WS No. 19 Mark III

P.W.—K.4.

POST OFFICE ENGINEERING DEPARTMENT

TECHNICAL PAMPHLETS FOR WORKMEN

Subject :

Pneumatic Tube Systems.

ENGINEER-IN-CHIEF'S OFFICE
1919

PNEUMATIC TUBE SYSTEMS

(K. 4).

Other matter of kindred interest is contained in .

Technical Instruction X., Pneumatic Tubes, Revised Edition.

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PNEUMATIC TUBE SYSTEMS.

1. GENERAL.

Pneumatic tube systems are made use of by the Department for sending telegraph message forms from one room to another in the same building, or from one office to another in the same town. The former are known as **house** tubes, the latter as **street** tubes.

Air is used to propel the carriers in which the messages are enclosed through the tubes. For sending in one direction, the air is slightly compressed, or increased in pressure, by means of an air-pump, and the carrier is then driven outwards towards the open end of the tube by this compressed air. This is called **pressure** working. To send in the opposite direction, the air is slightly rarefied, or decreased in pressure by means of the air-pump, and the carrier is drawn towards the station nearest to the pump, which is also usually the controlling station. This is known as the **up** station, and that at the other end of the tube as the **down** station.

2. TUBES.

For **house-tube** installations cylindrical brass tubes are used in practically all cases. They are of $1\frac{1}{2}$ in. and $2\frac{1}{4}$ in. internal diameter, and are fixed by clips and hangers to walls and ceilings. For tubes worked by a hand-pump couplings are generally used to join the various lengths or bends together; but for power-worked installations a close-fitting sleeve, sweated on to the two ends of the tube, is used. Standard brass bends are stocked for brass tubes, and are used wherever possible.

For **street-tubes** it is the general practice to use lead tubes enclosed in cast-iron pipes, and buried to a depth of about 2 feet in the ground. The lead tubes used are of $1\frac{1}{2}$ in., $2\frac{1}{4}$ in., and 3 in. internal diameter, and the corresponding protection is given by standard 2 in., 3 in., and 4 in. cast-iron pipes. Plumbers' wiped joints, made very carefully over a mandrel, are used for jointing the various lengths of lead tube together. Bends have a radius of at least 8 ft. 6 in.

3. CARRIERS.

The carriers usually used for house-tube installations consist of fibre cylinders of slightly smaller diameter than the tube. One end is closed, and to this is fixed a felt pad, exactly fitting the tube. The other end of the cylinder is open, and the messages are carefully rolled up and inserted here. They do not protrude beyond the end of the carrier, and are secured inside it by means of a spring or elastic band. The $1\frac{1}{2}$ in. carrier can

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take 10 plain or 6 enveloped forms, and the $2\frac{1}{4}$ in. 40 plain or 18 enveloped forms.

The carriers for street-tubes are composed of a gutta-percha cylinder covered with felt. To 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 $1\frac{1}{2}$ in. carrier will take about the same number of messages as the house-tube carrier of the same size, the $2\frac{1}{4}$ in. takes 35 plain or 15 enveloped forms, and the 3 in. carrier 75 plain or 30 enveloped forms.

4. TUBE FITTINGS.

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

House-tube installations worked by Hand-pumps. At the open end of the tube a **Carrier Cage** is used, and this is made up of a square wire cage with a wooden top. A swinging wire door is provided at the bottom of one of the sides to enable carriers to be inserted or removed. At the pump end of the tube a **Pneumatic Feed Slide,** which can be fixed vertically or horizontally, is fitted. This consists of a section of tube, with an opening cut in it to enable carriers to be inserted or removed. The opening is covered by a sleeve, which can be slid up when required.

House-tube installations worked by Power-pumps. For installations worked by pressure or moderately high vacuum, **Pneumatic Feed Slides** are used at both ends of the tubes. For systems worked on a very low vacuum, such as that provided by a rotary blower, **Flap, Door Despatch** and **Funnel Despatch Terminals** are used. The former is a receiving terminal, provided with a top hinged door or flap, which is knocked open by the carrier, which then drops out into a basket. The second provides for inserting a carrier by opening a door, normally kept closed by a spring; and the last is for the same purpose, but consists of a funnel-shaped terminal fitted at the open end of the tube.

