
- □ = Terminals. Pneumatic. Nos 3 or 4
- ⊗ = Cocks. Pneumatic Nos 5 or 5a
- --- = Discs. Wire Grid. Nos 1 or 2

Note:-

For 1 loop use Blower No 08 Pipe to Blower 1½" W.I.
" 2 " " " 07. " " " 2¼" "
" 3 " " " 06. " " " 3" "
and ½ HP. Motor in each case
For larger installations the case should be referred to Headquarters



D.C. MOTOR WIRING DIAGRAM.

Fig. 8.—Low Vacuum Tube System

The standard speed of carriers in house tubes is 25 to 30 ft./sec. and, owing to this, the vacuum to be applied to the tube varies with the length of the tube; e.g., 10″ water gauge is required with a tube 300 ft. long, but much less would suffice with shorter tubes. The vacuum applied to each tube, on systems consisting of more than one tube, is regulated by inserting an orifice or throttle disc on the service side of the "up" flap terminal (the terminal nearest the blower). In any case, even on the longest tubes, a throttle disc to drop 3″ water gauge at the normal air flow in the tube should be inserted, so as to limit the inrush of air when the flap of the receiving terminal opens to discharge a carrier. (For details of these discs, reference should be made to E.I. MISCELLANEOUS, PNEUMATIC TUBES, C 1008.)

In this, as in the previous systems, fluff from carriers and sometimes soft particles such as paper will lodge in the tubes or work their way down to the blower. Periodical tests of the water gauge maintained should, therefore, be made by means of a $\frac{1}{16}$″ hole drilled next the "up" flap terminal and the vacuum being measured by means of a "U" glass tube water gauge, as shown in Fig. 9. No permanent connexion is required; the reading can readily be made by holding a fairly stout $\frac{1}{4}$″ rubber tube connected to the gauge over the hole. The hole can be closed by means of a wafer when not in use.

9—Maintenance

The following are the principal points that require attention to obtain efficient maintenance.

Carriers.—These should be discarded when the felt pad or buffer is worn down by $\frac{1}{8}$″ in diameter. Care should be taken to see that the messages do not protrude beyond the end of the carrier, and all carriers should travel buffer foremost.

Tubes should be protected from damage, where they pass through floors, by means of wooden casing.

Hand-pumps.—The weight on the lever should be set to balance the combined weights on the handle side, so that the pump works quite freely. The moving parts should be occasionally lubricated.

Roots' blowers should be kept well lubricated, and, if the vacuum is found to fall off, a piece of engine grease or vaseline dropped into the blower will often provide a remedy. The blower should be taken to pieces and thoroughly cleaned every six months. Noise made by the plant can be reduced, by connecting the exhaust from the blower to the open air by means of a pipe.

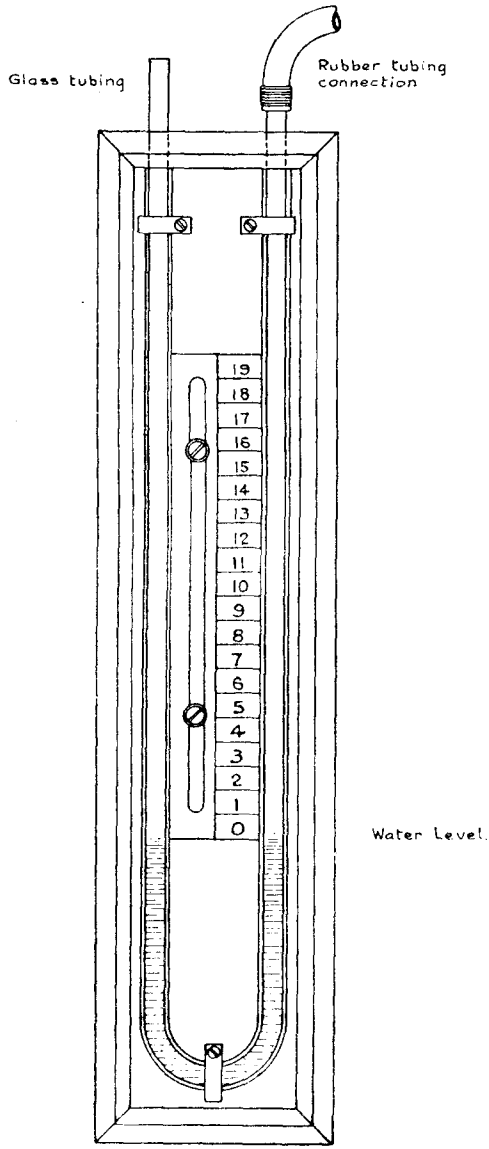


Fig. 9.—Water Gauge or " U " Tube

Centrifugal fans.—Special care should be given to the lubrication of the bearings. The set, having no other rubbing parts, requires no other attention if in proper adjustment.

Belts.—If of leather, a small quantity of resin powder may be used to remedy slipping ; if a prepared canvas belt is used, however, *belt composition* or *resin* must *not* be used.

Stoppages of tubes.—If a carrier stops in one of the tubes of a " parallel " system, the section can generally be cleared by, first, shutting off the control cocks of the other tubes so that the blower is working alone on the blocked tube and, then, applying the full vacuum available ; the obstruction can usually be moved by shutting and opening the control cock. If the section cannot be cleared thereby, the carrier should be located and removed by means of a " fish " wire of 14-gauge G.I. wire, inserted from either end of the tube.

PART 2.—TICKET DESPATCH TUBES

1—General

These ticket tubes are used in Trunk and Toll Telephone Exchanges, to collect or distribute the tickets used to record the details of the calls made. Two systems are in use, operated by air under vacuum and pressure respectively. The first-mentioned system is used to collect the tickets from the operators' Positions and, if the call has been completed, to deliver these tickets at the Filing and Sorting Position; or, in case the "Demand" operator cannot complete the call, to transmit the tickets bearing details of the calls required to the Pneumatic Distribution Position, whence they are re-transmitted to a Delay operator to complete the call, the

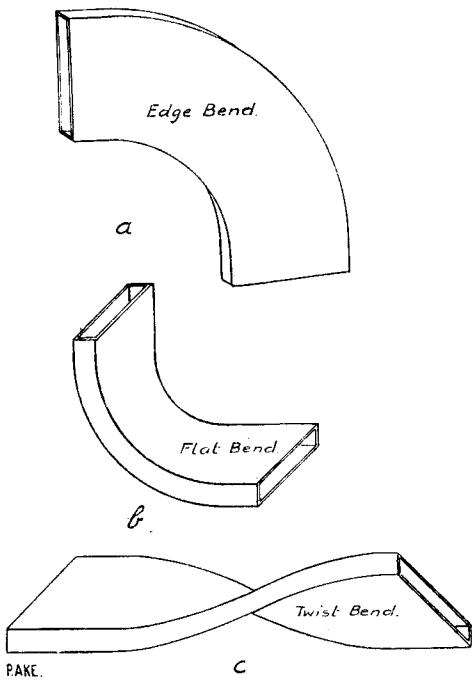


Fig. 10.—Bends and Twist Sections

tickets being finally sent on to be sorted and filed. The tubes on the distributing system are operated by air under pressure. In these tube systems carriers are not used, but the ticket is inserted directly into the tube.

2—Tickets

The tickets used by the Department are about $5\frac{1}{4}'' \times 2\frac{3}{8}''$, a special heavy-weight paper being used. The end of the ticket is bent up at right-angles, to form a sail 8 mm. high, and is inserted into the tube with the sail at the back. (The tolerance on the sail is $\pm$ 0·5 mm.)

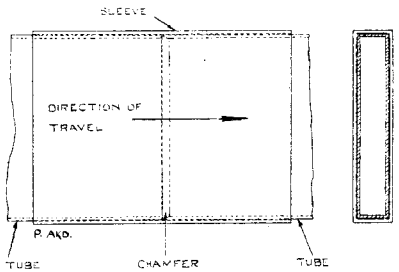


Fig. 11.—Joint

3—Tubing

The **tubes** used are not circular, as in the case of systems using carriers, but are rectangular (approx. $2\frac{3}{4}'' \times \frac{3}{8}''$) in section. Slight ribs are formed upon the surface, and these enable air to pass under and float the ticket in the column of air, thus reducing the friction.

Bends (Fig. 10) may be made either on the flat or on the edge; the latter are difficult and expensive to make and, generally, flat bends are used. The tubing is generally erected on edge, owing to the greater convenience in assembling the runs and the fewer supports required, as the tube is stiffer in this direction; it is therefore necessary to bring it to the flat before bending, and this is done by means of a twist (Fig. 10).

Inspection pieces are placed at intervals on the tubes, to facilitate the location of stoppages and to permit the removal of affected tickets by means of a " fish " wire.

Joints.—Joints are made by means of sleeves, the ends of the tubing being carefully butted together. Any edge on which the tickets might impinge must be chamfered away to a smooth and easy angle, as illustrated in Fig. 11. The joints are sealed by means of a special compound.

4—Air Supply

Fans.—The air supply for these tubes is provided by means of centrifugal fans as in the case of the house-tube systems, the pressure or vacuum maintained, however, being about 24 ins. water gauge. Usually, these fans are arranged in sets of one pressure machine and one vacuum machine, coupled direct to a driving-motor. Valves are provided, so that any machine not running may be isolated from the duct work. In some cases, these machines are provided with silencers.

Loads.—The load on the vacuum fan is constant, the vacuum-operated tubes being worked continuously. The pressure-operated tubes, however, are worked intermittently and the load may vary from nothing to a maximum ; a small bypass is provided to atmosphere from the pressure fans, therefore, to ensure a certain delivery of air at all times, otherwise the fan may heat excessively owing to churning up of the small quantity of air held in the casing.

Service Ducts and Headers.—The fans are connected to the tube headers by means of galvanized sheet-iron *ducts* or W.I. pipe. *Headers* are provided at the Ticket Sorting : Filing Position (T.F.P.) and the Pneumatic Distribution Position (P.D.P.), to which the tubes are connected.

