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A SPARK TESTER FOR P.V.C.-INSULATED WIRES

"Spark testing" is the term applied to a method of testing the insulating efficiency of coverings used on certain types of electrical conductors. General purpose spark testers have been available commercially for a number of years. The particular instrument described is one which has been designed and made by the Company to meet a specific need and to provide various ancillary facilities.

THE insulation of covered power cables was at one time tested by immersing the cable in water and applying a suitable voltage between the water and the conductor. A serious drawback of the method was the obvious one that the cable had to be dried after testing. Test equipment was developed later which dispensed with the need for a wet electrode. The cable under test was fed through a metallic electrode with a potential between it and the conductor of a voltage adequate to bridge the airgap wherever an absence of covering occurred ; associated apparatus indicated any breakdown. This method became known as spark testing.

Textile-covered wires used in the telephone industry, and switchboard wires bulk largest amongst these, were not tested in either of these ways. The main users of equipment incorporating switchboard wire insisted that where p.v.c.-covered wire was used it must be spark tested.

Spark testing equipment has been available commercially for many years, but the Company decided to develop its own, with various desirable additional facilities. The electrical requirements for spark testing are stated in a British Standards Specification (B.S.7) and are easily fulfilled by the tester to be described.

The spark tester, complete with winding gear, is illustrated in Fig. 1. It is a self-contained unit operated from the normal 50 c/s mains. It uses a single-phase supply and consumes approximately 150 V/A. The winding gear is driven by a $\frac{3}{4}$ h.p. three-phase motor, and brakes for the drums are connected between two phases.

The testing apparatus is contained in a cabinet, the electrode system being located in a section at the top which has a hinged lid with a substantial perspex window. The cabinet is of metal, an arrangement which facilitates protective earthing. Doors and removable panels to give easy access for maintenance purposes are provided. The cabinet has a base measuring 20″ x 20″ (50·8 x 50·8 cms) and a height

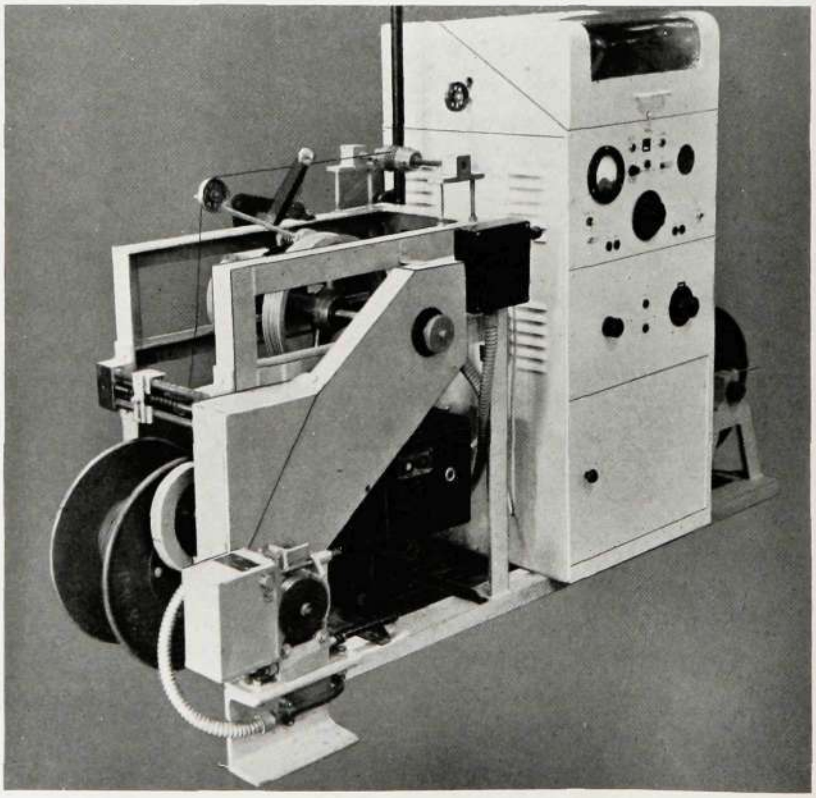


Fig. 1—The Spark Tester with Winding Gear

of 44″ (111.76 cms). These dimensions allow more space inside the cabinet than is required to accommodate the necessary equipment but provide a floor mounting model with electrode and controls at a height convenient for the operator.

In addition to the actual testing equipment, facilities are provided for the following purposes :—

(1) to count the number of faults ;

(2) to mark the approximate positions of faults ;

(3) to find the exact position of microscopic faults ;

(4) to repair small faults ;

(5) to wind off long lengths of wire with the testing equipment disconnected ;

(6) to measure in yards the length of the wire tested ; (this is a function of the winding gear).

High Voltage Electrode Section

Access to the electrode compartment is by a hinged lid, the raising of which automatically actuates protective switches and ensures disconnection of the supply to the electrode and the motor. A warning light inside the compartment indicates the presence of the high voltage.

Fig. 2 shows the electrode compartment with the lid raised and held in position by a ratchet device. The wire under test enters the compartment on the right-hand side via a guide wheel and bush, passes through an electrode and a marking device, and out via a guide bush and wheel on the left-hand side.

Guide wheels and bushes, being subject to considerable abrasive action, are of hardened steel and arranged for easy replacement.

The electrode consists of a pair of chain-mesh strips, 12″ (30·48 cms) long, which when in use are held together by springs, the wire under test passing between them. For setting-up, the strips can be separated. The length of the electrode was fixed after experiments had established the maximum practical speed of drive for the winding and braking gear which would also conform to the B.S.7 requirement that: " The speed at which the core or cable passes through the electrode shall be such that every point is in the electrode for not less than 0·1 second ".