Street-tube Installations. At the operating station or pump end of the tube, a "D" **Box, Double-sluice Valve,** or **Double Slide Switch** is used. The first, which is the oldest device, is so named because of the D shape of its cross-section. It is made up of a horizontal chamber, into which the carrier drops on its arrival. The tube is connected to one end, and the pressure or vacuum supply to the opposite end. The top is fitted with a sliding door provided with a glass inspection window through which the carrier can be seen when it arrives. The air service is then cut off by a sliding valve, and the door opened. Carriers are despatched by being inserted in the tube, closing the door, and turning on the pressure service.

The Double-sluice Valve is a vertical cylindrical chamber, with the tube connected at the top, and an opening at the bottom. Two sluice valves are fitted, one at the top, and one at the bottom, and these are so geared together that, when one is open, the other is closed. When a carrier arrives, the bottom sluice arrests it, the top one being open. The air supply is then cut off, and the bottom sluice opened, the top one being automatically closed. The carrier then drops out through the open end of the valve. To despatch carriers by the same apparatus, an auxiliary vacuum service is connected near the top of the valve to draw the carriers into it. The bottom sluice is then closed, and the pressure air service switched on.

The Double Slide Switch is a fitting more recently designed to take the place of the " D " Box and the Double-sluice Valve, both of which are now practically obsolete. It is illustrated in Fig. 1, and consists of two vertical sections of tube, A1, A2, fitted with glass inspection windows, and secured to plates at top and bottom. These plates slide along two horizontal plates, B1, B2, in each of which three holes of the diameter of the tube are provided. The centre hole in B2 is fitted with a grid to arrest the carrier, and the pressure or vacuum supply is connected to this hole. The tube is connected to the centre hole of B1. With the switch, as shown, for " Sending and Receiving," a carrier on arrival is observed in A1. The vacuum is then turned off and the switch moved over to the left-hand position by means of the handle E. A1 is then over the funnel C2, and the carrier drops out. The switch is then returned to the right-hand position, and is ready to send or receive another carrier. For sending, a carrier is inserted in C1, with skirt downwards, and the switch moved over to the left position. A2 will then be over the connection to the pressure supply, and, when this is turned on, the carrier will proceed on its journey, the switch being at once returned to the right position, which is the normal working position. In order to ensure this being done, springs can be fitted to the switch.

If the switch is to be used for sending only, the funnel C2 is changed with the blank piece D1, so that both funnels are at the top of the switch, If for receiving only, C1 is changed with D2, so that both funnels are at the bottom. In the latter case it is necessary to provide against the switch being blocked through two carriers arriving simultaneously. This is done by fixing an " emergency chamber " F, at the top of the switch as shown. This is fitted with a hinged door, through which the top carrier can be removed, and also with a sluice valve G, which cuts off the vacuum in the tube itself. A by-pass H, shown dotted, is also provided in this case to prevent the vacuum holding the carrier down on the grid when the switch is moved.

The above fittings for street-tubes are mostly used at the controlling office, where the pumps are fitted. At the out-stations, where the tubes terminate, a **wooden receiving box** is usually made use of. This consists of a wooden box, with the tube entering at one side, and an exhaust pipe to atmosphere connected to the other. The front is provided with a sliding

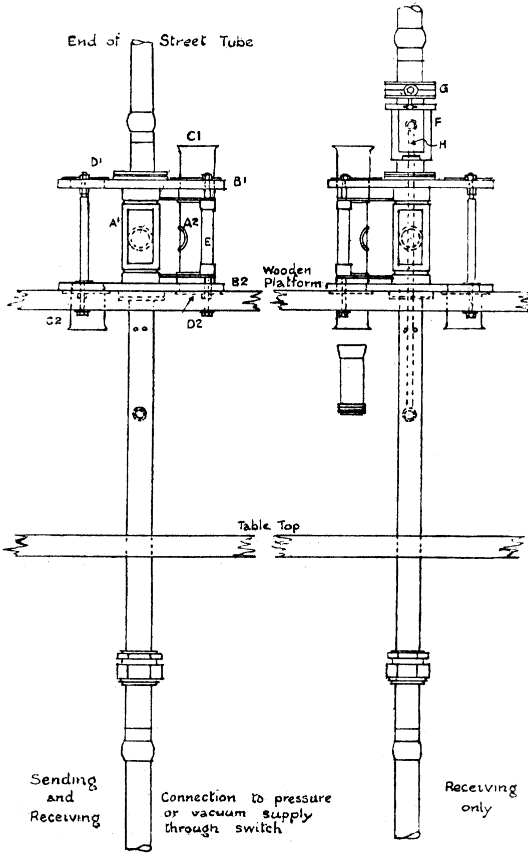

Fig. 1

door, through which arriving carriers can be removed, or carriers to be despatched can be inserted in the tube opening.