5—Systems and Apparatus

Types of Systems in use.—There are two types of pneumatic tube systems in use by the Department ; they are as follows :—

(*a*) The Mix and Genest (Pressure and Vacuum) system (Fig. 12).

(*b*) The McGregor (Vacuum) System. Patent No. 379544, foreign patents pending (Fig. 13).

The same tubing is used in both systems, the essential difference being in the apparatus used. Generally the installations will be found to be a combination of the two systems, the Mix and Genest terminals being used for the distributing tubes and the McGregor terminals for the collecting tubes, only a few Mix and Genest terminals (which are now obsolescent) having been installed pending the development of the standard apparatus.

Collecting tubes (vacuum-operated).—These tubes are run under the keyboards or behind the panels of the operators' Positions, and are each provided with up to 10 despatch valves. The tubes are usually taken to the back of the switchboard, and collected in runs overhead or in the floor, and thence to the P.D.P. or T.F.P.

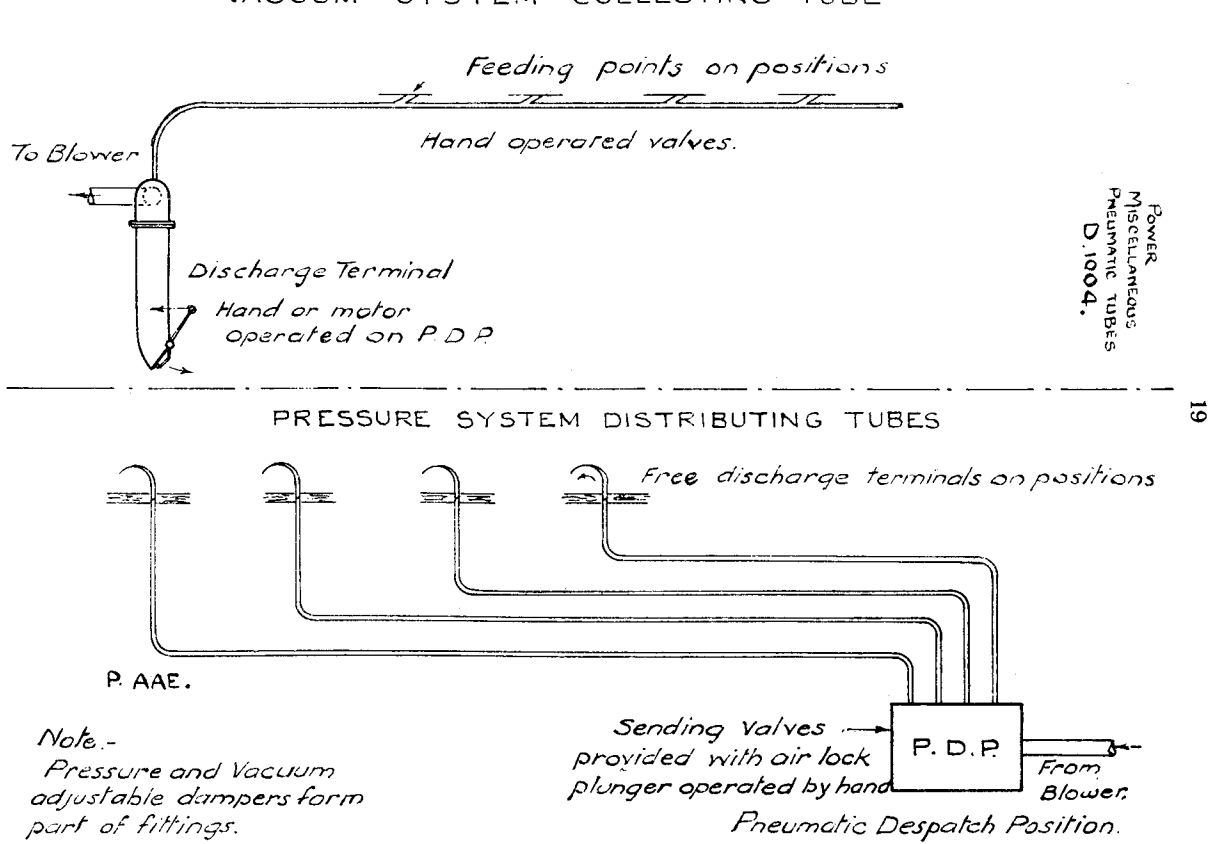


Fig. 12.—Mix and Genest System

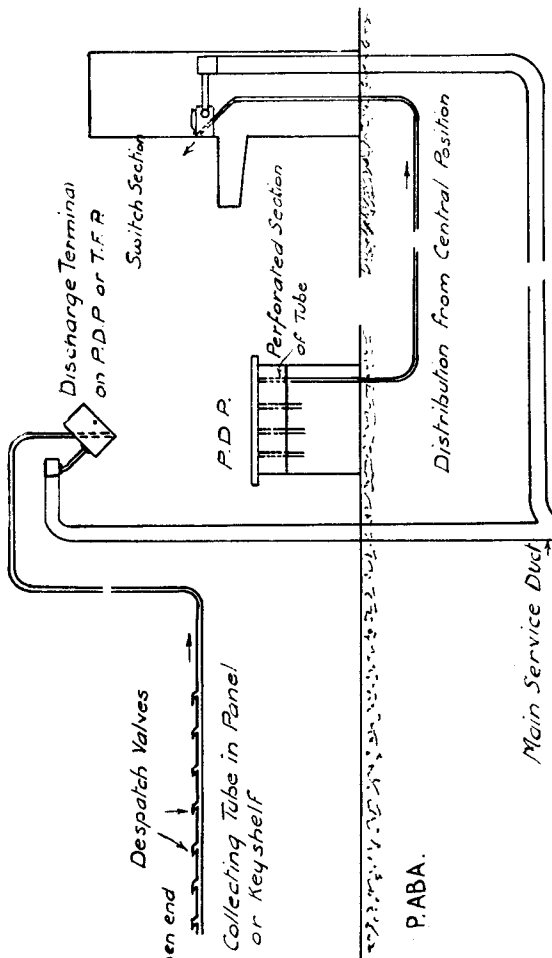


Fig. 13.—McGregor System

Despatch Valves.—These are very simple in form and consist of a metal casting on the tube, the top side of which has been cut open at this point. The casting is provided with a guide to lead the ticket into the tube, and a close-fitting spring lid, one end of which is depressed to open ; this is closed again by pressing down the opposite end.

Discharge Terminals.—The tickets are discharged through special terminals of either the Mix and Genest type (at Leeds and Bristol only) or the McGregor type, which is now standard. The **Mix and Genest** terminal is shown in Fig. 14 and consists of a casting containing two compartments A and B, separated by a movable flap door C. The upper compartment—to which the service pipe E from the blower is connected—forms an air lock. At the bottom of the valve or terminal, is another flap door D. The operating mechanism connecting these two doors is arranged to ensure that when D is open C is closed, and *vice versa*. Normally, the upper door is open and the bottom door is closed ; tickets arriving in the terminal fall into the lower chamber, where they may be observed through the windows. The door D is now opened by means of the lever F, this causing the door C first to close ; the bottom chamber is shut off from the air service and maintains the vacuum in the tube. As soon as the tickets have fallen out, the doors are restored to normal and any tickets which may have accumulated in the upper chamber fall through into the chamber below ; this process is repeated for all tickets arriving subsequently. The terminal is provided with a leak by-pass between the two chambers, to reduce the noise made by the opening of the inner door against the vacuum ; flexible leather is used to form the outer door, for the same purpose. A valve is provided, to regulate the air supply to the tube. These terminals may serve one or two tubes each, depending on the traffic conditions.

The valves are mounted in banks and operated in turn, by means of cams on a shaft driven by a motor ; alternatively, they may be operated by hand. The mechanical opening of the valves is generally timed to ensure that no ticket will be delayed in the terminal for more than 5 to 10 secs.

The McGregor terminal is shown in Fig. 15 and a short description of the principles involved is given so that its adjustment may be better understood.

The terminal is entirely automatic in action, no hand operation, or auxiliary motor, or other operating device being required ; there is no delay in the discharge of the ticket. The terminal consists of an inner casing A and an outer casing B, forming between them an air chamber, which is