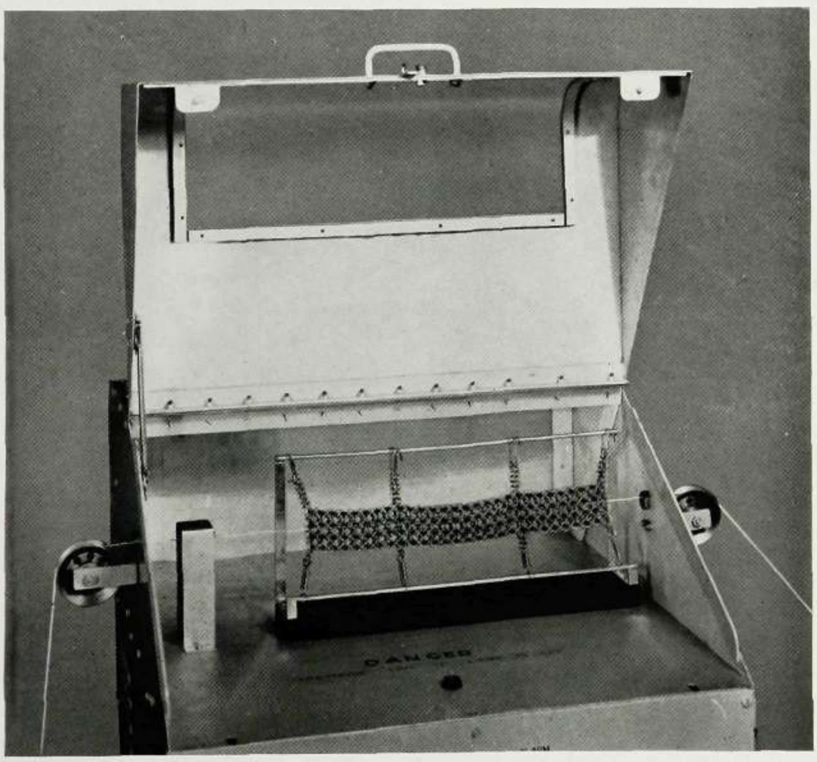


Fig. 2—The Chain Mesh Electrode Compartment

The marking device is solenoid-operated and can be seen near the exit bush. The solenoid is located in the control section immediately underneath the electrode compartment, into which extends a rod carrying an inked pad. When a fault occurs, the solenoid is energized, and, during armature over-shoot, the inked pad momentarily stamps the wire against another pad immediately above the wire.

Detection Principle

The detection principle can conveniently be described by reference to Fig. 3.

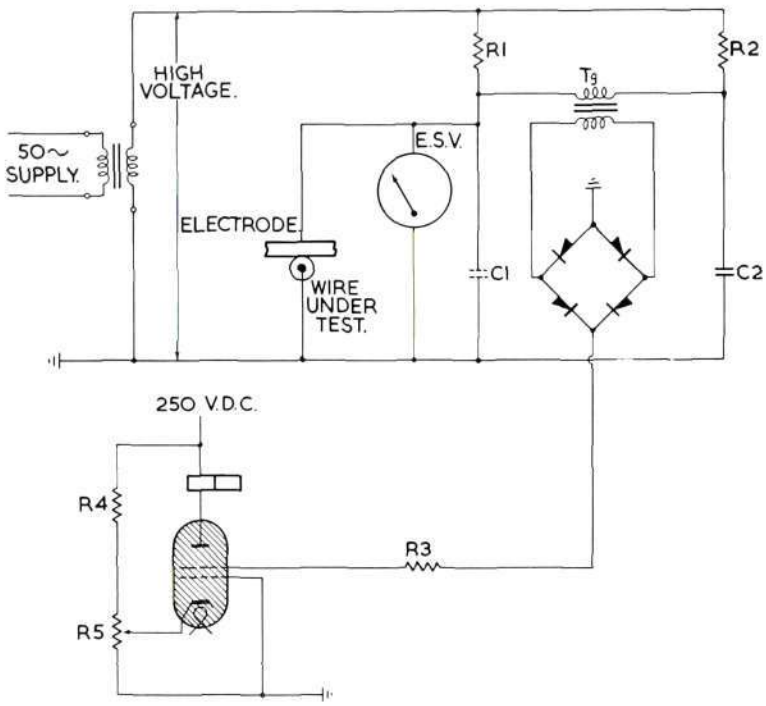


Fig. 3—Schematic Circuit of the Tester

R1, R2, C1 and C2 are the arms of an a.c. bridge network. R1 and R2 are of equal resistance and of a convenient value : C2 is arranged to be equal to C1, which represents the stray capacities to earth of the wiring and the electrode. In the absence of insulation breakdown between the electrode and the wire under test, the bridge will be in a state of balance, and no potential will appear across transformer Tg. Under this condition, the gasfilled valve can be set on the threshold of conduction by adjustment of the bias resistance R5. Whenever insulation breakdown occurs, the bridge becomes unbalanced and a potential appears across transformer Tg. This a.c. voltage is rectified on the transformer output side and causes the gas-filled valve to conduct and operate a relay in the anode circuit.

Spark testers now in service have components in the bridge circuit of such values that the maximum current between electrode and wire under test is approximately 2 m.A. at 3,000 volts. The virtues of such a low current are (1) negligible carbonization of the insulation surrounding a fault and (2) reduction of shock danger. Investigation into the detection circuit has now shown that completely satisfactory working can be achieved when components in the bridge circuit limit the maximum electrode current to 1 m.A. ; future models will be modified in accordance with this finding.

The system is so sensitive and rapid in its response that faults invisible to the naked eye are reliably detected with the wire passing through the electrode at 120 m.p.h., (193 km.p.h.). This is, of course, many times faster than the working speed of slightly over 5 m.p.h. (8 km.p.h.).

The sensitivity of the equipment easily satisfies B.S.7, but in order that it may be checked, access points have been provided for connection to a suitable artificial fault unit.

Operation of the relay in the valve anode circuit controls other relays, so that detection of a fault results in the following :—

(*a*) disconnection of the high voltage after approximately 25 milliseconds ;

(*b*) disconnection of the mains supply to the winding motor ;

(*c*) application of the mains supply to the drum brakes ;

(*d*) operation of the solenoid-operated marking device ;

(*e*) audible and visible alarm ;

(*f*) operation of the fault counter.

In conformity with B.S.7, the circuit is so arranged that fault indication is maintained after a fault has passed out of the electrode.

Winding Mechanism

Switchboard wires in common use in the telephone industry are 20 s.w.g. (.036″, .914 mm dia.), 23 s.w.g. (.024″, .610 mm dia.), and 25 s.w.g. (.020″, .508 mm dia.). Of these, 23 s.w.g. is by far the most common. In the testing of these thin wires, great care must be taken to avoid stretching, which may occur both when the mechanism is being started up and being stopped as a result of fault detection.

The wire is stored on drums carrying up to 10,000 yards (9 km.) of wire, a full drum weighing approximately 90 lbs. (40.8 kg.). When the machine is started, the feed drum (i.e. the drum holding the wire to be tested) must be accelerated from rest to the testing speed ; this is done by pulling the wire off the feed drum. In order to minimize the resulting mechanical shock, a spring-loaded jockey pulley is interposed between the feed drum and the drum on to which the wire is wound after test (winding drum). The jockey pulley is also necessary when winding is stopped, because faults can occur anywhere between the starting and finishing ends : it follows that the "fullness" relation and therefore weight relation between winding and feed drums varies from one extreme to the other. Similarly powerful brakes will stop a light drum more rapidly than a heavy one. If the heavy drum is the winding one, it will over-run more than the feed drum, and without the spring-loaded jockey pulley the wire would stretch or break. It might be thought that a more powerful brake should be fitted on the winding drum so that it always stopped sooner than the feed drum. This, however, would result in excessive over-run of the feed drum when full, and in uncoiling and tangling of the wire. It has been found by experience that at 5 m.p.h. (8 km.p.h.) the braking, in association with the spring-loaded jockey pulley, results in no appreciable stretch and no awkward uncoiling. At speeds significantly in excess of this, trouble is experienced.

