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P.W.—D.14.

**POST OFFICE
ENGINEERING DEPARTMENT**

**TECHNICAL PAMPHLETS
FOR
WORKMEN**

Subject :

**Telephone Exchange
Maintenance.**

ENGINEER-IN-CHIEF'S OFFICE

1919

==== LIST OF ====

Technical Pamphlets for Workmen.

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1. Magnetism and Electricity.
2. Primary Batteries.
3. Technical Terms.
4. Test Boards.
5. Protective Fittings.
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7. Sensitivity of Apparatus.

GROUP B.

1. Elementary Principles of Telegraphy and Systems up to Morse Duplex.
2. Telegraph Concentrators.
3. Wheatstone. Morse Keyboard Perforators.
4. Quadruplex. Telegraph Repeaters, Sx., Dx., and Quad.
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TELEPHONE EXCHANGE MAINTENANCE.

(D.14.)

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*The following pamphlets in this series are of
kindred interest:—*

- D.15. Telephone Testing Equipment.
- D.16. Routine Testing for Telephone Exchanges.
- D.19. Cord Repairs.

TELEPHONE EXCHANGE MAINTENANCE.

MAINTENANCE PROCEDURE.

General.—The term maintenance, used in connection with Telephone Exchange work, implies not only keeping the Exchange plant in efficient condition, but also the clearance of faults to that end. In connection with fault clearing, time enters largely into the question of good and efficient maintenance as generally understood, and the efforts of the Exchange Staff will be judged to a considerable extent by the duration of the faults.

Inspections.—By careful and systematic inspection and by regular testing many incipient faults may be found and cleared before they cause trouble. There may be said to be three classes of inspection :—

(1) The Daily Survey of the *A* and *B* positions made by the Traffic Branch, the result of which is recorded on a Form “ Daily Test of Cord Circuits ” and forwarded to the Exchange lineman for attention.

(2) The daily and continuous inspection which the Exchange lineman should make.

(3) The thorough and detailed inspection which is made once in six months by an Engineer or Inspector in accordance with the Engineer-in-Chief’s instructions.

In connection with (1), it should be remembered that faults on cord circuits and other defects are regarded as “ anticipated ” faults, and are not recorded on the “ Daily Fault Register ” form or on the fault cards; the more thorough this morning survey and test, therefore, the fewer the registered faults.

Daily Fault Register.—The defects revealed by inspection made under (2) may also be regarded in a similar light. The more thoroughly these inspections are made, therefore, the fewer will be the registered faults. With regard to (3), an abridged summary of the items enumerated on the Half-Yearly Inspection Form (T.E. No. 263) is given below. Reference to this Summary will be found of considerable assistance as a guide to what items should be inspected regularly. A more detailed summary of the items of plant which require to be inspected is given in the section headed “ Periodical Overhaul of Exchange Plant and Wiring. ”

Summary (Abridged) of Half-Yearly Inspection Report.—*Switchroom.*—Condition of woodwork of (*a*) sections, (*b*) lamp and key shelves, (*c*) spacing strips. Condition of plugs, cords, keys, indicators or lamps, keyboard, fuses and fuse fittings, labels,

operators' instruments. Condition of woodwork of (i.) information desk, (ii.) supervisor's desk. Condition of wiring, cabling and soldering, routine test sets, circuit markings. Generally, freedom from dust. Routine test schedules correctly dealt with? Engaged, out of order and busy back signals satisfactory?

Test or Apparatus Room.—Appearance, condition of M.D.F. (or test frame), I.D.F., relay racks, meter racks generally. Freedom from dust, earth connections efficient, uralite on M.D.F. and I.D.F., line fuses, protectors and heat coils, jumpers and soldering, test jacks, relays, meters, cables and cable runs, marking of fuse boards, spare fuses, alarm fuses, resistance lamp cabinet, circuit diagrams. (See also the section headed "Periodical Overhaul of Exchange Plant and Wiring," pages 11, 12 and 13.)