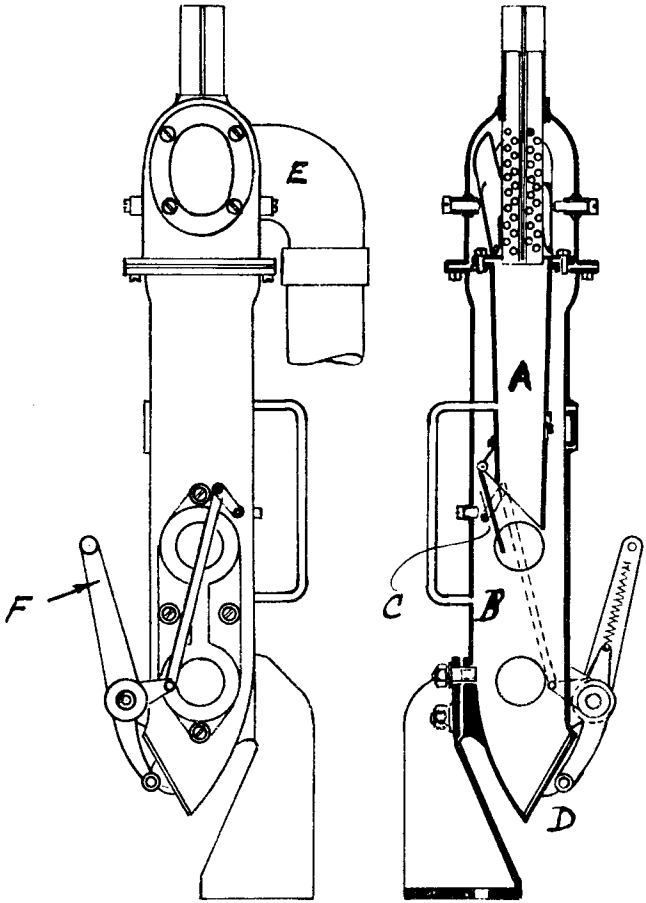
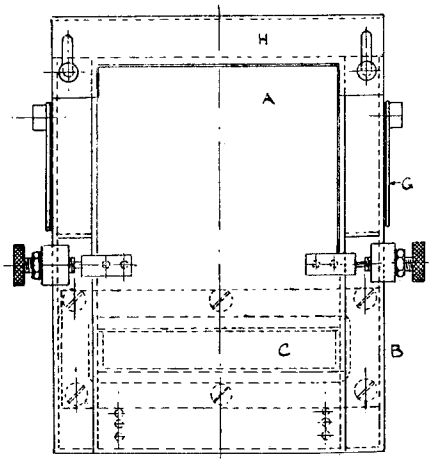
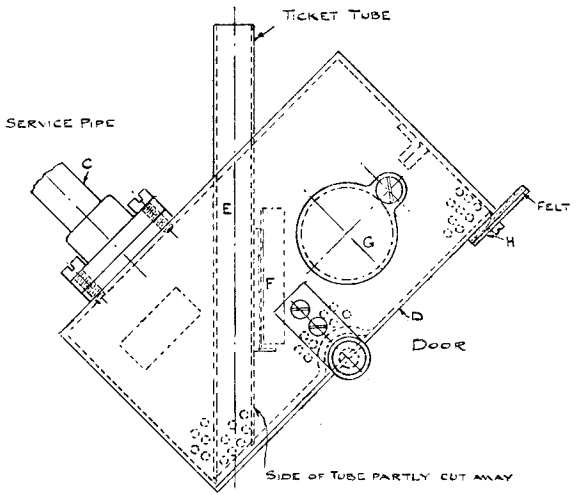


Fig. 14.—Mix and Genest Terminal



Front View



Elevation as erected

Fig. 15.—McGregor Terminal (Prov. Patent No. 28306/31). (Patent No. 379,544)

connected to the blower through the service pipe C. The inner chamber is connected to the air chambers by means of a number of holes, the purpose of which is to by-pass the current of air. The terminal is closed by a door, which is pivoted about its centre line and designed so that it is practically balanced as regards the forces exerted by the vacuum, atmospheric pressure and gravity. In the closed position it also has to be balanced against the force exerted by the moving column of air in the tube, and this force varies with each individual tube. The balancing of the door in the closed position is controlled by the slide H, which alters the area of the top half of the door exposed to the atmospheric pressure. The balance of the door when a ticket is being discharged is affected by the size and arrangement of the air by-pass holes, and it is essential that these do not become blocked. A valve, to control the vacuum on the tube, is embodied in the service pipe C.

Alarm Circuits.—On vacuum-operated collecting tubes, alarm circuits are provided and include an indicating lamp at each sending position. This lamp is operated by means of a Float Contactor. This piece of apparatus, illustrated in Fig. 16, is actuated by means of a light aluminium strip, pivoted across the tube so that it is lifted by, and floats on, the current of air so long as air is flowing through the tube. The float is biased towards the alarm position by a spring. A lever is mounted outside the tube—on the pivot of the strip—by means of a set screw, which provides the necessary

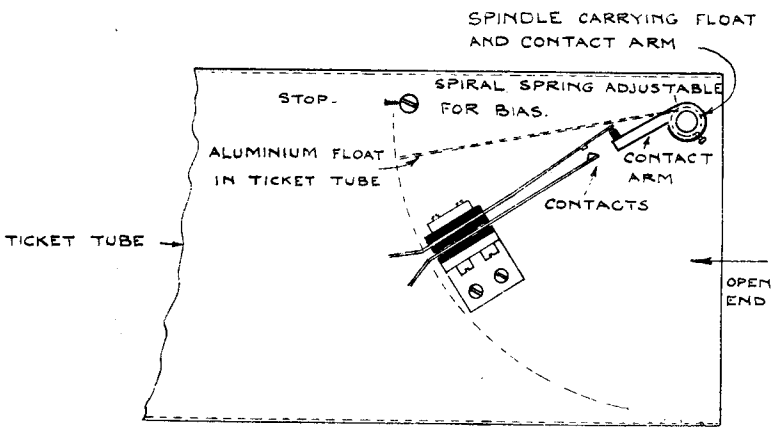


Fig. 16.—Float Contactor

adjustment. While the aluminium strip is floating on the full current of air, this lever causes the contacts for operating the alarm circuit to be opened, but allows a circuit to be made if the stream of air is reduced from any cause. Differential Indicators (*see* Street tubes) are also used to operate alarm circuits.

Distributing Tubes (pressure-operated).—*Despatch Valve.*—In the case of these tubes, the ticket is inserted into the end of the tube through the despatch valve, shown in Fig. 17. These valves are grouped conveniently at the P.D.P., to facilitate sorting and despatching the tickets. As these tubes are operated by compressed air, it is impossible to insert the tickets directly into the tubes, and the valves accordingly embody a form of air lock. The valve consists of a casting containing two chambers A and B, the chamber marked A being connected to the air supply header or pipe, and that marked B to movable flap C, while the chamber B—which receives the ticket—is provided at the top with a slot, through which the ticket is inserted. This slot is also provided with a movable cover D. Normally, the ticket slot is open, while the air communication slot is closed by the flap C. The ticket having been placed in the valve, the plunger E is depressed; this causes the flap C to open, and admits air to propel the tickets through the tube; at the same time, the flap D is closed. The depression of the plunger E also closes an electrical circuit to operate an electromagnet F, by means of which the plunger is retained against the pull of its restoring spring and a signal lamp is illuminated. On the arrival of the ticket at the far end of the tube, the ticket strikes a lever which causes the electromagnet circuit to be opened momentarily, and the plunger is restored to normal by its spring; the sending valve is thus restored to its initial condition, *i.e.*, the air valve is closed and the ticket slot in chamber B is opened, ready for insertion of the next ticket. A local open-circuit key H is also provided on or near the valve; this key is operated to release the electromagnet and cut off the air supply in the event of the failure of the trigger contact on the discharge valve. An adjustable valve K is provided near the connexion to the air supply, to regulate the air pressure according to the length of the tube. The proper closing of the covers C and D is essential, to prevent leakage of air.

The Pressure Discharge Valve or Terminal consists simply of the open end of the ticket tube, curved to meet requirements, and is provided with a guide to direct the discharge of the ticket. This guide is provided with slots, to ensure a free

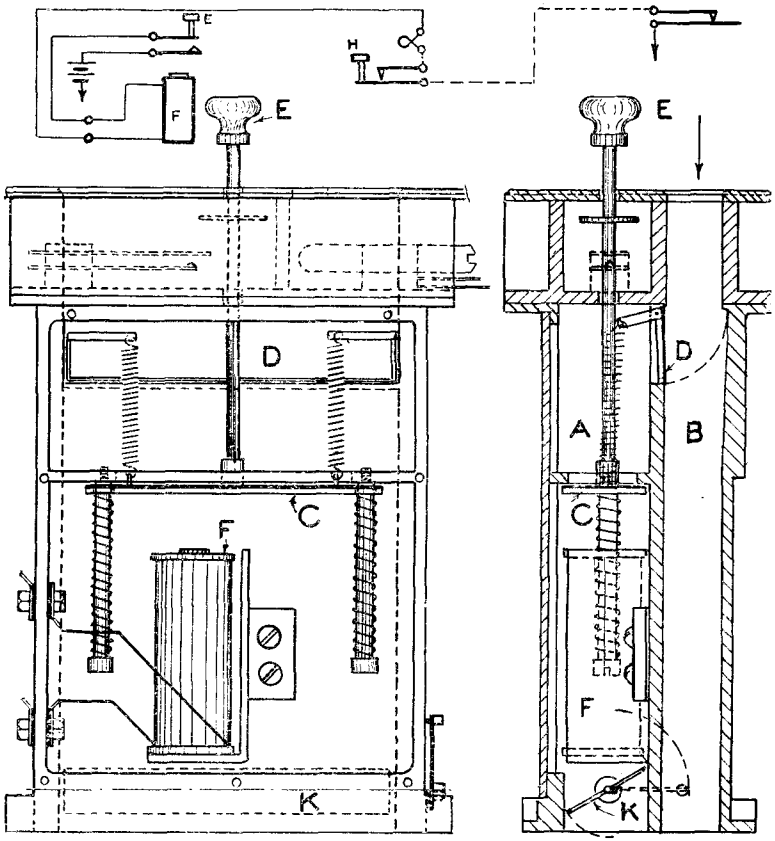


Fig. 17.—Mix and Genest Pressure Despatch Valve

passage for the air, away from the operator; also a trigger contact, to signal the arrival of the ticket.

6—Operating Pressure and Vacua

The pressure and vacuum at the blowers is generally about 24″ water gauge. This should, however, be reduced for normal working of the tubes, by adjusting the valves supplied adjacent to each terminal on the vacuum tubes, to about 10″ or 13″ w.g., as measured on the tube side of the terminal.

This will give a ticket velocity varying from about 30 ft./sec. on the shortest tubes, to 18 ft./sec. on the longest tubes. In the case of the pressure tubes, an adjusting valve is embodied in the despatch valve. In no case should a velocity of 30 ft./sec. be exceeded, as damage to the tickets may result.

It will be seen that, while there is a certain drop of vacuum and pressure across the terminals and valves, there is a considerable reserve of power, use of which is very valuable in case of a blockage being formed by the tickets (*see* maintenance); this reserve also comes into action automatically as, directly the flow of air is reduced by a ticket slowing up, say, at a bend in a tube, the vacuum tends to rise to the full amount available, thus causing acceleration till the air flow is again normal.