A constant speed drive has been incorporated and gives the following advantages :—

(*a*) Since experience has shown a practical limitation on maximum speed, it is clearly an advantage if the average (working) speed is never less than the maximum, i.e. a constant speed.

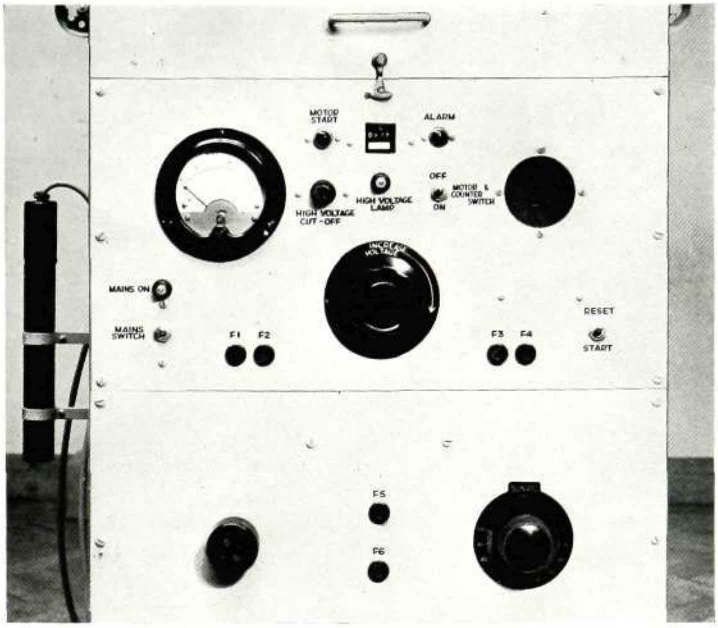


Fig. 4—Enlarged View of Control Equipment

(*b*) A constant speed drive in association with a substantially constant braking effort ensures a substantially constant over-run of the wire whenever a fault is detected. Thus all faults come to rest more or less in the same place.

(*c*) Linear measurement of the wire is facilitated.

LOCATING SMALL FAULTS

When a fault has been detected, the time that elapses before actual stopping of the wire is such that the fault comes to rest outside the electrode compartment and about 12″ (30·5 cms) from the exit bush. Usually the faults are so small that it is difficult to see them with the naked eye, indeed, in many cases they are microscopic. Since it is normal procedure to mend small faults, it is necessary to establish their position, and for this purpose a " probe " is provided. Functionally, the " probe " is similar to the electrode, but it has an effective length of $\frac{1}{4}$″ (.635 cms) and is so constructed that it can be stroked along the short length of wire known to contain a fault. The circuit is arranged so that when a spark occurs between " probe " and wire, the spark can either trigger the detection circuit in the usual manner, or part of the detection circuit can be cut off by a non-locking foot switch so that the spark is maintained.

The " probe " consists of a metal rod sheathed in an insulated sleeve increased in diameter at one end to form a hand grip, with entry for a high-voltage lead. At the other end, a slot is cut through one side of the sleeve and partly through the metal rod. The width and depth of the slot are such as to hold snugly the wire under test. The " probe " can be seen, in its holder, at the left of the cabinet in Fig. 4.

Mending Small Faults

After a fault has been recorded by the tester, and its position has been established by the " probe ", it is covered by p.v.c. tape which is gripped by electrically-heated hand pliers. These weld together the tape and the wire covering. The pliers are connected via a flexible lead to a socket on the front panel (Fig. 4, bottom left), which is associated with a thermostatic control (Fig. 4, bottom right) to maintain the working end of the pliers at a suitable temperature.

The Tester in Use

Before a drum of wire is spark tested, the wire must be checked for continuity of the conductor, since the conductor itself forms part of the testing circuit. Once continuity is assured, the inner end of the conductor is connected to the feed drum for earthing purposes. The drum is now mounted on its bearings, and the outer end of the wire is threaded through the electrode compartment, thence via the constant speed drive and jockey pulley to the winding drum.

It is now necessary to adjust the testing voltage. With the *Motor and Counter* switch " off ", the *Mains* switch " on " and the *Reset/Start* switch at " start ", the testing voltage is indicated by the voltmeter, and is adjustable by rotation of the large knob (centre, Fig. 4). Operation of the *Motor and Counter* switch to the " on " position completes the circuit for the winding gear, and testing commences. The machine may now be left unattended, since the incidence of a fault is accompanied by stopping of the machine, disconnection of the high voltage, and visual and audible alarms. The audible alarm is given by a bell mounted behind a wire-mesh screen (top right, Fig. 4).

To disconnect the alarm, the *Reset/Start* switch is moved to " reset ". With the " probe " foot switch depressed, the fault can be localized in the manner described. After the fault has been mended, the *Motor and Counter* switch is moved to the " off " position and the *Reset/Start* switch to " start ", so that when the probe is stroked over the repaired fault, an alarm is given if the repair is ineffective, without the fault being again recorded on the meter. Usually the repair is effective, and after checking it is necessary merely to move the *Motor and Counter* switch to " on " to continue testing.

Spark testers of the type described have been in constant use in the Company's works for over two years and have proved to be highly reliable. Quite apart from their main function of testing wire produced in bulk, they have assisted the Company's development of high-grade p.v.c.-covered wire.

P.A.B.X. No. 3

P.A.B.X. No. 3 is the largest of three types of private automatic branch exchange equipments recently standardized by the British Post Office. It is for use where the ultimate number of extension lines will be not less than 50 *and may be increased, as circumstances demand, to any desired capacity.*

BEFORE the 1939-45 war, the British Post Office had no agreed standard types of Private Automatic Branch Exchanges (P.A.B.X.). Thus a customer whose requirements included access to the public telephone network could approach any approved manufacturer of telephone equipment and request that a P.A.B.X. be " tailor-made " to suit his particular needs. The manufacturer would then prepare circuits and equipment drawings, submit them to the Post Office and obtain approval. Manufacture having been completed, the equipment would be installed and handed over to the Post Office for maintenance. This procedure was unsatisfactory to all parties.

To the manufacturer, because the differing individual requirements involved excessive engineering and draughting.

To the Post Office, because the varied types of P.A.B.X. presented ever-increasing maintenance problems.

To the customer, because long engineering time imposed delivery restrictions which he could not fully appreciate.

The British Post Office decided that standard P.A.B.X.'s should be designed, and that the task should be assigned to the British Telephone Technical Development Committee. Development of the following three types of P.A.B.X. was undertaken :—

(1) P.A.B.X. No. 1, having capacity for 10 exchange lines and 49 automatic extension lines, and employing a cordless manual switchboard.

(2) P.A.B.X. No. 2, having capacity for 10 exchange lines and 49 automatic extension lines, and employing a cord switchboard to accommodate also an additional 30 manual extension lines ;

(3) P.A.B.X. No. 3, for any requirement exceeding 10 exchange and 49 extension lines.