On a few street-tubes **intermediate offices** are connected, and in these cases an **intermediate switch** 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 connected to one of these latter openings, one on each side of the switch; and the other two openings have funnels fitted through which the carrier can be removed. Sluice valves are provided to intercept the carriers destined for the intermediate office. These valves are left open if the carrier is to pass straight through.

5. CONTROL COCKS AND FITTINGS.

Cocks are fitted in nearly all pneumatic installations to control the air supply to the tubes. For installations worked by **hand-pumps,** the **control cock** is fixed to the pump itself. It is a two-position cock with four connections so arranged that, with the lever in the " Receive " position, the pump suction valves are connected to the tube, and the delivery valves to atmosphere. With the lever in the opposite, or " Sending " position, the pump delivery valves are connected to the tube, and the suction valves to atmosphere. In order that two tubes can be operated by means of one hand-pump, **Switches, pneumatic, No. 2** are provided. This switch has a bottom opening, which is fixed to the usual tube connection of the pump, and at the top there are two openings, for the feed slides of the tubes.

For installations worked by **power-pumps,** three or four-way hand-operated valves are provided. The compressed or rarefied air is brought from the compressor room to the control station through wrought iron pipes, and, if the installation consists of a number of tubes, one or two **common connection boxes** are placed under the **tube table.** These are simply to provide a convenient means for connecting up a number of tubes, through their control cocks; but if the installation is a small one, branch connections from the wrought iron supply pipes suffice. From the common connection boxes, or supply pipes, the air is first taken through **throttle cocks,** which are simply plug cocks, by means of which the amount of air supplied or withdrawn can be regulated. From the throttle cocks, the air is then taken to the control valves by lead service pipes. The **control valves** are fitted below the switch. Both the three-way and the four-way valves have three positions, **send, off, and receive.**

Where house-tubes are worked by low-vacuum rotary blowers, running continuously, no control cocks are required.

6. SIGNALLING APPARATUS.

In order to signal the despatch or arrival of a carrier, electrical apparatus is made use of on practically all pneumatic installations. The only exception is the continuously worked low-vacuum house system.

For **hand-worked** installations **trembler bells,** type 13A or 24A, with press buttons, usually suffice; but there are cases where house telephone circuits have been found necessary to supplement them.

For **power-worked** house-tubes, with the exception mentioned above, similar devices are used, with differently toned bells to distinguish between the various tubes. A more elaborate means can be obtained by the use of a **block instrument, pneumatic,** for house-tubes, and this is usually preferred. It is made up of a wooden box, on the top of which is mounted a single-stroke bell. The front of the box is fitted with a glass window, behind which is a dial, marked "**Carrier in Tube,**" and "**Tube Clear,**" with a pointer to show which condition is in force. The pointer is worked by two electro-magnets, fitted inside the box, and two push-buttons fixed to the front of it. The electro-magnets are each of 150 ohms resistance, and are intended to be connected to a 24-volt Universal battery supply.

For street-tubes, **block instruments, pneumatic, street,** are used, these being somewhat similar to the house-tube pattern, but more sensitive and larger. To signal the arrival of a carrier in a wooden receiving box, **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 a second carrier is inserted, a **Pneumatic Tube Service Regulator** is made use of. This instrument is worked by clock-work, and gives the "**Tube Clear**" signal on the sending station block instrument after a definite time interval has elapsed since the introduction of a carrier. To prevent a blockage in the tube the clockwork mechanism is so constructed that, unless clearing signals are given at the receiving station, the block instrument at the sending station is not actuated after a certain number of carriers have been despatched.

7. AIR PUMPS OR COMPRESSORS.

The Standard Hand Pump, **Pump, Pneumatic, Hand,** used by the Department 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. 2.