7—Installation

Ticket Despatch Tube systems of the Mix and Genest and McGregor types are installed by Contractors, as this work is of a highly-specialized character. The blowers and air-supply ducts, however, are installed separately by the Department, or by contract. Any defect in the erection of the tubes may cause endless trouble in maintenance; it is, therefore, essential that the installation shall be carried out with great care and under strict supervision. It must be borne in mind that the slightest projection, or burr, in the tube is sufficient to impede the travel of the tickets.

During installation, special attention should be paid to the various important points detailed in the following paragraphs, which also apply to any work carried out in connexion with the maintenance of the tubes. The tubes are supplied as bends, twists and straight lengths, the latter being either 12 or 15 ft. long. The individual lengths of tubes must be handled with the utmost care, to avoid deformation, bending or other damage. Long lengths should be carried on edge, and, when supported on trestles or by some other means—whether for installation operations or storing purposes—the tube should always be kept on edge.

The tube runs must be rigidly supported by hangers, brackets or other means at intervals of at least 8 ft. where the tubes are erected on edge, and every 4 ft. if the tubes are run on the flat. Generally, a clearance of about $\frac{1}{2}$ in. has to be allowed between the tubes, where a number of them are erected parallel to each other, to facilitate maintenance operations; separators will be inserted between the tubes to hold them in place.

The run of the collecting tube—when McGregor type terminals are fitted—should be arranged to provide for a vertical drop down to the discharge terminal for about 4 ft. or more—clear of the last bend or twist, whichever is employed—to ensure that the final run of the tickets is straight and not restricted. This is not important as regards the distribution tubes, however, as the traffic conditions are very different, and only one despatching valve is fitted per tube.

The ends of all details (edges or joints, etc.) facing the direction of flow of the tickets must be internally chamfered, to an angle of about 30°. All scratches, burrs, etc., which may be caused to the inside of the tube by the chamfering or other causes, must be removed; perfect smoothness is essential.

Tube sections.—No tube section shall be used which has become dented, buckled or which is in any way so imperfect as to impair its function. No section of tube shall be installed in the tube run until it has been cleaned, by pulling a tightly-fitting dry clean felt pad backwards and forwards through it. Tube sections in unfinished runs must be protected internally against dust and moisture during the installation, and should be plugged up during the periods when installation work is not actually in progress.

Bends and Twists.—If, when being fitted, bends or twists are found to be out of position by more than $\frac{1}{32}$" to $\frac{1}{16}$"—depending on radius and length—no attempt should be made to change the amount of bending or twisting until the bend has first been filled with a bending tool—or, in the case of a twist, with leather—to avoid distorting the tube.

Joints in the tube must be made by means of coupling sleeves. At these joints, the tube ends must be truly squared and must butt together, as near the centre of the coupling sleeve as is possible. To ensure this, lines must be scribed across the tube before the joint is made and the distance between these lines—after the sleeve has been placed in position—must be accurately checked. The internal edges of the tube sections must be chamfered, and joints in adjacent tubes must be staggered.

All joints must be made air-tight by means of the special sealing compound, care being taken that none of the compound enters the tube. The ends of the tubes at a joint must be close fit in the sleeve, but must not be so tight that the tube is distorted inwards. For this reason, the tube ends should be given a slight inclination outwards, by means of the use of a drift. If it is necessary to resort to hammering the

sleeves or tube ends, a large wooden, or hide, mallet must be used in conjunction with the drift, and the tube end, or sleeve, must be protected above and below by pads of linoleum or similar material. On no account must a metal-faced hammer be used for this work.

Avoidance of Strains.—Every endeavour must be made to ensure that the runs of tubing shall not be subject to strain. If this is unavoidable, as may be possible over a long length, the strain should tend to press the joints together.

Inspection Covers should be fitted on the upper narrow side of the tube.

Auxiliary Air-inlets.—On very long tubes exceeding 200 ft. in length, it is found advisable to fit an auxiliary air-inlet to the vacuum-operated tubes, about 30 ft. from the terminal. This takes the form of a slot in an inspection cover, about $\frac{1}{4}'' \times \frac{1}{8}''$. In tubes exceeding 300 ft., an additional air-inlet may be inserted about 100 ft. from the terminal, the air-inlet being $\frac{1}{8}'' \times \frac{1}{8}''$. When this course is adopted, a slightly higher vacuum may be used on the tubes.

8—Maintenance

Vacuum Dispatch Valves.—To prevent loss of vacuum, which would interfere with the despatch of tickets from other valves serving the same tube, each valve lid must make a close contact with its seating.

Vacuum Tube Discharge Terminals (Mix and Genest type).—*The adjustment of the leak by-pass,* between the inner and outer chambers, should be such that, while the noise caused by the opening and closing of the inner flap is reduced as much as possible, the amount of air passing through the by-pass must be kept at a minimum. If this condition is not maintained, the uprush of air when the outer flap is opened may tend to drive back the tickets which may be already in the terminal.

Doors and Seatings.—It is also essential that the doors close properly on to their seatings; the outer door should open fully, to ensure that there shall be no interference with the discharge of the tickets, since this is by gravity only. If the internal door does not close properly, there will be an uprush of air which will hold back the tickets, and leakage past the outer door will result in a loss of vacuum.

The holes for the passage of air to the suction pipe must be kept clear; inspection covers are provided to facilitate this cleaning.

Vacuum Tube Discharge Terminal (McGregor type).—*Adjustment of Dynamic and Static Balance of the Door.*—The discharge of the ticket through this terminal depends on the balancing of the two halves of the door as regards vacuum, atmospheric pressure, gravity and the inrush of air when the door opens, as against the downward movement of the column of air in the tube.

Hingeing of Door.—It is essential that the hingeing of the door should be perfectly free, and practically free from shake. The hinge contact should be on the points of the pivots only, and the hinges must not be allowed to wear down so that there is rubbing on the shoulders. The hinges must be kept clean.

The hingeing of the door is so arranged that the bottom of the door closes properly on to the metal seating of the casing, and the top end presses slightly against the Cut-off H. This pressure must be such that the felt on the cut-off makes good contact with the door but does not force the door off its seating.

Adjustment of Cut-off.—The cut-off H should be adjusted to balance the door, so that the slightest impact by the ticket causes it to open. In adjusting this, it must be remembered that the felt has to make good contact, as above, with the door (otherwise it is ineffective in reducing the active area of the door) ; and, the vacuum being on, it is necessary first to make a trial adjustment, by slackening the screws holding the slide and moving it one way or the other until it seems correct on tightening the screws, and then slightly readjusting it till the balance is delicate. This is quite easily carried out, the door tending to stick closed if the slide is moved too far down, and vibrating or remaining open if it is too high. If the door is vibrating slightly, a final adjustment of the shutter F, which controls the open portion of the ticket guide, will usually give the finishing touch required. This shutter should usually be adjusted to leave an opening on the guide about 1 in. from the bottom.

Examination and Adjustment after Installation.—Each terminal requires adjustment after fitting to its own tube, owing to one of the factors being the moving column of air in the tube. The working vacuum for the tubes is from 10″ to 13″ water gauge, measured on the tube side of the terminal, and this is controlled by the damper, or cock, adjacent to the terminal. If the slide and shutter referred to above are correctly set for the higher vacuum, no further adjustment is generally required for working with a lower vacuum. Once the terminal has been adjusted there should be no need to alter the adjustments again, except for renewal of the felt when required.

Cleaning of By-pass Air Holes.—It is necessary to see that the by-pass air holes in the terminal are kept free from dirt or bits of paper, as they are arranged on a definite plan to balance the door against the inrush of air when the door opens. Cleaning apertures G, with sliding covers, are provided for this purpose. These must be properly closed against leakage. A cleaning tool is stocked for use.

If the terminal ceases to work satisfactorily, it should be examined to ensure that :—

(1) Hingeing is perfectly free
(2) All air holes are clear
(3) Sliding shutter on guide has not slipped
(4) Felt on cut-off slide is making good contact with door
(5) Vacuum on tube is not excessive.

9—Stoppages, Alarm Circuits and Clearance of Faults

Stoppages may occur occasionally, especially on tubes employed for collecting tickets, and are usually the result of tickets overtaking each other and consequently piling up ; this will occur chiefly at bends in the tube, and is generally due to the use of faulty tickets.

Alarm Circuits in accordance with diagrams TL 1549 and TL 1594 are provided, to indicate the progress of tickets through the discharge valves. It is essential that the alarm contact mechanism shall be maintained in an efficient state.

Inspection pieces are provided at intervals of about 30 ft. on straight runs of tube, and also near bends. When the blockage cannot be removed by one of the methods detailed below, the covers of the inspection pieces are removed, and the piled-up or damaged tickets are removed by means of a " fish " wire.

Clearance of faults.—*At the outset,* an attempt to clear the stoppage should be made by setting up pulses in the column of air, by opening and closing the air supply (in the case of a pressure-operated tube) or the open end of the tube, if it is vacuum-operated.

As a further operation, the air pressure or vacuum may be raised to the full amount available from the blowers, by opening the adjusting valve on the tube. Alternatively, a vacuum-cleaner blower may be connected to the open end of the tube. The cleaner blower should be employed as an exhauster when a pressure-operated tube is involved, but as a blower when a vacuum tube is being cleared. The available

pressure or vacuum, as the case may be, may be considerably increased by this means ; care must be taken, however, as, if the blockage is serious, the increased pressure or vacuum may tend to jam the tickets still more.

If this method is successful in removing the stoppage, care must be taken to restore the adjusting valve on the tube to its correct working position.

Use of " Fish " Wire.—If neither of the methods detailed above are successful, it becomes necessary to use the " fish " wire to locate the stoppage. The position of the stoppage may sometimes be approximately located by the sound of fluttering tickets ; otherwise, it is necessary to proceed from one inspection piece to the next until the fault is found.