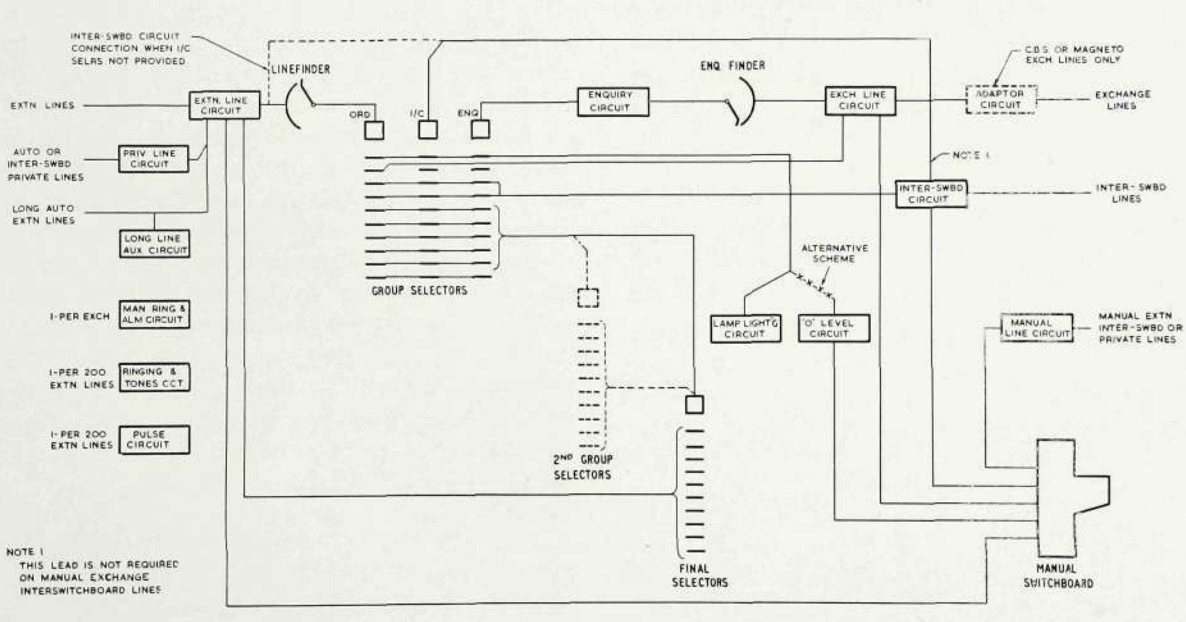


Fig. 1—Trunking Arrangements for P.A.B.X. No. 3

While the standardization of P.A.B.X. Nos. 1 and 2 was a relatively simple matter, more work was involved in standardizing P.A.B.X. No. 3. It was decided to concentrate on a system (Fig. 1) using a cord type manual board, 50-point linefinders of the uniselector type, and 100-outlet two-motion selectors. These decisions culminated in the development of standard circuits ; but, whereas complete standardization of the equipment units of P.A.B.X. Nos. 1 and 2 followed, the P.A.B.X. No. 3 apparatus layout was left to the discretion of each manufacturer, though with certain provisos, chief among which are the following :—

(1) Components shall be of established P.O. standard types. This determines, among other things, the precise layout and size of each jack-in selector and relay set.

(2) Shelves, etc. shall be of standard type. This ensures that racks are of standard widths.

(3) The number of linefinders and group selectors for each 50-line group shall be limited to a maximum of 10.

(4) The manual switchboard shall be of the type used for the P.O. No. 1A private manual branch exchange.

Another difference between P.A.B.X. No. 3 and the two smaller equipments is that the latter were to be made for sale to the Post Office, who would rent them to the public, whereas it was agreed that P.A.B.X. No. 3 should, in the main, be sold direct to the public, the Post Office being responsible for maintenance as soon as installation was completed.

Partial standardization having been thus effected, it lay with each manufacturer's designers to evolve the most advantageous and economic lay-out possible within the provisions of (1) to (4) above.

In our own case, the main objectives sought were maximum advantage to the customer and convenience of maintenance. The realization of these objectives was in turn dependent upon the fulfilment of the following conditions :—

(*a*) the equipment must be readily and economically extensible ;

(*b*) it must, in order to conserve floor space, have maximum compactness, consistent with accessibility for maintenance.

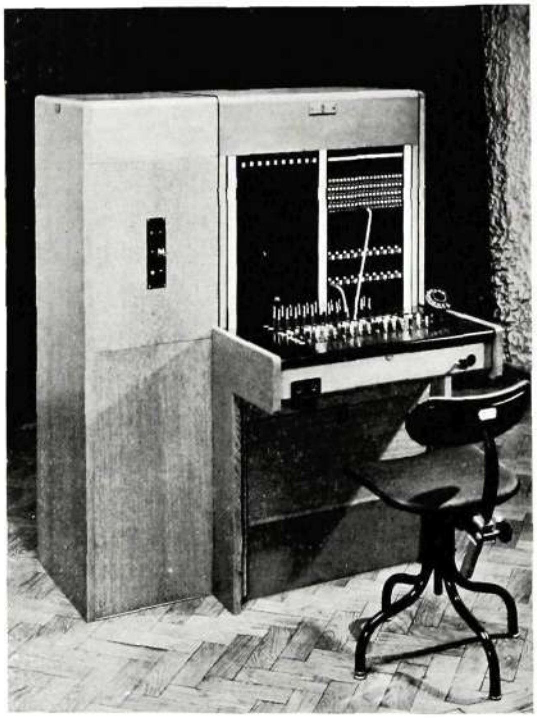


Fig. 2—Typical One-position Switchboard with Cable Turning Section

It will be shown that these conditions have been satisfied, as far as the automatic equipment is concerned.

The obligation to provide a switchboard of regulation pattern did not preclude the possibility of improving its appearance. Some improvement seemed desirable, because the orthodox standard colour combination of mahogany woodwork, black apparatus and red fibre was deemed too sombre for the modern office and not conducive to efficient operating. Brighter colour tones were therefore obtained through the use of light oak timber with green " Wareite " (plastic) facings on the keyshelf and on the spacing strips in the jack field ; the operator's chair was also finished in green and the kicking panel covered with light brown linoleum. A typical one-position board with cable turning section is shown in Fig. 2.

In the case of the automatic equipment, since the size of each relay set and selector was pre-determined, the desired compactness could only be achieved by disposing them on racks to the best advantage.

The agreed maximum provision of 10 group selectors per 50 lines prompted the use of a standard ten-selector shelf and, consequently, a rack 4′ 6″ (137.2 cm) wide.

It was essential that the line circuits, being connected to the final selector multiple, should be mounted on a rack with final selectors ; but before a layout could be devised, it was necessary to decide how many selectors would be required for any chosen size of line group.