Routine Testing.—Tests have been devised which cover practically all the apparatus and circuits in use in Exchanges. These tests secure not only that the apparatus shall give good results under normal conditions, but that it shall respond accurately under the most severe conditions met with in practice. The Traffic Staff carry out some of the tests and the Engineering Staff carry out the remainder of the tests specified, the results being recorded on routine test forms. All faults thus recorded are cleared by the Exchange lineman. A detailed explanation of the tests concerned and the apparatus used will be found in the pamphlet on Routine Testing for Telephone Exchanges (P.W.—D. 16).

Fault Reports. What is known as the "Docket" method of reporting faults is in use at large exchanges. This system was introduced in order to save time, to ensure accuracy, and to expedite the clearance of faults. In large exchanges the maintenance of work is divided into three classes, *viz.*, Exchange, Apparatus, and Line. It is the general practice, before handing out a fault to a lineman, to prove that the fault is not in the Exchange or at the subscriber's premises.

The following is a brief description of the procedure regarding faults and maintenance adopted at Exchanges with a capacity for 300 or more direct Exchange lines:—

A subscriber desiring to make a complaint is connected to one of a group of circuits between the Switchboard and the Monitor's desk. The monitor records particulars of the complaint on a Docket Form T. No. 3, and if the complaint appears to refer to an engineering defect he despatches the docket to the testing telephonist, where one exists, or otherwise to the Test Clerk direct. In the majority of C.B. Exchanges a special position in the exchange is equipped with testing apparatus and a testing telephonist is provided by the Traffic Staff. One of the duties of the testing telephonist is to make a preliminary test on all circuits reported as faulty, so as to ensure that only those lines which are actually faulty are reported to the Test Clerk.

The testing telephonist's position is equipped with the following apparatus :—

Voltmeter test set.

Connecting cords.

Howler cords.

Plugging-up cords.

Test Extension circuits from and to the test clerk (plug-ended on switchboard).

Circuits to the last working " B " position if two lines of boards.

Order wire circuits from " A " positions and from test clerk.

Service lines from the switchboard and monitors' positions.

The apparatus on the Testing Telephonist's position permits of rapid tests for earth, contact, disconnection, etc., to be made.

The circuits to the end *B* positions permit the tests over a subscriber's line to be made from the end multiples and, consequently, it embraces the complete circuit.

On receipt of a Docket in the Test Room the relevant Fault Card is extracted from the Card Cabinet, and particulars of the complaint and of the Testing Telephonist's test are entered thereon, the docket is stamped "Registered," indicating that the complaint is entered in the Engineering records, and the docket and fault card are then referred to the Test Clerk, who, in due course, tests the line, etc. If the circuit tests clear of faults, the docket is stamped "R.W.T." (right when tested) and returned to the testing telephonist. If the fault be in the exchange, the docket is stamped "Exchange Fault," and is forwarded to the Exchange lineman. If the fault is outside the exchange the docket is returned to the testing telephonist. "R.W.T.'s" are entered on the fault card, thus ensuring that special attention will be given to a second fault report on that particular circuit. Clears are received from the linemen and entered direct on the fault card by the Test Clerk.

The procedure with regard to obvious Exchange faults is somewhat different. Two fault dockets are issued; one gives full details and particulars of the fault and is passed direct to the Exchange lineman, who, when the fault has been cleared, forwards it to the Test Clerk in order that the necessary entry may be made on the Fault Card; the other is a dummy docket, which bears the registered number of the first and the circuit designation only. It is forwarded direct to the Test Clerk, who transfers particulars to the fault card, stamps the docket "Registered," and returns it to the Switch Room. The first docket, when received in the test room after

the fault has had attention, is also stamped "Registered" and returned to the testing telephonist by the Test Clerk. The object of this variation in procedure is to avoid the delay which would be caused by circulating dockets for obvious exchange faults *viâ* the Test Clerk to the Exchange lineman.