Before the " fish " wire is used, however, the following method may be tried as an aid to locating the trouble. Normally, with the air flowing freely in the tube, the water gauge reading falls fairly regularly along the tube from the supply header to the open end of the tube, depending on the length of the tube and the number of bends, etc., between the test points ; the curve representing this should be recorded as a standard. Water-gauge readings may be taken most conveniently by means of a water gauge, or manometer, permanently connected by a rubber tube to and through a spare inspection-piece cover, which may then be substituted temporarily for the permanent inspection-piece cover at any point at which it is desired to make a test. (A manometer fitted up for attachment to a spare inspection cover is provided with each tube installation.) When a blockage occurs it will be found that, generally, the air pressures (negative and positive) between the supply header and the blockage are increased, and those towards the open end of the tube are decreased.

Care should be exercised in the use of the " fish " wire, to avoid scoring the internal surfaces of the tube, or the edges of the aperture of the inspection chamber. If the latter has been unavoidable, the damaged edges should be carefully rectified.

Chaser Tickets.—Flattened tickets left lying in the tubes may generally be removed by means of a chaser ticket. This may take either of the forms shown in Fig. 18, consisting of (*a*) a specially-folded ticket, and (*b*) two tickets gummed together at one end.

Out of use Plugs.—When pressure tubes are out of use for maintenance or other reasons, the opening of the sending valves should be closed by " Plugs, out-of-use, for Ticket Tubes."

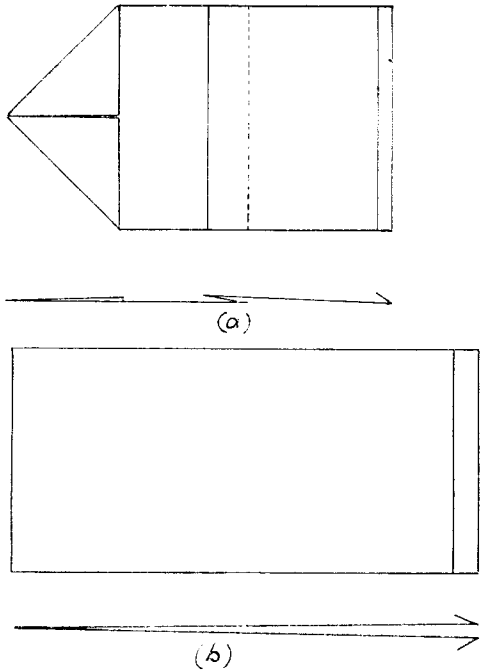


Fig. 18.—Chaser Tickets.

Centrifugal Fans.—Reference for information as regards these should be made to Part I of this pamphlet. As the load on the pressure blower may vary from full load to no load, a small by-pass to atmosphere is usually fitted to allow of a small discharge of air from the fan when all the tubes are shut off, to prevent overheating.

PART III.—STREET TUBES

1—General

Pneumatic tube systems which are made use of by the Department for sending telegraph message forms from one Office to another in the same town are known as *street* tubes.

Air which has been compressed is used for driving the carrier in one direction towards an open end, while a vacuum is employed to draw a carrier to the station nearest the pump. The latter is known as the *up* station and that at the other end as the *down* station.

The flow of air in the tubes is maintained by electrically-driven pumps, which are connected as required through pipes and valves to the tubes. Tubes may be used alternatively for "up" and "down" working, by connecting to the vacuum or pressure sides of the pumps as required, or, where the amount of traffic is large, separate "up" and "down" tubes are used.

2—Tubes

Lead tubes, enclosed in cast-iron pipes, are used for street tubes. These are buried to a depth of about 2 ft. in the ground. The lead tubes used are of $1\frac{1}{2}$″, $2\frac{1}{4}$″ and 3″ internal diameter, and the corresponding protection is given by standard 2″, 3″ and 4″ cast-iron pipes.

Protection and Jointing of Lead Tube.—The lead tube is supplied in wooden troughs, to enable it to be handled without damage. The tubes and pipes are prepared for jointing as follows :—

In the case of a $2\frac{1}{4}$″ tube (standard length 28 ft.), a 3″ spigot-and-socket pipe 9 ft. long is passed over the tube until it occupies the middle position. Another spigot-and-socket pipe is passed over one end of the tube, and a double-spigot pipe over the other. These are jointed to the middle length with a caulking of yarn and lead. Similarly, a length of $1\frac{1}{2}$″ tube (25 ft.) requires 3 lengths of 2″ spigot-and-socket pipe and one length of double-spigot pipe. For the 3″ tube, each length (19 ft.) requires one 4″ spigot-and-socket length of pipe and one double-socket length.

The pipes and tube are then carefully lowered into position and a "Slide, solid, 2 ft.," passed over the forward end of the pipe. When the two lengths are in position, the lead tube is joined by a plumber's wiped joint made over a heated mandreal attached to a chain, by which it is withdrawn when the joint is complete. The solid slide is then drawn over the joint, and the spaces between the slide and spigoted end of the cast-iron pipe are caulked with yarn and lead.

Bends must have a radius of at least 8 ft. 6 ins., and must be formed very carefully so as to maintain the circular section of the lead tube.

Brass Tubes.—If the portion of a street tube inside a building is short, or if it is to be laid horizontally, it is often convenient to continue the lead tube up to the despatching or receiving apparatus, but in all other cases it is necessary to use brass tube, the joint being made by means of brass flanges fixed near the point of entry.

3—Carriers

Carriers for street tubes are composed of gutta-percha cylinders, covered with felt. At the closed end, a felt pad of the same diameter as the tube is fitted. At the open end, the felt covering is extended for a short distance to form a skirt.

The number of telegraph forms taken by the carriers is 5 (for the $1\frac{1}{2}$" carrier), 35 (for the $2\frac{1}{4}$"), and 55 (for the 3").

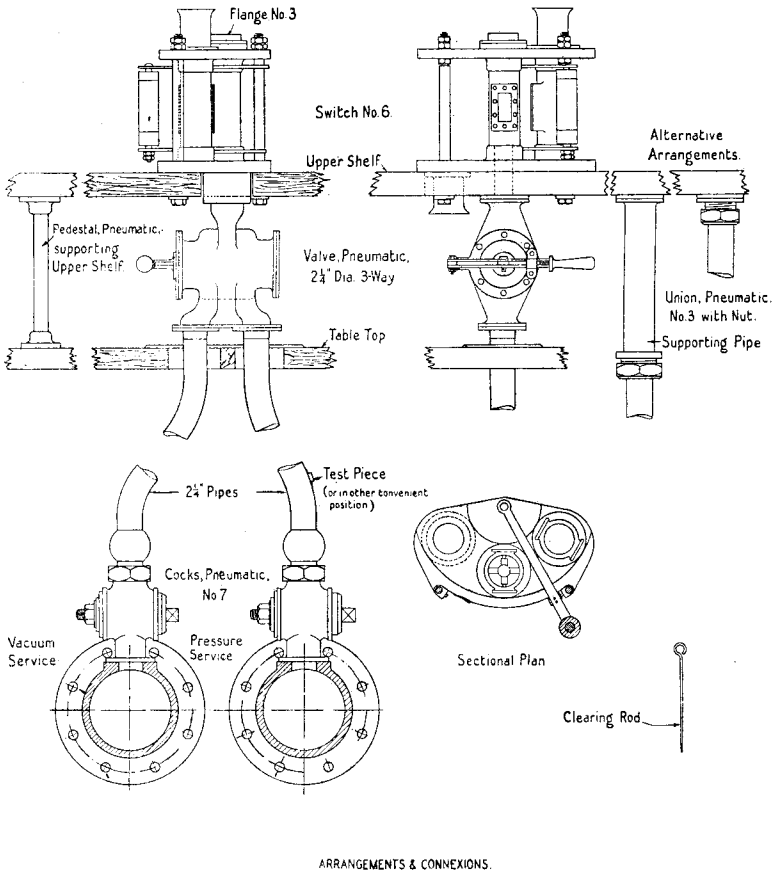


Fig. 19.—Double Slide Switch.

4—Tube Fittings

Various fittings are provided for inserting or removing the carriers from the tubes. These are briefly described as follows :—

At the operating station or pump end of the tube a *Switch, Pneumatic, Double Slide,* is generally used. This is illustrated in Figs. 19 and 20, and consists of two vertical sections of Tube A1 and A2, fitted with glass inspection windows and secured into plates top and bottom. This portion is provided with a handle, and slides between two horizontal plates B1 and B2, in each of which three holes C1, D1, E1, and C2, D2, E2 are provided.

The air supply is connected to the centre hole in B2, which is fitted with a grid to arrest the carrier. The tube is connected to the centre hole of B1.

Funnels F1 and F2 are fitted for the insertion and removal of the carriers.

Sending and Receiving.—With the switch arranged for " Sending and Receiving," as shown, a carrier on arriving is observed in A1. The vacuum is then turned off and the switch moved over to the left-hand position, and the carrier drops out through the funnel F1.

The switch is then returned to its original position and is ready to send or receive another carrier.

For sending, a carrier is inserted in F2 with skirt downwards and the switch moved to the left, bringing the carrier into the mid position. The pressure supply being turned over, the carrier proceeds on its journey. The switch is then returned to its normal position.

Sending only or Receiving only.—When the switches are used for sending only, or receiving only, the switch is provided with two funnels at the top and bottom respectively, the holes not required being covered by blank flanges, and in these cases the switch is not returned to a normal resting position.

The blank flanges are provided with a hole through which an iron rod can be passed if a carrier jams accidentally.

Emergency Chamber and Sluice Valve.—When arranged for receiving only there is a possibility of two carriers arriving simultaneously, and an emergency chamber with hinged door is fixed at the top of the switch so that the second carrier may be removed. It is provided with a sluice valve to cut off the chamber from the vacuum which exists in the tube itself.