The agreed grade of service was 1 lost call in 200 calls ; thus 10 group selectors (for a 50-line group) could carry 3.96 traffic units, and 20 selectors (representing a group of 100 lines) could carry 7.92 traffic units. The latter could be interpreted as the maximum traffic to be carried by one group of 100-outlet final selectors. For this traffic 18 final selectors would be needed. This seemed a too liberal provision, but experience has since proved it justified where considerable numbers of tie lines terminating on special incoming group selectors have added to the traffic from the ordinary group selectors. If in such cases the capacity for final selectors had been less than 18 per group, it would have been necessary either to provide auxiliary final selectors on a separate unit (thereby increasing the amount of floor space required) or to maintain the ratio of line circuits to final selectors by reducing the number of line circuits per unit ; this again would have necessitated more units and floor space.

The decision to cater for 18 final selectors having been made, it remained to decide which of the three available standard selector shelves, i.e. 5-, 7- or 10-way, could best be used. A 10-way shelf was preferred, as this was of the same width as the latest standard combined uniselector and line relay shelf. Its width was also the same as that of the group selector shelf, and the possibility of designing one unit to accommodate the line circuits, group and final selectors for 100 lines was envisaged.

The only other equipment having a direct quantitative relation to the 100-line group was ringing, tone and pulse equipment ; but, since the basis of provision for some of this was 1 per 100 lines and for the rest 1 per 200 lines, it seemed uneconomic to fit the equipment on alternative units, leaving vacant space on the others. A better solution was to mount the equipment on the relay set rack, where ringing and tone services would be needed for the exchange and inter-switchboard line relay sets.

The enquiry facility, a special feature of P.A.B.X. No. 3, necessitates the provision of a separate group selector which is multipled with the ordinary group selectors. It was decided that if the full complement of ten group selectors was not needed the enquiry selector could occupy one of the unequipped group selector positions. Failing this, the spare positions resulting from fitting 18 final selectors on two 10-way shelves could be used. This arrangement permits the provision of two enquiry selectors per 100 lines, should heavy exchange traffic require it.

The line unit, originally expected to be 8′ 6″ (304.8 cm) high, was finally made 7′ 9″ (236.2 cm) high and 4′ 6″ (137.2 cm) wide. Relay set racks of the same height but in two widths, 4′ 6″ (137.2 cm) and 2′ 9″ (83.8 cm), were designed, and the production of racks and shelves for stock was commenced. It was decided not to fit the shelves on the racks until the requirements for each particular P.A.B.X. were known ; this would make for easier storage and quicker delivery.

Facilities Provided

(a) Intercommunication between Extensions

All connections between local extensions can be completed automatically by dialling. Calling extensions are switched by a uniselector line-finder to a first group selector, which receives the first digit. Subsequent digits operate a final selector and direct the call to the required extension. A " forced release " condition, operating after a delay of 30 to 60 seconds if dialled pulses are not received, is provided on the group selector, so that line faults do not degrade the service.

The progress of calls is indicated by tones in the following manner :—

(i) Dial tone at a frequency of 20 cycles per second is returned to the caller when the handset is lifted.

(ii) When a free extension number is dialled, ringing tone, pulsed 0.4 seconds on/0.4 seconds off/0.4 seconds on, at 2 seconds intervals, is returned to the caller.

(iii) When a spare digit or unalloted extension is dialled, number unobtainable tone at a frequency of 400 cycles per second is returned to the caller.

(iv) Engaged outlets or spare extension numbers are arranged to extend engaged tone at a frequency of 400 cycles per second, interrupted for 0.8 seconds at 0.8 second intervals, to the calling extension.

(v) Ringing current at a frequency of 20 cycles per second, pulsed similarly to ringing tone, is applied to the bell of a called extension.

Special provision is made for 5 specified extensions in each group of 50 to be used as manual extensions with or without access from the final selector levels.

Extension-to-extension calls are normally released by the first party to replace the receiver, but it can be arranged that only the originating caller controls the release of the call.

(b) Exchange Line Calls

The exchange line circuit permits bothway working to the main exchange, with joint access on the outgoing side from both the manual switchboard and the selector level 9. Through dialling from an extension to the main exchange is possible on calls set up via the manual board, and, on these calls, through clearing and follow-on call trap facilities are provided. Disconnect clearing is given on outgoing calls, and the circuit is arranged to maintain the P.A.B.X. equipment in the engaged condition until the main exchange connection has released.

Incoming calls from the main exchange to the P.A.B.X. light a calling lamp on the manual board, calls then being routed by the operator. On multi-position switchboards the calling lamps can be repeated as required over the several positions.

(c) Calls via Inter-switchboard Lines

Several different circuits are available to provide communication with various types of distant switchboards on a manual-to-manual, auto-to-manual or auto-to-auto basis. A discriminating facility can be used when appropriate to prevent inter-switchboard lines from being connected to exchange lines, and free line signals can be given on lines with joint manual access. The enquiry facility is not provided on inter-switchboard tielines.

(d) Extension to Manual Board Calls

Extensions or incoming tie lines are given access to the manual switchboard when " O " is dialled. The method of operation can be either of the following :—

(i) *Lamp per Line Working*

This is the normal provision up to a maximum of 800 lines. Each extension and dialling-in inter-switchboard line jack on the switchboard has an associated lamp which glows when " O " is dialled on the particular line.

(ii) *" O " Level Working*

In this arrangement, made essential by limitations of the multiple when 800 lines are exceeded, " O " level calls are directed to special relay sets, each of which has an associated jack and calling lamp on the manual switchboard.

(e) Enquiry Circuit

An extension engaged on an exchange line call can, by pressing a button on the instrument, dial any other extension over the enquiry circuit. During the enquiry, the exchange line is held and isolated. The extension can re-establish connection with the exchange line by again pressing the instrument button.

Should all enquiry circuits be engaged, operator re-call conditions are automatically set up, assistance being thus made available.

(f) Operator Recall

An extension engaged on a call via the manual board can re-call the operator by pressing a button on the extension instrument. When the call is connected to an exchange line, the button must be pressed twice to set up the operator re-call flash. If the call is by direct access from selector levels, the exchange line calling lamp flashes, instead of the supervisory lamp.

(g) Transfer of Exchange Line Calls

Transfer of these calls can only be effected by recalling the operator by a double operation of the instrument button. Verbal instructions for re-routing the call can then be given.

(*h*) *Night Service*

The manual switchboard can be fitted with additional jacks which enable selected extensions to be left connected to exchange lines by means of cords after normal business hours.

Alternatively a night service switchboard, intended for operation by a night watchman or similar person, can be provided. The switchboard has 4 connecting circuits and is used in conjunction with a key on the main switchboard. This key is operated after normal hours to divert four exchange lines and four " O " level circuits to the night switchboard, so that calls over these circuits can be connected by the night operator.

(*j*) *Switching*

The linefinders connecting the group selectors to calling extensions are non-homing type uniselectors. Each linefinder is permanently wired to a particular 100-outlet group selector, the circuit of which is of orthodox type.