In large Exchanges a docket tube is usually provided between the Monitor's Desk, Exchange Testing Position and the Test Desk. In the smaller Exchanges, but where there is an Engineering Officer in attendance all day, the tube or docket carrier is between the Exchange and the Test Desk only. At Exchanges with equipped capacity for *less* than 300 Subscribers, direct Exchange lines, one of the two following systems is adopted :—

The selection of the system to be adopted depends largely on the size of the area and the means of communication between the Exchanges therein, preference, however, is given to system (a) which secures control by telephone from a selected centre; in system (b) the exchanges are usually widely scattered, and the means of communication between them more difficult.

In system (a) faults at outlying exchanges are reported by telephone to the Exchange at the controlling centre. Dockets are then issued by the Traffic Officer and passed to the Engineering Officer for attention. The fault cards in respect of the Exchanges concerned are kept at the Engineering Fault Control Centre, and entries are made thereon in the usual way. The faults are then given out for attention, and as soon as cleared the clears are reported by the linemen in the first instance direct to the Exchanges concerned, and subsequently to the Engineering Officer at the control centre. The telephonist at each small Exchange records all faults in an "Abstract of Faults" book. Where the Engineering Officer at the control centre is not stationed in an Exchange building, the telephonist or other Traffic Officer at the control exchange telephones particulars of all faults received from the outlying Exchanges to the Engineering Officer, who records the details on dockets and makes the necessary entries on the fault card.

In system (b) the telephonists advise the linemen direct by the most expeditious means available, and also notify the Engineering Officer holding the fault records. The reporting telephonist records details of each fault in the "Abstract of Faults" book in duplicate, and forwards a copy to the Engineering Officer each night in confirmation of the faults reported to him during the day.

The lineman reports clears direct to the Exchange concerned, stating the location of the fault, *i.e.*, Exchange, Line, or Subscriber's apparatus, and records full particulars in duplicate in his Telephone Fault Book. One copy of the record is retained and the other is forwarded to the Officer holding the fault cards.

Analysis of Faults.—At Exchanges equipped for 300 or more Exchange circuits, a quarterly analysis is taken with a view to ascertaining whether the behaviour of the various items of Exchange equipment is normal or otherwise. The result of this analysis must be carefully studied by the responsible engineering officer and compared with previous analyses. In the event of an abnormal increase in faults at any Exchange, the immediate cause of which is not apparent, an analysis should be taken as soon as the increase comes under notice.

Faults due to Working Parties.—The Traffic Branch must be advised when engineering work is to be performed which is likely to disturb the working of subscribers' circuits, whether it be Exchange work or External work.

GENERAL PRINCIPLES TO BE FOLLOWED IN THE LOCALISATION OF FAULTS.

1. The localisation of Exchange faults entails a thorough knowledge of the circuits and of the functions of the numerous pieces of apparatus of which they are comprised. Rule of thumb and haphazard methods are to be strictly guarded against, as the effects of such methods react seriously on the general efficiency of the plant.

There should be a complete set of diagrams, both wiring and explanatory, in every exchange, the more important and frequently used of which should be mounted on card or linen. The diagrams should be indexed for easy reference and filed in a suitable diagram case.

Considerable time is saved if defects are fully and accurately reported by the Exchange Supervisor or Testing Telephonist, but the amount of space on the Monitor's docket is limited, as also are the codes, and it is necessary, therefore, in some cases to seek further information from the Supervisor or Telephonist before the localisation of a fault is attempted. The point it is desired to emphasise is that in those cases where the nature of the complaint is not clear from the docket it may be profitable to spend a little time in making verbal enquiry before proceeding with tests. No attempt should be made to localise until the probable *cause* has been carefully reasoned out.

It would obviously be impossible to describe all the kinds of faults met with in an exchange, but a study of the following analysis of faults at a No. 1 C.B. Exchange, combined with the notes that follow, may prove of assistance.