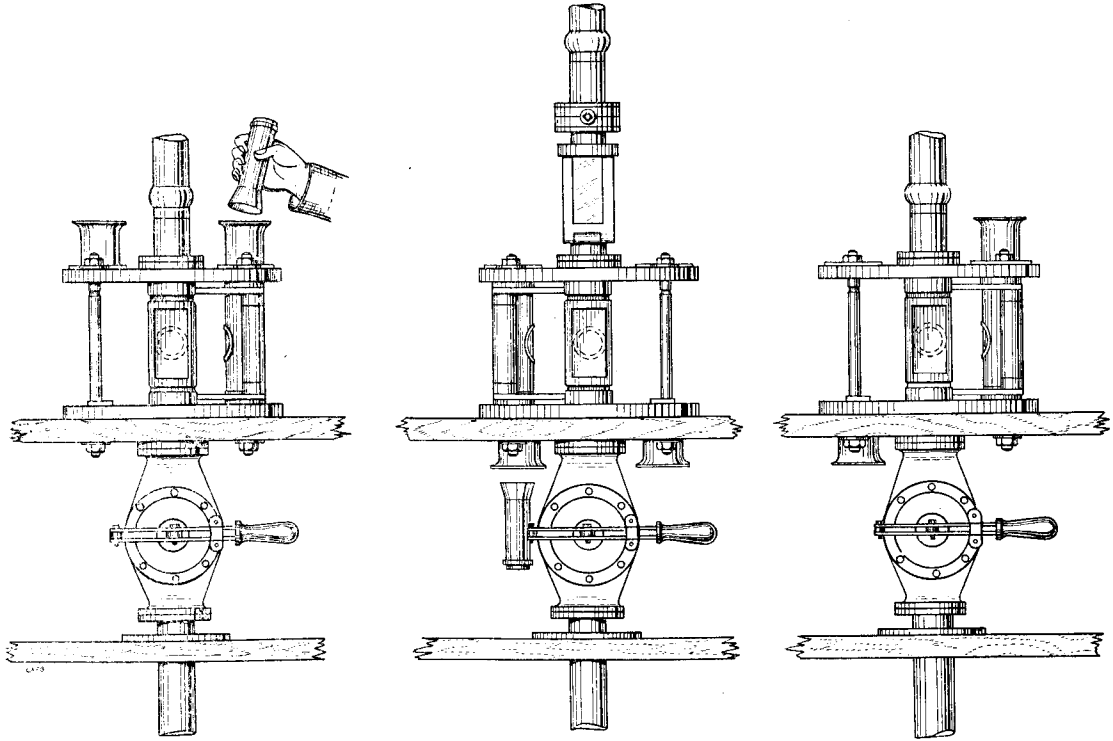


Fig. 20.—Double Slide Switch.

The emergency chamber and sluice valve are not fitted when the switch is used for both sending and receiving, as the insertion of carriers is controlled by a block signal system.

On a few street-tube intermediate offices are connected and, in these cases, a *Switch, Pneumatic, Intermediate,* is fitted. This is composed of two sections of tube, fitted in circular plates, which can be revolved opposite openings in fixed plates. The incoming and outgoing tubes are each connected to one of these openings, one on each side of the switch, and the other two openings are fitted with funnels through which the carrier can be inserted or removed. Sluice valves are provided to intercept carriers intended for the intermediate office. These are left open if the carrier is to pass through.

Where a tube has two alternative terminal positions (for day and night working), a *Diverting Switch* is used.

The standard terminal used at down stations is a *Terminal, flap,* similar to that used for house tubes but with a spring-controlled flap door (Terminals Nos. 11, 12, 13).

A wooden *Box, Receiving, Pneumatic,* is fitted at some down stations. This consists of a wooden box with the tube entering at one side, and an exhaust pipe to atmosphere on the other side. The front is fitted with a sliding door, through which the carrier can be removed or inserted in the tube opening. These are obsolescent.

5—Control Cocks and Fittings

Cocks or Valves are fitted in the pneumatic installation to control the air supply to the tubes. The compressed or rarefied air is brought from the pump room through iron pipes to the switches, or, where there are a number of tubes, to *Common Connexion Boxes* or headers placed under the *Tube Table.* From these the air is first taken through *Cocks, Pneumatic, Throttle,* which are simply plug cocks by means of which the amount of air supplied to or withdrawn from the tubes can be regulated. From these cocks the air is taken to the *Valves, Pneumatic, 3-way,* through lead or brass *Service Pipes.* These valves are fitted below the switches, are three-way or four-way, and in both cases have three positions—send, off and receive. The four-way valve is used where both pressure and vacuum are supplied from the same pump cylinder or blower for a single tube. It is formed by removing a blank flange at the back of the three-way valve and connecting an atmospheric exhaust pipe to it. This is necessary to ensure a supply of air to the pump.

6—Signalling Apparatus

Electrical apparatus is made use of to signal the despatch or arrival of a carrier. This is called a *Block Instrument, Pneumatic, Street,* and consists of a mahogany wooden box, fixed vertically, in which two electro-magnets are arranged to attract a pivoted armature (which is polarized by means of a permanent magnet), carrying a pointer, to one side or the other when a current is sent through them. The index shows on one side " Carrier in tube," and on the other " Tube Clear." When current passes, a bell on top of the instrument is also struck. The windings on the electro-magnets for operating the bell are so wound that the bell is not struck at the home station except by incoming currents. Secondary batteries are used where available, and reverse currents are required at each station. Signals are given by means of press-button switches.

Differential Signallers or *Differential Indicators* are sometimes used to indicate the passage of a carrier at an intermediate point or its final discharge. This apparatus consists of a casing, divided into two halves by a flexible diaphragm, which operates a pair of electrical contacts. If one side is connected to the tube and the other to atmosphere, or to another point of the tube, the diaphragm moves from its central position when a difference of pressure exists, and opens or closes an electric circuit as may be required (*see* Fig. 21).

This may be used in place of the Service Regulator mentioned below, and is also used in conjunction with a meter to indicate the number of hours a rented tube may be in use.

Where wooden receiving boxes are used, *Signallers, Pneumatic, No.* 3, are provided. These are made up of a hinged grid, fitted to the bottom of the box and provided with a bell contact, which is made by the weight of the carrier on the grid.

Where street tubes are worked in one direction only, and are so busy that it is not possible to cope with the traffic if the tube has to be cleared before another carrier is inserted, a *Regulator, Pneumatic Tube Service,* is employed. The instrument is worked by clock-work, and gives the " Tube Clear " signal on the sending station block instrument after a definite time has elapsed since the introduction of a carrier. To prevent an accidental blockage of the tube the mechanism is so constructed that, unless clearing signals are sent from the receiving station, the block instrument at the sending station is not cleared after a certain number of carriers have been despatched.

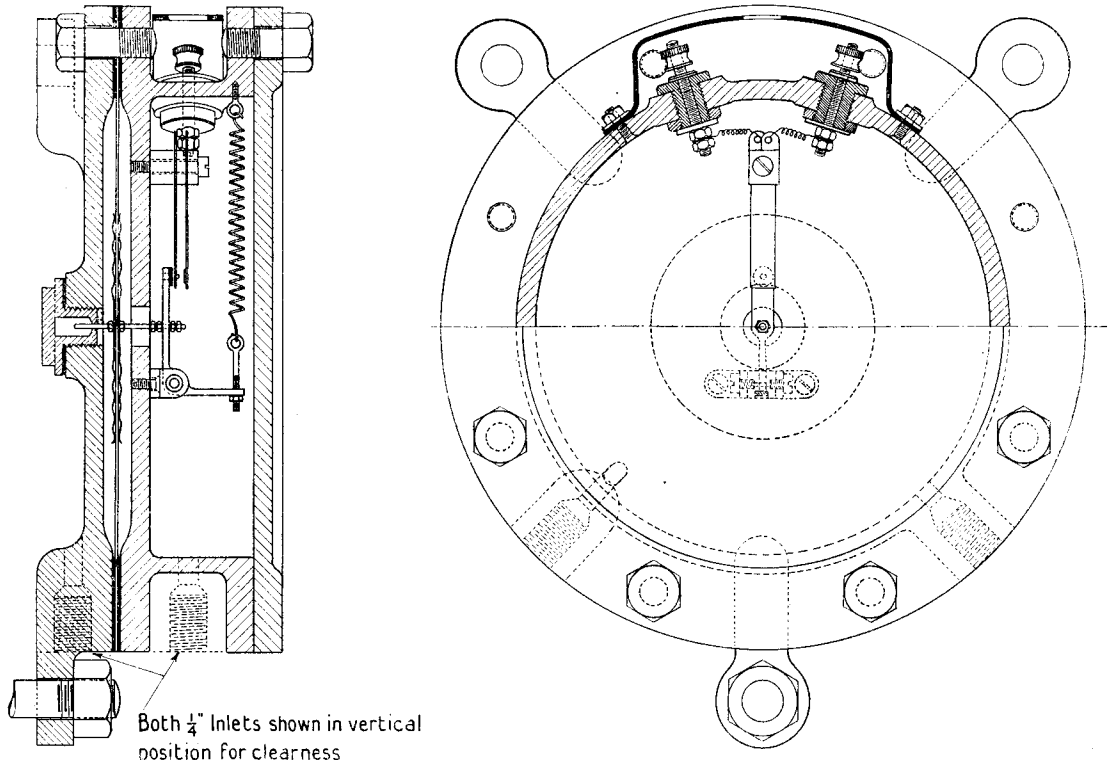


Fig. 21—Differential Indicator.

7—Air Pumps or Compressors

For street tubes the air is compressed or rarefied by *power-driven pumps* of the *reciprocating type*, and these vary in design according to the manufacturers. A few are of the single-acting type, in which the air is dealt with on one side of the piston only, but the great majority are *double-acting*. In some the cylinders are mounted horizontally, in others vertically. They are generally driven by electric motors. The drive is usually by a belt, but in some cases the motor is mounted on the same bed-plate as the pump, which is then driven direct or through gearing.