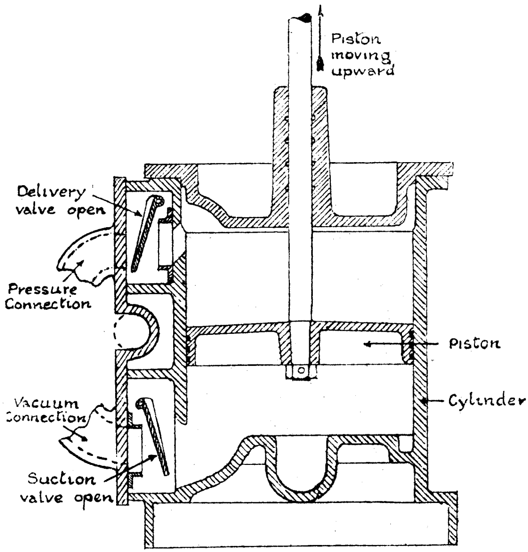

Fig. 2.

The control cock, described on page 6, fits over the passages marked Pressure and Vacuum Connections. The **piston** is shown moving in an upward direction, and if the control cock is set at "Sending," the air above it is being compressed, and driven through the **delivery valve,** and control cock to the tube. At the same time air is being drawn into the portion of the cylinder below the piston through the **suction valve** and control cock. When the piston commences to descend, the two valves, shown open, at once close, and two other valves, not shown in the sketch, are opened. One of these latter two 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 into the space below the piston on the upward stroke is compressed, and driven out to the tube on the **downward** stroke.

Pumps arranged to work in this manner are called "**double-acting**" pumps. When the control cock is changed over to the "Receive" position the Vacuum connection is joined to the tube, and the Pressure to atmosphere. The pump then supplies a vacuum to the tube, and so draws the carrier towards the station nearest to the pump. The pumps are provided with control cocks. If it is intended to work only one tube, the feed slide is usually bolted direct to the pump. If two tubes are to be dealt with, a Switch, Pneumatic, No. 2, described on page 6, is also provided. The small pump can be fixed to a table; but it is usual to mount the larger one on a **base** for Pneumatic Pumps. **Spare parts** supplied for Hand Pumps are as follows:—**clacks** (valves), **springs** (for valves), and **washers, leather** (for fixing on piston rod).

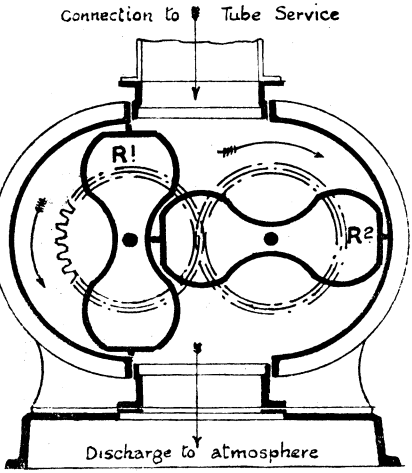

Fig. 3.

The usual standard form of **Power-worked** Pneumatic Pump is the Rotary Blower, or **Root's Blower.** This pump, in its most simple form, can only provide a small vacuum, and consequently is only used on the **low vacuum** system for house-tubes. It is composed of two rollers, mounted on spindles, and so geared together that, when one is vertical in position, the other is horizontal with its top fitting fairly closely into the "waist" of the vertical one. A diagram showing a sectional view of such a Blower is given in Fig. 3.

The two rollers, R1 and R2 may be imagined to "scoop" the air through the Blower as they revolve; and as they fit fairly closely together, and to the sides of the casing, a small vacuum is obtained. The two rollers are geared together at one end of their spindles, and the other end of one of the spindles is taken through the case, and has a driving pulley mounted on it outside. The blower is driven by a small electric motor, by means of a belt, and runs at a speed found suitable for the particular installation it is used for. Usually a speed of about 200 revolutions per minute is found satisfactory, and at this speed the plant is fairly quiet.*

The remainder of the power-driven pumps used by the Department are of the Reciprocating type, and these vary in design, according to the manufacturers. A few are of the single-acting type, where the air is dealt with on one side of the piston only; but the great majority are double-acting. In some cases the cylinder is mounted horizontally; but the more common

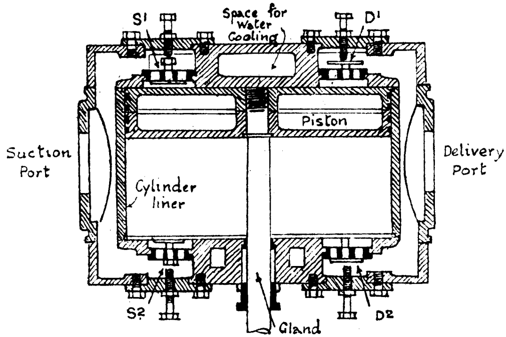

Fig. 4.

practice is to fix it vertically. The driving power most commonly used is supplied by an electric motor, but there are cases where oil and steam engines are made use of. The drive is nearly always by means of a belt; but in some instances the motors have been mounted on the same bedplate as the pump, which is then driven direct, or through gearing. 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 to the seat of the valve 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. 4 shows a section taken through a typical cylinder, with the piston having just completed one of its upward strokes. The delivery valve at the top of the cylinder liner is shown open, and the air is being discharged through this to the Delivery

* The revised edition of T.I.X. will contain a description of centrifugal blowers, which are now also used for this purpose.