Analysis of One Week's Faults. No. 1 C.B. Exchange.

1. Cords and plugs.
2. 12,000 ohms relays.
3. Supervisory relays (A and B positions).
4. Outgoing order wire keys.
5. Listening keys.
6. Lamps.
7. Wiring.
8. Jacks, Multiple and Answering.

In this list the apparatus responsible for the greatest number of faults is shown first on the list, *viz.*, cords and plugs, and that responsible for the smallest number last, *viz.*, jacks.

Notes on Analysis.—These notes are intended to serve as a general guide only. They indicate how faults on the various classes of apparatus usually reveal themselves, and the most likely causes of trouble. On the "Analysis of Faults" Form, twenty-seven items appear in the Exchange group, but only eight of the items responsible for the greatest number of faults have been selected for comment.

1. *Cords.*—In the majority of cases the fault is reported as "noisy" and no special knowledge is required to locate. The cord is repaired in the majority of cases without removing it from the switchboard and is retested before being brought into use again.

2. *12,000 ohm Relay.*—Usually reported at the incoming end as L.G. (Lamp glows) or N.G. (no glow) on Clearing lamp. The most frequent causes in both cases are (a) relay out of adjustment, (b) dirty knife edge on relay armature, (c) armature fouls on screw which passes through armature into the core. N.G.'s may also be due to the non-operation of the 12,000 ohm relay owing to a disconnection or Earth in the circuit.

3. (a) *Cord Circuit Relays on "A" Positions.*—Faults on these relays are generally indicated by the Supervisory lamp glowing permanently or failing to glow, and are reported as L.G. or N.G. The most frequent causes of the former are (1) relay out of adjustment, (2) dirty knife edge on armature of relay, (3) dirty contacts which, on the 22-volt system, prevent the lamp being shunted. In the case of N.G. reports the faults may be due to (1) relay out of adjustment, (2) faulty lamp. In both cases, loose relay covers, screw threads defective, etc., may cause failure in the operation of the relays.

(b) *Supervisory Relays on "B" Positions.*—Faults on these relays are indicated on the Supervisory signal at the distant Exchange and are reported at the incoming end as "no busy back flash" or as L.G. or N.G. The most frequent causes are as in the case of the "A" board supervisory signals.

4. *Outgoing Order Wire Keys*.—Reported as “Can’t get” on positions specified. Usual causes (1) dirty contacts on springs, (2) springs out of adjustment, (3) disconnections in wiring, usually on the keys.

5. *Listening Keys*.—Usually reported by a telephonist as “cord OOO,” or “cord faint.” Usual causes (1) dirty contacts, (2) weak springs, (3) springs out of adjustment.

6. *Lamps*.—Reported as N.G. Usual causes (1) filament broken, (2) lamp out of adjustment, *i.e.*, not inserted properly in lamp jack. “Faint glows” may be due to (1) lamp being inserted too far into lamp jack, (2) high resistance lamp, (3) low voltage on power supply lead.

7. *Wiring*.—Earths, disconnections, contacts, overhearing due to proper twisted pairs not being used in cable for speaking circuits.

8. *Jacks*.—Reported as “can’t get” at panel specified. Usually due to an obstruction in Jack such as broken plug tip, a piece of pencil, badly worn jack or the like, causing disconnections, short circuits, contacts, etc.

Example showing Procedure in locating a “No Glow” Fault on “A” Position Cords. C.B. No. 1 Exchanges.

The fault may be due to one of the following causes:—

1. Fuse blown.
2. Supervisory relay armature sticking.
3. Lamps inserted wrongly in jack or burnt out.
4. Short-circuited lamp, or disconnection in sleeve conductor of cord, or in wiring of lamp and resistance spool circuit.
5. Earth fault between spools and lamp.
6. High resistance fault.