A special start circuit determines the sequence in which the selectors are taken into use, and the same circuit initiates the hunting of the linefinder. If the calling line is not found within two seconds, the start condition is transferred to a subsequent group selector and linefinder.

Normal post springs, operating on level 9, are fitted to provide for the return of number unobtainable tone to any barred extension attempting to make a direct call to the main exchange.

The standard final selector has 100 outlets ; its circuit is conventional but includes an arrangement for changing the normal connections for " first party release " to " calling party release " by a simple wiring modification on the shelf jack.

Should group hunting final selectors be required, they can be fitted in place of the normal type without modification to the mounting arrangements.

(*k*) *Ringing and Tone Generation*

Tones and ringing current are generated in relay sets which incorporate vibrating relays working in conjunction with suitable inductors and transformers. The circuit does not operate continuously ; it is brought into use by a start signal. An alarm, extended to the manual switchboard, is given if the ringing current fails. A relay set associated with the ringing and tones relay set, and accommodating interacting relays and a uniselector, supplies the necessary pulses.

Continuous ringing current for the manual switchboard is generated separately in a special relay set which also houses the alarm equipment. Routine test facilities are provided on the ringing, tone and pulse circuits, and all feeds are wired via connection strips at the rear of the shelf for ease of identification and distribution of the various services.

(1) *Numbering Scheme*

For exchanges of 500 lines, or less, a 3-digit numbering scheme is used. If more than 500 lines are required, second selectors are introduced and a 4-digit numbering scheme is adopted. The allocation of first selector levels is as follows :—

Level 1	Spare
Levels 2 to 8	Extension and inter-switchboard lines via second selectors if necessary.
Level 9	Access to main exchange
Level 0	P.A.B.X. operator (assistance calls).

EQUIPMENT

The major items of equipment are the main distribution frame, line unit, group selector unit when required, relay set rack, manual switchboard and power plant.

The British Post Office supplies the power plant for exchanges under its jurisdiction.

The main frame accommodates line fuses, protectors incorporating electrodes, heat coils and test springs, and I.D.F. type connection strips if necessary ; I.D.F. facilities are, however, rarely warranted, because the inter-unit connections are quite flexible, furthermore, facilities for any jumpering likely to be needed are provided on the units. For the smaller exchanges a single-sided wall type M.D.F. usually suffices. Otherwise the double-sided type is used. In either case the frame is of standard construction.

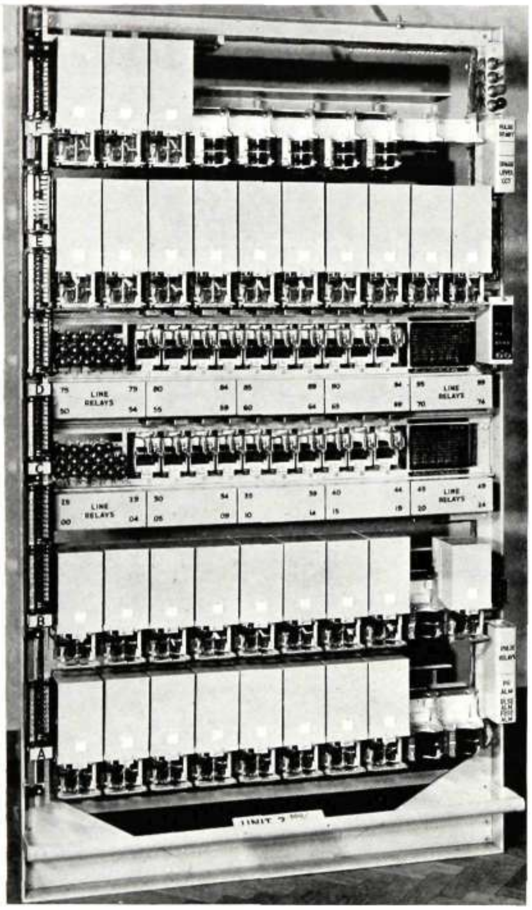


Fig. 3—Typical 100-Line Auto Unit

A front view of a typical partially equipped line unit is shown in Fig. 3. That the fullest possible use is made of the available space without sacrifice of neatness and accessibility for maintenance is made clear in Fig. 4, which is a rear view of line units with cables in position.

The two lower shelves are occupied by the jack-in type group selectors. Above these are two shelves, each carrying line relays and linefinders for 50 lines. The uppermost shelves accommodate final selectors. In Fig. 3 an enquiry selector is in the tenth position on shelf B, but when the full complement of group selectors is required the enquiry selectors are mounted at the end of the top shelf.

Units which are partially equipped are fully wired, to simplify the installation of additional equipment. Grading facilities are provided at the rear of the group selector shelves, and the bank outlets are connected to the succeeding rank of selectors by jumpers which can be easily re-routed whenever required. Inter-unit tie cables are run horizontally across the adjoining uprights of the respective units.

Second group selectors, when required, are not associated with any particular line group and may therefore conveniently be separate from the line unit. The group selector rack is of standard construction and of the same dimensions as the line unit. It will accommodate six shelves of ten selectors, which may comprise incoming first selectors, second selectors or enquiry selectors, according to requirements.

In Fig. 5 are shown two relay set racks, each 33″ (83.8 cm) wide, equipped with jack-in relay sets for exchange line, inter-switchboard line, long line, lamp

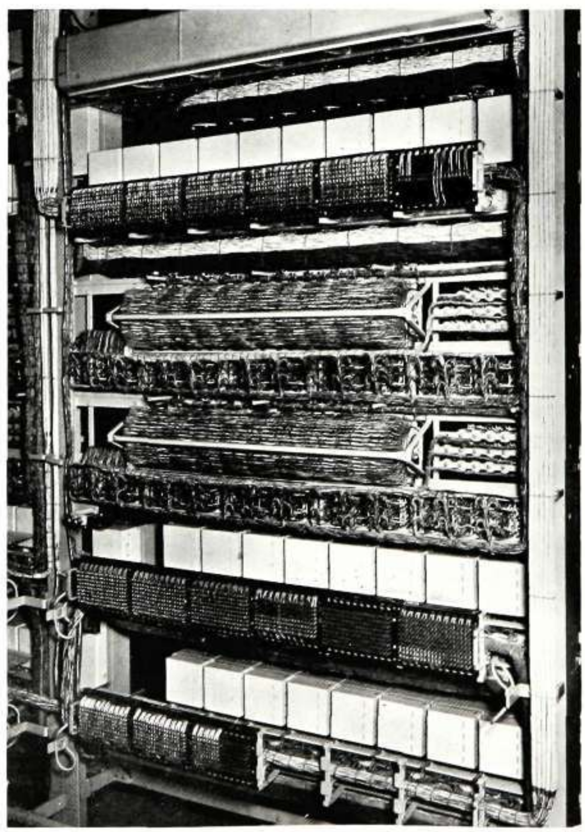


Fig. 4—Rear View of Auto Unit with Cables in Position

lighting and miscellaneous circuits. The particular requirements for each exchange determine the number and type of circuits to be accommodated, and, consequently, the type of rack —wide or narrow— supplied.