Port. Meanwhile the incoming air has been drawn in to the bottom of the liner through the Suction Port, and the **suction** valve S2. On the **downward** stroke the reverse action takes place, the air being discharged through D2 at the bottom of the liner, and drawn in through S1 at the top of the liner. In fact the action is similar to that described for the hand-pump, except that in this case there are a number of Suction and Delivery valves dotted around both the top and bottom of the cylinder liner. In the case of the power-driven pump, it is also necessary to keep the cylinder liner as cool as possible in order that the pump may perform its work efficiently; and this is arranged for by providing a **water-jacket** between the outer cylinder wall and the liner. Only a small portion of this can be seen in the diagram, as the suction and delivery ports are shown; but the remainder of the space around the cylinder is all water-jacket. The water supply is usually connected to one or more circulating tanks, which are used for cooling the water as it leaves the compressor. The circulation is sometimes purely a thermal one, where the difference in density of the water at the top and bottom of the tank, caused by the difference in temperature of the outlet and inlet water of the cylinder, is sufficient to set up all the circulation required. More often a small auxiliary water pump, driven by the compressor, is used to supplement this arrangement. Various methods are adopted for **lubricating** the pumps, but the most common consists of splash lubrication for the internal revolving parts, and feeds from a reservoir for the cylinder and the other bearings. For some large compressors a forced system of lubrication is employed. It will be seen, from the above description, that these air pumps can be used to provide either a Vacuum or a Pressure service, or, if required, can draw from a Vacuum service and deliver into a Pressure service. In nearly all instances, a **container** is provided between the pump and the tube supply, to level up the pressure or vacuum before it is delivered to the tubes; and also to trap any oil or moisture in the compressed air as it leaves the pump, or any fluff or foreign matter from the tubes in the rarefied air before it enters the pump.

The various parts which make up a Pneumatic Tube Installation have now been described, except the Electric Motors, or Engines, and it is not proposed to deal with these in this pamphlet.

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 is bolted direct on to it, and from the latter the brass tube is run to the Instrument room, and terminated in a carrier cage. All joints in the brass tube are made with couplings, pneumatic, or sleeves, brass.

The **low vacuum system** is probably the most economical and satisfactory of the purely house-tube installations worked by power. The various tube fittings have been described on page 2, and these can be connected up in a number of ways to suit local requirements. The fittings and tubes are all connected in

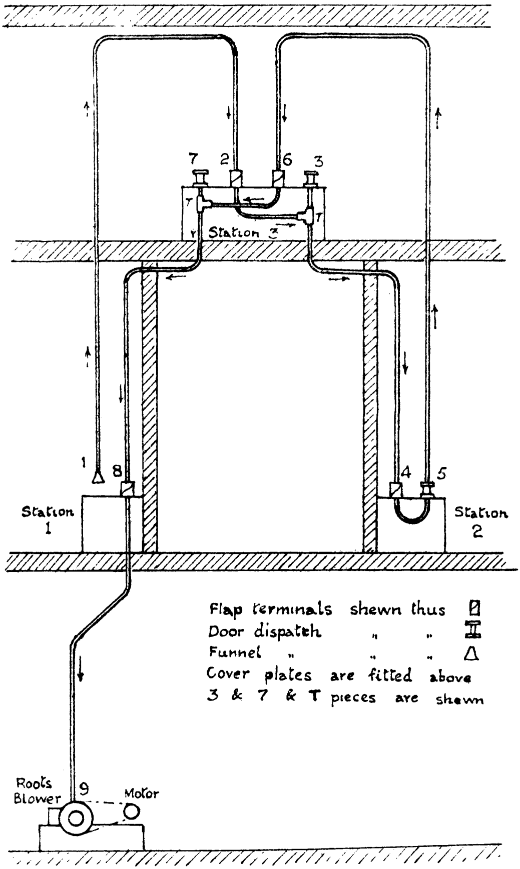

Fig. 5.