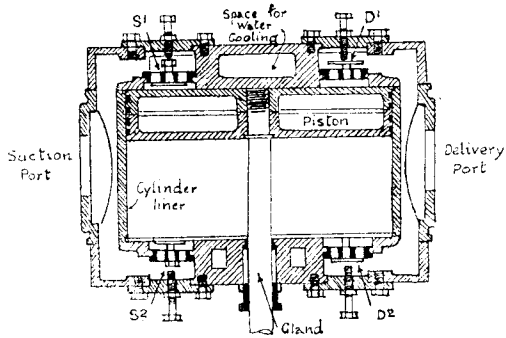


Fig. 22—Pump Cylinder.

The valves most frequently used are of the disc or plate type, consisting of a light metal disc covering an aperture. The disc is normally held down on the valve seat by a light spring and, when the air is discharged or drawn through it, the disc has first to be lifted by the air.

Fig. 22 shows a section taken through a typical cylinder, with the piston having just completed one of its upward strokes. The *delivery valve* D1 at the top of the cylinder liner is shown open and the compressed air is being discharged through this to the *delivery port*. Meanwhile, the cylinder has filled with air on the other side of the piston through the *suction port* and the *suction valve* S2. On the downward stroke, the air is compressed and delivered through D2 at the bottom of the cylinder and drawn in through S1 at the top.

Actually these single valves are replaced by a number of valves arranged ound the top and bottom of the cylinder

liner, so as to obtain as large a port area as possible for the air to pass through.

It is necessary to keep the cylinder as cool as possible in order that the pump may work efficiently, and this is arranged for by providing a *water jacket* between the outer cylinder wall and the liner. Only part of this can be seen in the diagram as the suction and delivery valves are shown, but the remainder of the space round the cylinder is also water jacket. The water supply is obtained from one or more circulating tanks, which re-cool the water for further use after leaving the pump. The circulation is sometimes purely thermal, where the difference in density of the water at the top and bottom of the tanks caused by the difference in temperature of the inlet and outlet water of the cylinder is sufficient to set up the circulation required. More often a small auxiliary water pump, driven by the compressor, is used to supplement this arrangement.

Lubricating the Pumps.—Various methods are employed, the most common consisting of splash lubrication for the internal revolving parts, and feeds from a reservoir for the cylinder and other bearings. For some large compressors forced lubrication, by means of a small auxiliary pump, is employed.

It will be seen from the foregoing description that the same pumps can be used to provide either a Vacuum or Pressure service.

The various parts making up a Pneumatic Street Tube Installation have now been described, except the electric motors or engines which are not dealt with in this pamphlet.

8—Systems

The Double-Cylinder System (Fig. 23) provides both vacuum and pressure by means of separate cylinders, on one pump or two separate pumps, one cylinder for each service. It is used in large towns for street-tube installations which consist of more than one tube worked in both directions and, in the larger installations, separate pumping units are employed for the pressure and vacuum services.

If duplicate pumps are installed, *Stop Valves* are fitted on the outlet of each pressure cylinder and a small *Safety Valve* inserted between the stop valves and pumps so that if the stop valve is accidentally left closed when the plant is started, the air in the cylinder can be released before any damage is done. These small safety valves should be set to act at about 5 lb. above the working pressure.

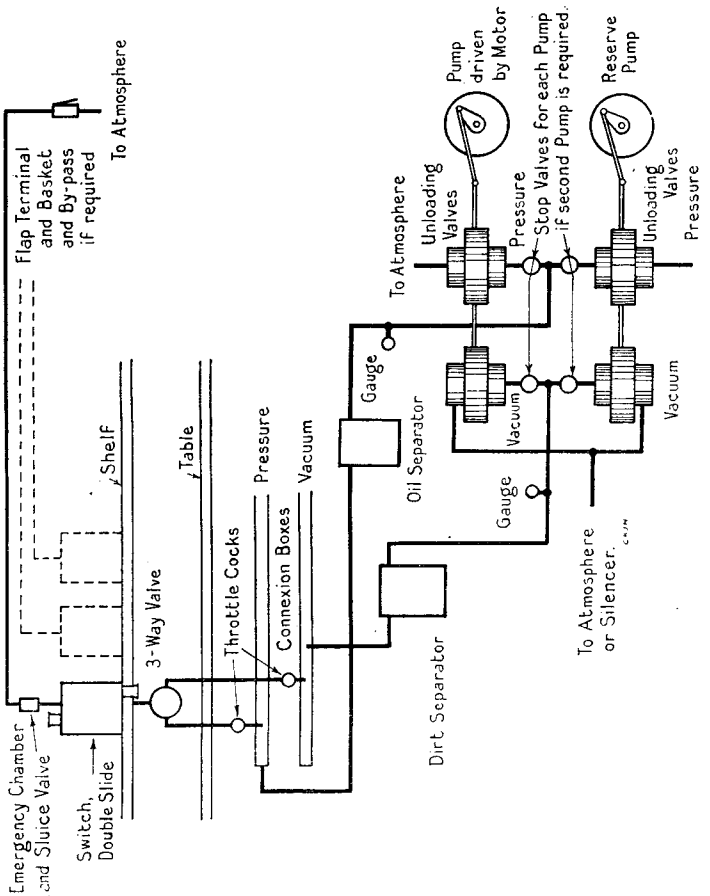


Fig. 23—Double Cylinder System.

It is necessary to fix a larger safety valve in the pressure main, to allow a portion of the compressed air to escape should the working pressure be exceeded from any cause. In order to prevent a waste of energy from this cause, it is necessary to provide some means of unloading the pressure cylinder. This is done by fixing an *Unloading Valve* in the inlet pipe of the pressure cylinder, which cuts off the air supply to the cylinder when the pressure in the system becomes too high.

Vacuum and Pressure used.—The plant is run continuously and maintains a steady vacuum of up to about 6½ lb./sq. in. below atmosphere, and a pressure of about 10 lb. above atmosphere, when several tubes are installed. The pressure or vacuum on each tube is regulated, however, by means of the control cocks, so that the velocity of the carrier in the tube is from 25 to 30 ft./sec. The speed of the pumps is regulated to provide the vacuum or pressure required to give this velocity on the longest tube connected.

Pumping through System (Fig. 24).—In this system only one cylinder is employed, the air being sucked from the vacuum tubes and delivered to the pressure supply.

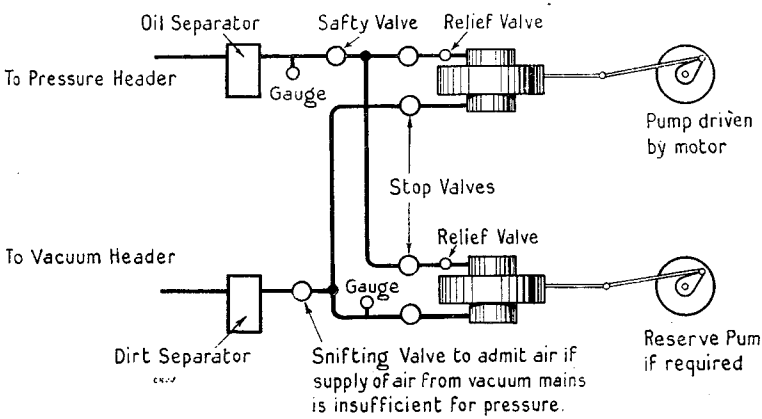


Fig. 24—Pumping through System.

The system is not generally used under normal conditions, as it has serious disadvantages.

The air in the cylinder has to be taken through a larger range of compression, with consequent extra heating. This reduces the efficiency of working and causes other troubles owing to condensation of water and oil in the tubes, while, owing to the impossibility of exactly balancing the pressure and vacuum services, it is necessary to arranged for supplementary provision of air to the cylinders by means of a *snifting valve.*

9—Maintenance

The following are the principal points that require attention o ensure proper maintenance.

Carriers.—For satisfactory working these should be discarded when the felt pad is worn down by as much as $\frac{1}{8}$" in diameter. Care should be taken by the users to see that the messages do not protrude beyond the carrier, and it is essential that carriers travel buffer foremost.

Street-tube faults which are causing blockages must not be dealt with without first asking for instructions. It would, however, probably save much time if any recent excavation on the route of the tube were noted, as such work may have caused damage to the tube. When a carrier sticks in the tube, no attempt should be made to drive it through with another carrier; this would probably make matters worse. Instead, an attempt should first be made to withdraw it, by switching on the vacuum service. The effect of this can be increased by stopping up the open end of the tube temporarily, by means of a book or other object, and then letting the air rush in suddenly by removing the book. Maintenance Tests of street tubes are taken yearly and recorded on Form TE 212.

Tube fittings require very little attention, but it is important that the moving parts of the double-slide switch should be kept quite clean and well lubricated.

Throttle Cocks should be set so that the longest tube is worked with the cock full open and the shorter ones regulated accordingly, so that the speed of the carrier is about 25 to 30 ft./sec.

Common Connexion Boxes should be cleaned out every 3 months, by removing the end-plates.

Containers, if fitted, should be cleaned out every year, and thoroughly overhauled every 2 years. On these latter occasions, they should be tested by hydraulic pressure up to twice their working pressure.

Pressure gauges and **Safety valves** should be tested every year.

Power Pumps should receive careful attention. The *speed* of the machine is to be such that there is sufficient vacuum or pressure to maintain a carrier velocity of 25 to 30 ft./sec. in the longest tube connected. Special care must be given to the *lubrication*, which should not be stinted except in the case of the cylinder. The oil taken by the cylinder is often carried over by the air and deposited in the tubes, which is very undesirable; it should, therefore, be cut down to the

absolute minimum required for satisfactory running. The *temperature of the circulating water* should not be allowed to exceed 120 deg. F. at the top of the tank ; above that temperature, cold water should be admitted when some of the hot water has been drawn off.

If the plant is stopped in *frosty weather*, the water should be drained from the *circulating pipes* and *cylinder jackets*, if the building is unheated.

Any *knocking* or *abnormal noise* made by the plant should be reported at once.