(1) Prove by testing both cords. Tap the sleeve of each plug in turn on to an earth connection. If one lamp lights, the fault is not due to the fuse.

(2) Remove opal cap from jack of faulty lamp; note whether there is a dull red glow when sleeve is connected to earth. If there is a glow, the fault in all probability is due to relay armature sticking, thus keeping the lamp shunted.

(3) Remove and examine lamp. Now test the lamp or insert a good lamp in lieu and again test sleeve circuit.

(4) Use a localising lamp (12v.) tester No. 8, one side connected to earth and the other to a clip. Tap the clip on to the sleeve cord fastener. A dull red glow on the testing lamp indicates that current is passing through both lamps and 83^w spool in series. The fault is then due to a disconnection between cord fastener and sleeve of plug. If a bright glow is obtained on tester lamp, this indicates a short-circuit on the supervisory

lamp. If no glow is obtained, the test lamp should now be connected first to one and then to the other terminal on lamp. Assuming that a glow of any description is not obtained, make a similar test on the tabs of the 83^w spool. A brilliant glow will be obtained on the battery side of the spool if circuit is O.K. from battery to that point. If 83^w spool is disconnected, no glow would be obtained on lamp side of spool.

Item (5) is rare, and if it be a full earth it can only be discovered by a P.D. test, using detector No. 2 (50v. termls.) and observing whether a deflection is obtained when tapped across 83^w spool, or 43^w spool, or across lamp. The resistance spool would also be very warm, due to the excessive current through it.

(6) May be due to badly soldered connections or dirty springs on lamp jacks, and occasionally by a high resistance cord conductor.

Testers.—For the purpose of assisting in the localisation of exchange faults, various testers are available, and a description of these is given in the pamphlet on "Routine Testing for Telephone Exchanges."

CLEANLINESS AND TIDINESS OF EXCHANGE PLANT.

The necessity for cleanliness and tidiness in Exchanges cannot be over emphasised. The inside as well as the outside of the switchboards, the associated desks and other plant should be cleaned and dusted. Ironwork, cables, cable forms, cable shelves, relay covers, condensers, in fact all places where dust can accumulate should receive attention. This work must be undertaken systematically so that each portion of the plant receives regular periodical attention.

Much can be done to improve the appearance of the plant apart from dusting. Lacings on relay racks can be straightened, and in some cases a coating of shellac varnish will not only improve the appearance but will facilitate dust removal. Black enamelled relay covers can be retouched with black paint, and meter covers wiped over with a slightly oiled rag. Aluminium covers of relays can be cleaned after removal with fine silver sand and water, and so on. Fittings with a bright finish should be kept bright; the glass of glazed cabinets should receive attention, also notice boards and other fixtures. Various simple and inexpensive means whereby a clean and bright appearance can be imparted to the Exchange plant suggest themselves from time to time, *e.g.*, the whitening of the floor under and around frames and racks. Too much, however, must not be attempted in this direction without authority.

Tidiness is essential more particularly in regard to the actual wiring. All jumpers on test boards and Main and Intermediate Distribution frames should be correctly run through the jumper rings and kept clear of ironwork. They should be drawn taut

and the soldered connection to the tab should be neat and effective. The clean cut insulation should be close up to the tab and there should be no sign of fraying. Where it has been necessary to disarrange wiring in locating and clearing faults it should be made neat and tidy on completion of the work. Careless soldering, dry joints, and ends of wire projecting through tags must be guarded against. Fragments of wire and cord cuttings should be removed as soon as repairs are effected, and where cords are repaired at the back of the switchboard cuttings should be prevented from flying into the section by a canvas sheet suspended on hooks placed just inside at each end of the section. The end of the cord to be repaired is passed through a hole in the pilot lamp panel to the back of the board and then through a hole made in the canvas sheet.

The adage "a place for everything and everything in its place" is particularly applicable to a telephone exchange. Positions should be assigned for all movable items of plant, and receptacles provided for heat coils, fuses, jumper wire, scrap wire, etc.