The manual switchboard section (Fig. 2) has two panels and is approximately 56″ (142.2 cm) high, 26″ (66 cm) wide and $3\frac{1}{4}$″ (8.25 cm) deep. When multipling is necessary, 4-panel repetition is usually arranged, any 30° angle sections in the suite having a single multiple panel.

All extensions have a combined call and answer jack ; when lamp-per-line working is adopted, the calling lamp can have only one appearance, but "O" level, exchange and inter-switchboard lines may have ancillary 6-volt lamp appearances. Provision is made for free line signalling when desired on exchange and inter-switchboard circuits.

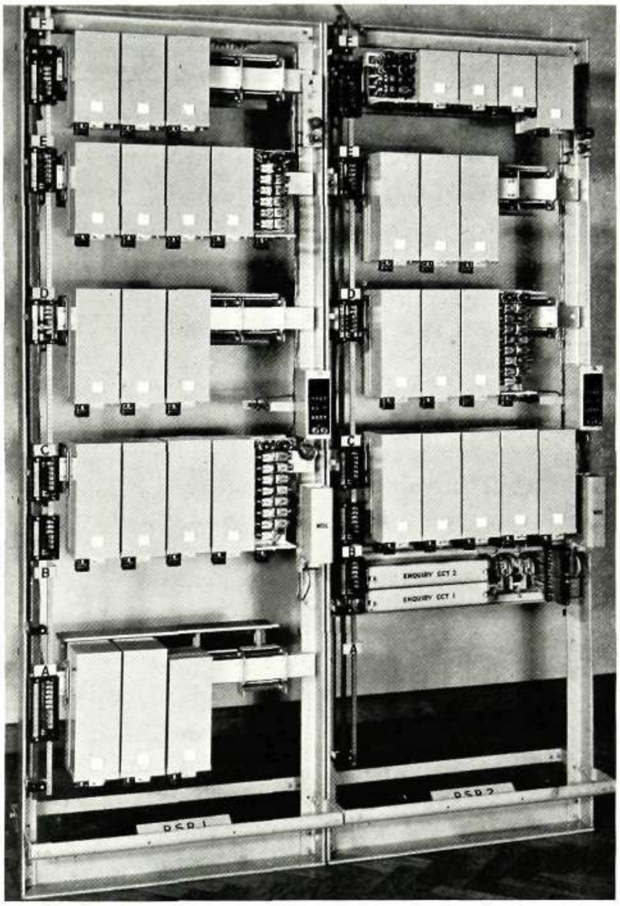


Fig. 5—Typical Relay Set Racks

It has been stated that the sections are similar to those of P.M.B.X. No. 1A, but there is this slight difference, that the P.A.B.X. No. 3 section has capacity for 15 cord circuits.

The Company's choice of the self-contained line unit design for P.A.B.X. No. 3 was based on the recognition of the definite quantitative relationship between the line relay groups, the line finders, group selectors and final selectors. The adoption of this design has effected economies in floor space, in the amount of cable required and, therefore, in the volume of installation work, while the relatively small size of the units facilitates handling and transport.

V.F. SIGNALLING SYSTEM

TYPE PC5

The PC5 system has been designed to provide, by means of pulsed signals, all the facilities for rural automatic type exchanges.

It is a compound 2 VF system employing frequencies recommended by the C.C.I.F. and is capable of operation over radio links, carrier channels or physical circuits. Not only will it meet the most stringent short haul requirements, but it can readily be adapted to operator or subscriber dialling for national networks.

In this article, a general description of the system is given, together with an outline of some of the design problems inherent in the provision of a manual hold feature over pulsed v.f. links. The associated electronic equipment will be fully described in a subsequent article.

FOR any particular application, the choice between a separate channel voice frequency system and one which signals over the speech path is rarely difficult to make. Separate channel working requires some bandwidth to be used entirely for signalling, but yields, in return, considerable maintenance advantages if operating facilities are limited. Furthermore, initial cost is often lower. But in large multi-channel carrier systems the greater signalling energy which must be transmitted may tend to overload line amplifiers, whilst in the case of some two-wire systems the cost may rise to prohibitive heights. The provision of completely separate filtered " go " and " return " signalling channels can often be expensive when a reduction in speech bandwidth is not permissible, and, in any case, modification of existing transmission equipment is frequently impracticable.

Systems which signal on the speech path can, on the other hand, be made to operate over almost any circuit where speech is possible. This inherent virtue of speech path v.f. systems has been fully retained in the PC5 system. If advantage is taken of signal characteristics in any part of a four-wire transmission path, one major advantage over separate channel systems is lost. Both then require hybrids to be located at the exchange, or necessitate the use of additional wires for control purposes over the two-wire tail, extending for perhaps a considerable distance.

PC5 signalling equipment is therefore arranged for connection to the two-wire line at the exchange. Large administrations often regard this as an advantage, since one group of engineers can be made responsible for signalling and another group for transmission.

SIGNALLING FREQUENCIES

In the design of a complete system, many factors of v.f. signalling must be considered jointly. For instance, the choice between signalling frequencies, signalling codes and end-to-end or link-by-link operation is not only inter-dependent, but dependent also on transmission characteristics and traffic facilities. No simple criterion can be applied to any one aspect independently.

Problems of voice immunity arise in receivers which are capable of only a compromise solution. A very narrow bandwidth is ideal for voice immunity but not for good pulsing performance. Sensitivity requirements also conflict. Other things being equal, the more sensitive a receiver is made to signals, the more prone it will be to blocking by noise.

It is well known that one solution to the blocking problem is to interrupt continuous " noise ", such as NU tone, in order to check for the existence of a true v.f. signal. Such " chopping " must be at a sufficiently slow rate to avoid confusion with interrupted tones, and may entail a delay of up to five seconds in the clearing of unanswered calls. Furthermore, any chopping whatsoever is usually intolerable on a subscriber dialling network, and, when subscribers dial a code to reach an assistance operator, the need arises for the " forward clear " and " reseize " signals to give supervision. Clearly, such a slow signalling speed would render efficient flashing impossible. The receiver for the PC5 system had to be designed to respond in the presence of noise at high levels, and receiver guard circuits could not be made any more sensitive than was essential for good pulsing and the prevention of voice operation. In other words, the problem was one of designing a receiver with the lowest possible guard coefficient.

Recent investigations into the question of voice immunity with respect to signal frequency lead to two important conclusions : first, that frequencies above 2000 cycles show a marked increase in immunity ; and secondly, that a compound signal (i.e. consisting of two frequencies transmitted together) is about one hundred times less liable to voice imitation than a simple signal. By making full use of these factors, guard circuit sensitivity may be reduced to a lower level than is possible for simple signals without prejudice to a satisfactory degree of voice immunity. The use of two different frequencies is also an advantage in the formulation of the signal code, since it permits both frequency and time discrimination to be used to identify different signals. Thus, higher signalling speeds can be attained than are possible on a 1 v.f. system. Voice immunity characteristics of the simple signal can be rendered relatively unimportant by suitable circuit arrangements.