The valves should be examined at least once a month, to ensure that the *valve plates* are bedding evenly on their seats.

The whole of the *compressor* must be overhauled by a competent fitter at least once every year.

If the *belt* is of *leather*, and squeaks or slips, a small quantity of resin or approved belt composition should be used. If a prepared *canvas* belt is used, however, belt composition or resin must not be used ; a few drops of castor oil should in that case be applied to the face of one of the pulleys.

Reference should be made to Pamphlet G 3 for troubles in connexion with electric motors, and to K.5 as regards gas and petrol engines, which may be used for driving the air pumps.

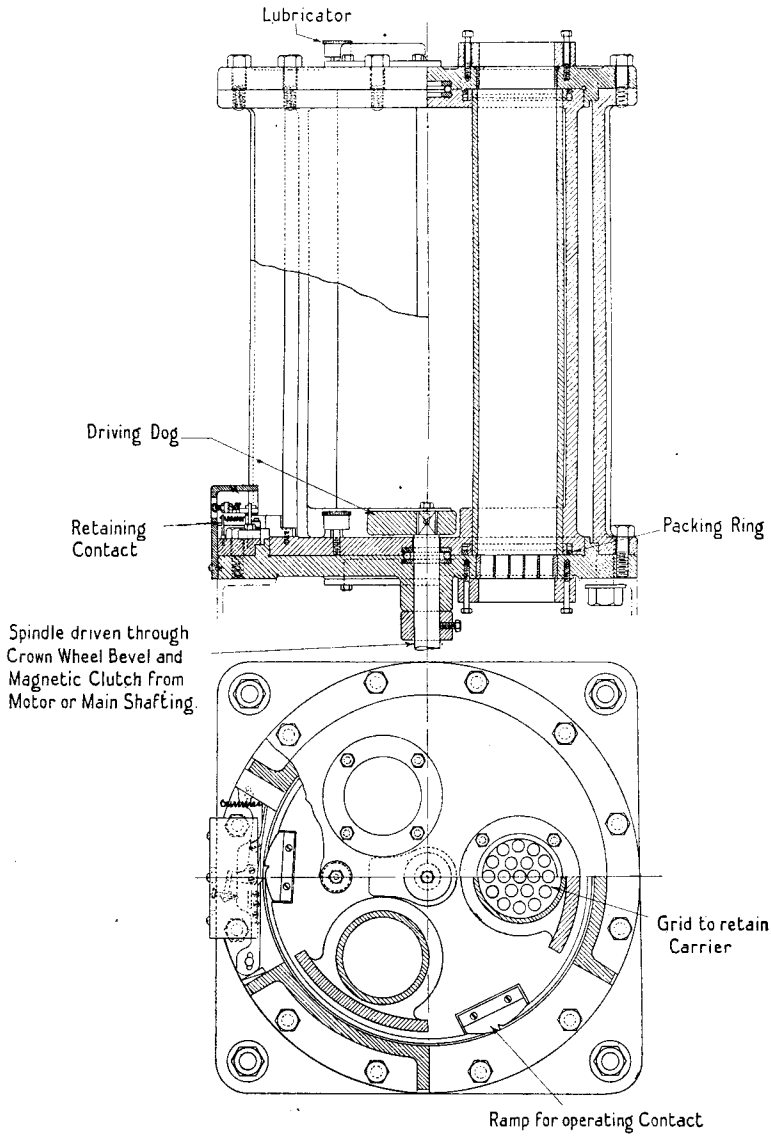


Fig. 25.—Automatic Switch

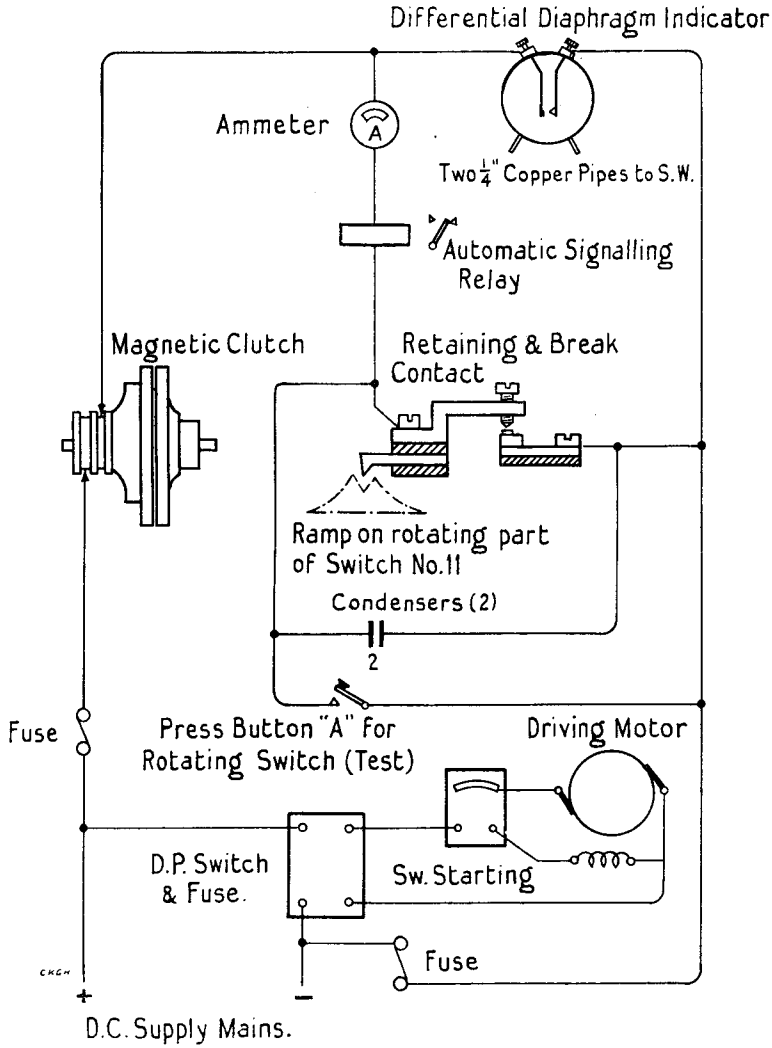
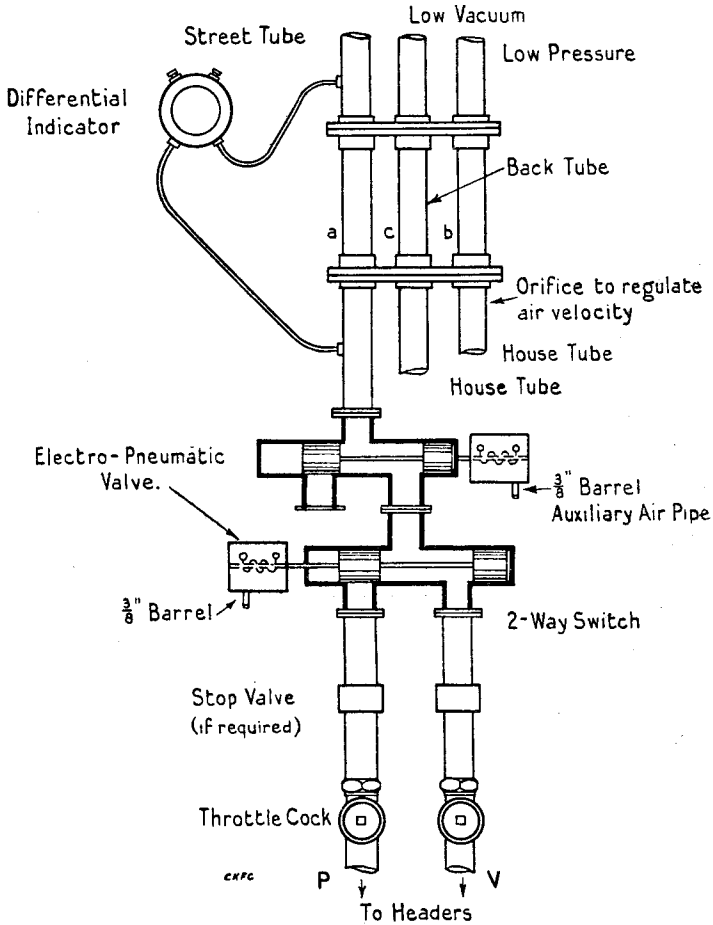


Fig. 27.—Automatic Switch—Electrical Connexions



Note:-

The pipework connexions may be reversed or varied as long as the carrier always moves Buffer foremost on both House and Street Tubes.

Fig. 26.—Automatic Switch—Pipework Connexions

Appendix I.

Automatic Street-Tube Systems.—Although not in general use throughout the country, the street-tube systems in London have now been converted to automatic operation. In this system, the hand-operated double-slide switch shown in Fig. 1 (Street Tubes) is replaced by a pneumatically-controlled electrically-operated rotating switch, which transfers the " up " carrier from the street tube to a house tube operated at low pressure, the carrier being automatically ejected through a flap terminal. Similarly, the " down " carriers are inserted into a low-vacuum-operated house tube through a funnel terminal, and automatically transferred by the rotating switch into the street tube. This does away with any delay due to inattention of the Tube Attendant and enables the traffic to be speeded up.

The switch used is shown in Fig. 25, the pipework connexions in Fig. 26, and the main electrical connexions in Fig. 27.

The switch is controlled by the arrival of a carrier which partially blocks the air flow, and causes a piece of apparatus called a *Differential Indicator* (Fig. 21, Street tube) to operate owing to the change of pressure (this is described on page 39). As soon as this completes the electrical circuit, a magnetic clutch is energized, which couples the switch to a motor or motor-driven shaft and rotates it for one-third of a revolution when the switch is in position for the carrier to be delivered into the other tube.

The same closing of the contacts in the differential indicator can be used, through relays, to operate signal circuits and control the supply of air to the street tubes, a solenoid-controlled pneumatically-operated valve being used in this case.

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