The following is a list of fittings provided for the purpose mentioned in large exchanges :—

1. Heat coil boxes (one for good and one for faulty coils) to be fixed near Main frame or Test Board.
2. Portable wire swifts or drums permanently fixed to the Main and Intermediate frames.
3. Main Fuse cabinet, to accommodate fuses of various sizes—fixed near power board.
4. Alarm Fuse Cabinet, with shelves to accommodate alarm fuses of various sizes fixed near fuse panel.
5. Cord repair-part box.
6. Cord repair table.
7. Diagram case.
8. Wire bin for scrap Jumper Wire.
9. *Metal* bin for oily waste and rags.
10. Back board with clips for accumulator inspection lamp.
11. Spanner board.
12. Emergency Key cabinet.
13. Notice Board.
14. Racks for operators' instruments awaiting repair.
15. Saddles or hooks for spare cords.

Notice Boards should frequently be inspected and all out of date and obsolete notices removed. Nothing detracts from the appearance of the face of the Switchboard so much as untidy and temporary notices affixed thereto. Exchange men should co-operate in every way with the Traffic Officers to prevent this by suggesting alternatives.

These details may appear somewhat trivial, but it is the constant attention to such matters that will ensure the results aimed at.

PERIODICAL OVERHAUL OF EXCHANGE PLANT AND WIRING.

Unless a systematic overhaul of the Exchange plant, including the wiring and cables, takes place periodically serious deterioration in the Maintenance will occur. Every effort should be made to guard against temporary wiring, loose jacks, omissions to clean out soldering tags, presence of dead jumpers in main and intermediate distribution frames, and the like. During the periodical maintenance overhaul the following matters should receive attention :—

Generally throughout the Exchange.

1. Examine wiring to see that it is neat and properly run; remove temporary wiring of any description unless specially authorised.
2. Examine ironwork, clean and paint as required.
3. Examine cable ties, and renew or repair where required.
4. Examine connections on tags and re-solder where necessary.
5. Examine all cable skimmers and see that insulation is intact up to tags. Where the covering has run back the ends must be re-insulated. Frayed ends should be beeswaxed where necessary.
6. Tighten up all jumper rings and fixing nuts where necessary.
7. Examine all labelling and numbering and renovate where required.

On Main Frames, Intermediate Distribution Frames and Test Boards.

1. Examine connections of jumpers to tags and re-solder where necessary. See that all jumpers are correctly run, that the insulation is good and that they are not bearing against the ironwork of the frame.
2. Examine all fuses, protectors and heat coil fittings. If any corrosion exists clean or renovate as required.
See that :—
 - (a) Heat coils are correctly fixed between springs, and replace any coils that have collapsed.
 - (b) Fuses are correctly fitted and making secure contact.
 - (c) Micacs and carbons of protectors are in order. (Special care should be exercised in removing dust from the upper edges of carbon blocks.)
 - (d) Mounting springs have adequate tension.
3. Verify that dummy heat coils are correctly fitted.
4. See that shelves on M.D. and I.D. Frames are fitted with Uralite.

On Fuse Boards and Fuse Panels.

1. Examine alarm fuses and replace defective ones.
2. Test fuse alarm bell and pilot lamps on every row where fuses are fitted, removing any defects.

Switchboard.

Face Equipment.