"Series" to form one continuous length right down to the blower, and as a total length of 500 feet of $1\frac{1}{2}$ in. tube can be worked quite well by the smallest of the Roots blowers stocked, most house-tube installations come within the scope of this type of plant. In Fig. 5 a lay-out for one of these systems is shown, dealing with both sending and receiving tubes for two stations, connected to a third station.*

These stations might represent the counter, delivery room, and instrument room respectively. When the Roots blower is supplying the vacuum required the air flows in the direction shown by the arrows, and the carriers therefore travel in the same direction. To send from station 1 to station 3, the carrier is inserted in the **funnel** terminal 1, and is discharged automatically at the **flap** terminal 2. To return the carrier from station 3 to station 1, it is inserted in the **door despatch** terminal 7 and is discharged at flap 8. In this case the door despatch terminal is fitted with a **plate cover** at the top to prevent the vacuum being lost, and connection is made to the tube service through one branch of a "T" piece. To send from station 2 to station 3, the carrier is inserted at the door despatch terminal 5, and is ejected at flap 6, the return journey being arranged for by inserting at door despatch 3 and receiving at flap 4. A large number of different lay-outs can be made with this apparatus so long as it is borne in mind that the air must have a continuous flow throughout the complete lengths of the tubes added together. For instance, instead of providing a plate cover at 7, and a "T" piece underneath, the return tube could be connected direct to the top of 7, and taken up to the ceiling before descending to station 1. Fluff from carriers will work its way down to the blower in time, and sometimes soft articles such as paper will reach it. To prevent this the tube or pipe can be cut near the blower, and an air-tight wooden or metal box fitted to the two ends to catch such articles. The blower is driven by a small **motor**, through a belt, and the starter can, if required, be placed at the busiest station, so that the plant need only be run when the tubes are actually being worked.

The **double cylinder system** was originally employed for providing both vacuum and pressure services for street-tubes, combined, if necessary, with house-tubes. The pump in this case is arranged with **two** cylinders, one dealing with the vacuum service, the other with the pressure. It was found from experience that the former cylinder should be about double the size of the latter. The plant is run continuously, and a steady vacuum of 6½ lbs. per square inch below atmosphere, and a pressure of about 10 lbs. above atmosphere, are aimed at.

It was later found more economical to make use of one cylinder to perform the double duty of providing a vacuum and

* Alternative lay-outs of this system will be described in the revised edition of T.I. X.

pressure supply, and the **pumping through system** was introduced. This is shown in diagram form in Fig. 6.

The chief difficulty at first experienced on this system was to even up the two services, so that the required pressure of 10 lbs. per square inch, and vacuum of $6\frac{1}{2}$ lbs., could be obtained. It will be realised that, at times, a small demand on the vacuum service would create a larger vacuum than is desired, with the pump running steadily. Consequently the amount of air to be compressed might not be sufficient to supply the pressure service demands. To overcome such a condition, an **auxiliary suction valve** was designed to admit air from atmosphere to the pump suction in order to make up for the smaller quantity received from the vacuum service. This valve is composed of the three Rate Book items, **valves pneumatic automatic regulating vacuum, contact gauge and relay, and electro pilot vacuum.** The first-named is the valve proper, and is inserted in the pipework between the pump and the vacuum container, as shown at E2. Normally it allows direct

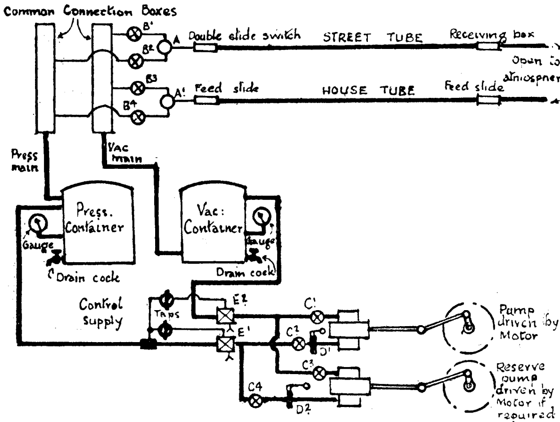

Fig. 6.