1. See that all number plates, style strip labels and opal caps are in position and that the marking is satisfactory.
2. Examine spotting and marking of jacks and renovate where necessary.
3. Secure all loose jacks, lamp jacks, spacing and style strips, label holders, etc.
4. Examine plugs and cords, replace defective ones and see that cords of correct colour are restored as soon as possible.
5. Examine plug shelves, renovate worn leather and plug holes, also numbering of key shelves and plugs where necessary.
6. Examine keys, verify that axle pins are not unduly worn, and that springs operate satisfactorily. Repair worn parts or replace. See that key plates are secure.
7. *Jack Test.*—Test multiple and answering jacks with special plug to check worn bushes or weak springs. Faulty jacks should be restored or replaced.
8. *Engaged Test.*—Verify that bushes of answering and multiple jacks are clean and that engaged test is satisfactory. Clean bushes if necessary.
9. *Key Shelves Wiring.*—See that cable forms are fixed in such a manner as to prevent strain on wires when key shelf is opened or closed and that cables do not chafe against ironwork.
10. *Multiple Cables.*—See that all cables are held in their correct position and renew defective tapes.
11. *Fireproof Bulkheads.*—Where fitted, see that all fireproof screens and bulkheads are in position and in good condition.
12. *Woodwork.*—Examine all woodwork, doors, shutters, etc., and effect any necessary repairs. If any portion of the switchboard woodwork is deteriorated to such an extent as to need re-surfacing or extensive renewal, report for special attention.
13. *Cleaning.*—Thoroughly clean all Exchange plant by removing dust, dirt, scrap wires, etc., particular attention

being paid to tops of Switch Sections, troughings, and other enclosed spaces.

14. *Polishing*.—All woodwork of Switch Section Desks etc., which is French polished should be polished with oil polish once in three months.

VACUUM CLEANERS.

The necessity for perfect cleanliness in Exchanges is especially important, and is emphasised by Mr. J. E. Kingsbury in his book, "The Telephone and Telephone Exchanges." He quotes the Chairman of the Switchboard Conference of 1887 as follows: "In my judgment the one great need of our Exchanges to-day, and one that could be supplied almost without cost, is *cleanliness*. I use the word in a broad sense, clean offices, clean lines, clean switchboards, clean batteries, and clean operating. It seems to me that this committee might add materially to the good work . . . if it could devise some way of impressing on every officer and employee . . . the fact that no piece of electrical machinery ever has or ever can be devised that will work well unless it is kept clean and is handled properly." The need exists to-day to a much greater degree owing to the multiplicity of the apparatus and the more complicated and delicate items it comprises. Blowing by means of bellows or special blowers and by the improvised use of desiccating apparatus has been tried, but the results were not entirely satisfactory, as although the dust could be blown from inaccessible places, such as in the multiple jacks, it found a lodgment elsewhere, and the plant was never properly free from dust.

The systematic use of vacuum cleaning machines in Exchanges, particularly those of large size, has effected a very considerable improvement in the general condition of the equipment, and the liability of faults due to dust and dirt has been greatly reduced. The hygienic conditions of the Exchanges has also been improved by the regular removal of dust.

There are in the main three types of vacuum cleaners, *viz.*, those which employ fans, pumps, and bellows, respectively. The majority in use in the Engineering Department are of the latter type, and a description of one of this type follows:—

The $\frac{1}{2}$ h.p. Electric "Pulvo" Vacuum Cleaner.

This machine consists of two sets of bellows, each of which is connected to a double crank shaft, the cranks being on

opposite sides of the shaft (Fig. 1), so that when one set of bellows is opening the other is closing, and *vice versa*. This provides practically continuous suction. The shaft is fitted with a flywheel and connected by a belt to a $\frac{1}{4}$ H.P. motor. Each set

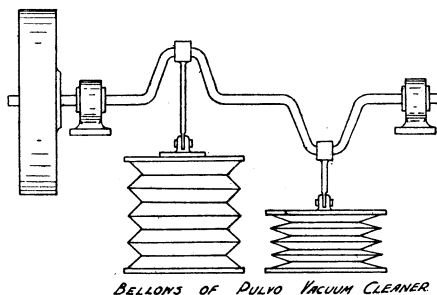
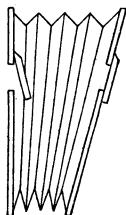


Fig. 1.

of bellows has two valves, an inlet and outlet, so arranged that when one of the sets of bellows is performing its opening movement its front valve is open and its back valve closed (Fig. 2). The dust-laden air is sucked through the nozzle into a metal container, through a linen filter (which prevents the dust passing



SECTION THROUGH BELLOWS
OF PULVO MACHINE SHEWING
VALVES

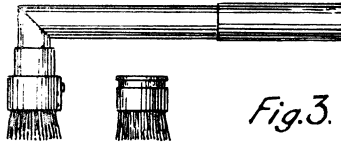
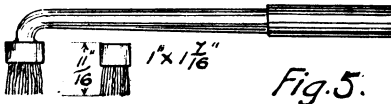
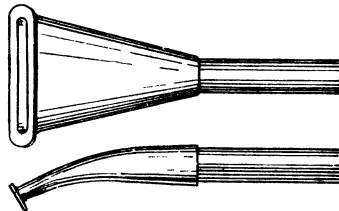
Fig. 2.

into the bellows), and then through the front valve and out of the back.

To prevent loss of power the linen bag or filter should be cleaned frequently, and the bellows should be examined occasionally with a view to detecting any defects in the fabric. It is also necessary to see that the tube connections between the hose, nozzles, and machine are good, otherwise the efficiency will be impaired.

Vacuum Cleaning Tools.

There are various kinds of vacuum cleaning tools or nozzles in use. The form which these take is very important, and care must be taken to select the most suitable tool for the work to be done. Plain flat surfaces can, as a rule, be cleaned effectively with a tool without bristles, but where the surface is rounded or irregular, bristles are provided on the tool with

*Fig. 3.**Fig. 4.**Fig. 5.**Fig. 6.***VACUUM CLEANING TOOLS.**

which to disturb the dust, which is then drawn through the orifice in the tool. Figures 3 to 9 illustrate some of the tools in use.

Fig. 3.—This tool is for general use, but particularly for cord and key shelves and for cable runs.

Fig. 4.—Used between relay covers and retardation coils.

Fig. 5.—For general use, but particularly for repeater coils.

Fig. 6.—For jumper runs on M.D.F. and I.D.F. and flat surfaces.

Fig. 7.—For general use.

Fig. 8.—For general use, particularly in the lower portion of switchboard.

Fig. 9.—For use in chases and spaces between cables.

SYSTEMATIC TESTING OF PRIMARY BATTERIES

The need for strict attention to primary battery maintenance cannot be too strongly emphasised, and much study and investigation has been devoted to finding a means of determining with absolute reliance the exact condition of cells.

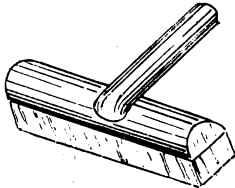


Fig. 7.

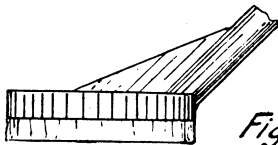
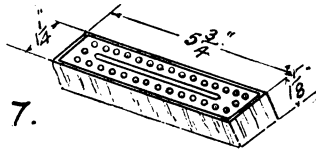


Fig. 8.



Fig. 9.

VACUUM CLEANING TOOLS.

All primary batteries in use should be examined and tested periodically in order that any incipient defects may be found and remedied before the working is affected. The frequency of the test depends on the amount of use each battery has; this can only be determined by experience. Cells must be kept in a state of cleanliness and all connections and leads free from corrosion. The electrical condition of a cell can only be determined by actual test designed to show its open circuit voltage, its internal resistance, and its liability to polarise on load. The comprehensive tests standardised by the Department fulfil these requirements and are dealt with in detail in Loose Leaf Diagram T. 102, Tests No. 21 and 22.

==== LIST OF ====

Technical Pamphlets for Workmen.

(Continued.)

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1. Automatic Telephone Systems

GROUP F.

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3. Subscribers' Apparatus Magneto.
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7. House Telephones.
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GROUP G.

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GROUP H.

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GROUP K.

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