connection between the pump and the container; but, when operated, it closes the connection to the container, and opens the pump suction to atmosphere. It is operated by the electro pilot valve, which simply allows compressed air from the pressure container to enter a lower chamber of the main valve, and work a piston to which the valve is attached. This pilot is, in turn, operated by an electric current taken from a 40-volt battery through contacts on the contact gauge and relay. This gauge is connected to the pressure container, and the contacts are set to bring the auxiliary suction valve into operation when the pressure falls below a pre-determined limit. Similarly it cuts the auxiliary suction valve out when the pressure becomes normal. It may also happen on this system that, at times, there is too much air available for the pressure service demands. The simplest way to deal with this would be to fit a safety valve set to unload at a pressure above normal. This, however, would be uneconomical, and an electrically-operated **unloading valve** is provided. This valve is composed of three similar items to the auxiliary vacuum valve, described above, except that the pressure main valve and electro pilot are used. The main valve is fitted on the delivery side of the pump, between it and the pressure container, as shown at E1. When operated, this valve closes the pump connection to the container and opens up the pump delivery to atmosphere, thus unloading the compresser without wasting air already compressed. The valve is similar to the auxiliary suction valve, and is worked in a similar man-

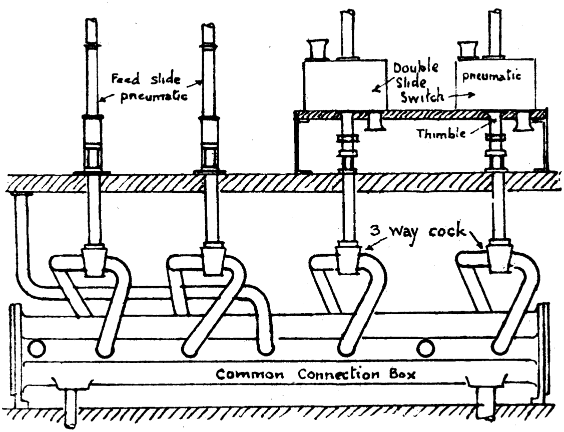

Fig. 7.

ner. The contacts on the gauge are set to operate the main valve when the pressure reaches a certain point above normal, and to restore the usual conditions of running when it becomes normal again. If more than one pumping set is provided on an installation worked on this system, **stop valves,** C1, C2, C3, C4, are fixed on the delivery and suction pipes of each pump, and between these valves and the pump on the delivery side, small **safety valves** D1, D2, are fixed to guard against accident, if the pump were started up with C2 or C4 closed. B1, B2, B3, and B4 represent throttle cocks, and A and A1 three-way control cocks.

Fig. 7 illustrates a lay-out for a **tube-table,** making use of the obsolete three-way cocks, dealing with two-street and two-house tubes.

The throttle cocks are, in this case, screwed direct into the common connection box, and a lead service pipe taken from them to the three-way cocks. The second common connection box stands behind the one shown in the sketch.*

Having concluded a brief description of the various parts and systems in use, it may be useful, before concluding, to give a few **hints on maintenance.**

Carriers.—For satisfactory working these should be discarded when the felt pad is worn down by as much as one-eighth of an inch in diameter. Care should be taken to see that the messages do not protrude beyond the end of the carrier, and all carriers must travel buffer foremost.

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

Do not attempt to deal with **street-tube faults** which are causing blockages without first asking for instructions. It would, however, probably save time if the route taken by the tube were walked over, and any recent excavation work noted. Such work may have damaged the tube. When a carrier sticks in the tube do not attempt to drive it through with another carrier. This would probably make matters worse. Instead, first try to withdraw it by switching on the vacuum service. The effect of this can be increased by temporarily stopping the open end by means of a book or similar object, and then letting the air suddenly rush in by removing the book. **Maintenance tests** of street tubes are taken **quarterly,** and recorded on Form T.E.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.

Common connection boxes should be cleaned out every **three months** by removing the end-plates.

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

The **weight** on the lever of the **hand-pump** 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 dropped into

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* A revised lay-out embodying the use of three- and four-way valves will be described in the revised edition o T.I.X.

† Fuller details will be found in T.I.X.

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 atmosphere by means of a pipe.

Power pumps should receive careful attention. Special care should 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 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. The water should be drained from the **circulating pipes** and the **cylinder jackets** when the plant is stopped in **frosty** weather. 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** powder may provide a remedy; but if a prepared **canvas** belt is used, belt composition or resin must **not** be used. A few drops of **castor oil** should be applied to the face of one of the pulleys.

Printed by HIS MAJESTY'S STATIONERY OFFICE.

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