The frequencies recommended by the C.C.I.F. for 2 v.f. working, 2040 and 2400 cycles, have therefore been adopted.

Link-by-Link Operation

When calls are established over v.f. links in tandem, two distinct modes of operation may be employed. In one method, v.f. signals can be allowed to pass from end to end along the route ; in the other, known as link-by-link signalling, v.f. signals are intercepted, converted to d.c., and regenerated at each tandem switching stage.

V.F. receivers in a link-by-link system always operate in conjunction with similar receivers at the distant end of the same circuit, but in end-to-end systems a receiver may be called upon to respond to signals generated several links distant. This necessitates either a higher performance receiver or a better transmission path, since signals received are attenuated by the algebraic sum of the loss or gain in each link forming the connection. Noise levels, and possibly frequency drift, in carrier systems add to the difficulties which often make end-to-end signalling impracticable over more than four links. High signal frequencies do not always help, since they tend to be more prone to attenuation and crosstalk than lower frequencies. Sensitive receivers can also be adversely affected by echoes from hybrid transformers along the route, so that, apart from losses in transmission bridges, the limit of end-to-end signalling is determined by the characteristics of the transmission path.

Link-by-link signalling principles have been used for the PC5 system, since receiver operating conditions are less onerous and allow line plant greater tolerance.

Signalling speed is of course slower on tandem connections than in end-to-end working, but since fast flashing signals are temporarily stored and transmitted out of phase on different links, signalling speed is adequate.

Choice of Signal Code

Owing to the exceptionally severe signalling requirements, due to the provision of a manual hold feature, the release of the outgoing circuit is necessarily dependent on d.c. conditions encountered by the incoming relay set. But in two-wire pulsed v.f. signalling practice it is not usual for release to be entirely dependent on signals received from the far end of a line. Pulses may be lost through temporarily degraded transmission or blocking by noise and speech. Furthermore, signals may be transmitted simultaneously or nearly simultaneously from both ends, with the result that part of a signal code may be lost. The remainder, if it registers at all, may then indicate some condition entirely different from that intended.

" Forward Clear " and " Backward Clear " are two signals which can be expected to collide frequently, " Ring Forward " and " Answer " less often. Normally, for forward clearing, a long signal is employed, so that, in the event of a collision, sufficient pulse length remains for recognition, even after clipping by the shorter answer signal. This practice usually entails the use of a pulse of more than one second duration ; the principle of over-riding signalling cannot therefore be applied when flashing facilities are necessary.

Nevertheless, owing to the energy which would be transmitted were a number of circuits on a large multi-channel carrier system transmitting simultaneously, continuous tones or a continuous series of pulses can only be allowed for infrequently used signals of short duration. Since any signal may occasionally be blocked by speech or noise, the only solution is to transmit a series of pulses until an "acknowledge" signal is received from the distant end.

The acknowledge signal introduces further complications. Like all other signals, it must be voice immune ; but when the two ends of a circuit send simultaneously, no portion of a signal code must be capable of being clipped into such a form that it can be accepted as an acknowledgment. For instance, if a portion of a forward clear signal were clipped by a backward clear, a badly conceived signal code might allow the incoming relay set to accept the remainder of the forward clear as an acknowledge signal. Since the outgoing relay set would not have received an acknowledge, a further forward clear would be transmitted. This time the acknowledge would be sent, and signals over the line would cease. Nevertheless, the outgoing relay set would not have received the backward clear, so, on a manual hold system a lock-up would result. A similar sequence of events can readily be constructed for other collision conditions.

A further difficulty concerns the simultaneous seizure of bothway circuits. With short d.c. junctions the unguarded period is little more than relay operate times, but, particularly on long physical v.f. circuits, propogation time may be considerable. Then it is clearly impossible to avoid simultaneous seizure, and it is necessary to ensure that both callers can release themselves independently in spite of the provision of manual holding facilities. This is done by arranging that seizure signals from both ordinary and coin box subscribers, dial pulses and forward clear signals, either complete or clipped by nearly simultaneous signalling from both parties, can under no circumstances register as an answer signal. Whilst from the point of view of relay set design it is advantageous to use the minimum number of signal codes, answer and forward clear signals must obviously be different.

Similarly, the use of the same signal for answer and backward clear is often attractive. If each accepted signal is arranged to operate a relay group analogous to a two-to-one reduction gear, the 1st, 3rd, 5th etc. signals actually received indicate answer signals, and the 2nd, 4th, 6th, etc. signals indicate backward clears. Over noisy transmission lines or long radio paths subject to fading, it is possible for the operative signal to register, but for the acknowledgment to fail. Further operative signals are then transmitted until eventually an acknowledgment is received. Then it is an even chance that the two ends of the circuit will be out of step, in which case a lock-up will again result on a manual holding system.

It has been necessary to consider these problems in some detail, since in most systems occasional failures cause only inconvenience, whereas in the PC5 system they have had to be eliminated, to prevent equipment from being locked up.

Earlier it has been shown that a compound signal is preferable for reasons of voice immunity and may be used to " split " the line from extraneous noise on the two local ends. The initial compound signal or prefix can however serve a dual purpose. If a compound prefix is used for splitting at the beginning of each signal code and at no other time, a second very important advantage accrues. The prefix is easily identifiable by the incoming relay set and acts as a synchronizing pulse by reference to which the following simple pulses can be timed or counted for decoding purposes. In this way the majority of difficulties due to signal collisions on simple v.f. systems are overcome.

Even from this point, however, the technique of signalling may be developed in two different ways. Firstly, the signalling code can be in binary form, each signal consisting of the same number of elements to correspond to mark or space conditions as in telegraph practice, with recognition achieved mainly by counting in the incoming relay set. Spacing signal elements can be included in the transmitted code, so that the need for critically timed receiving relays is avoided. With register switching schemes it is often economic to transmit digital information in binary form as well, since this can effect a saving in transmission time. Secondly, timed pulses and timed relays can be used in the simplest possible recognizable code.

The send and receive relay groups for the PC5 system can be arranged for either mode of operation, but subsequent description is concerned mainly with the non-binary or " A " scheme, which requires less equipment than the other. Although it uses fewer signal elements it is not necessarily faster, as due allowance must be made for safety factors on relays.

THE CODE OF SIGNALS

The PC5A signalling code is illustrated by Fig. 1, in which arrows represent the direction of transmission, and tone blocks should in both cases be considered to move in the same direction.

Seizure by " ordinary " subscribers causes the transmission of a single X frequency pulse of 40 milliseconds duration. On calls from a coin collecting box to the operator, the X pulse is immediately followed by a 100 milliseconds pulse of Y frequency. The signalling time of 40 or 140 milliseconds is of no consequence on assistance calls,

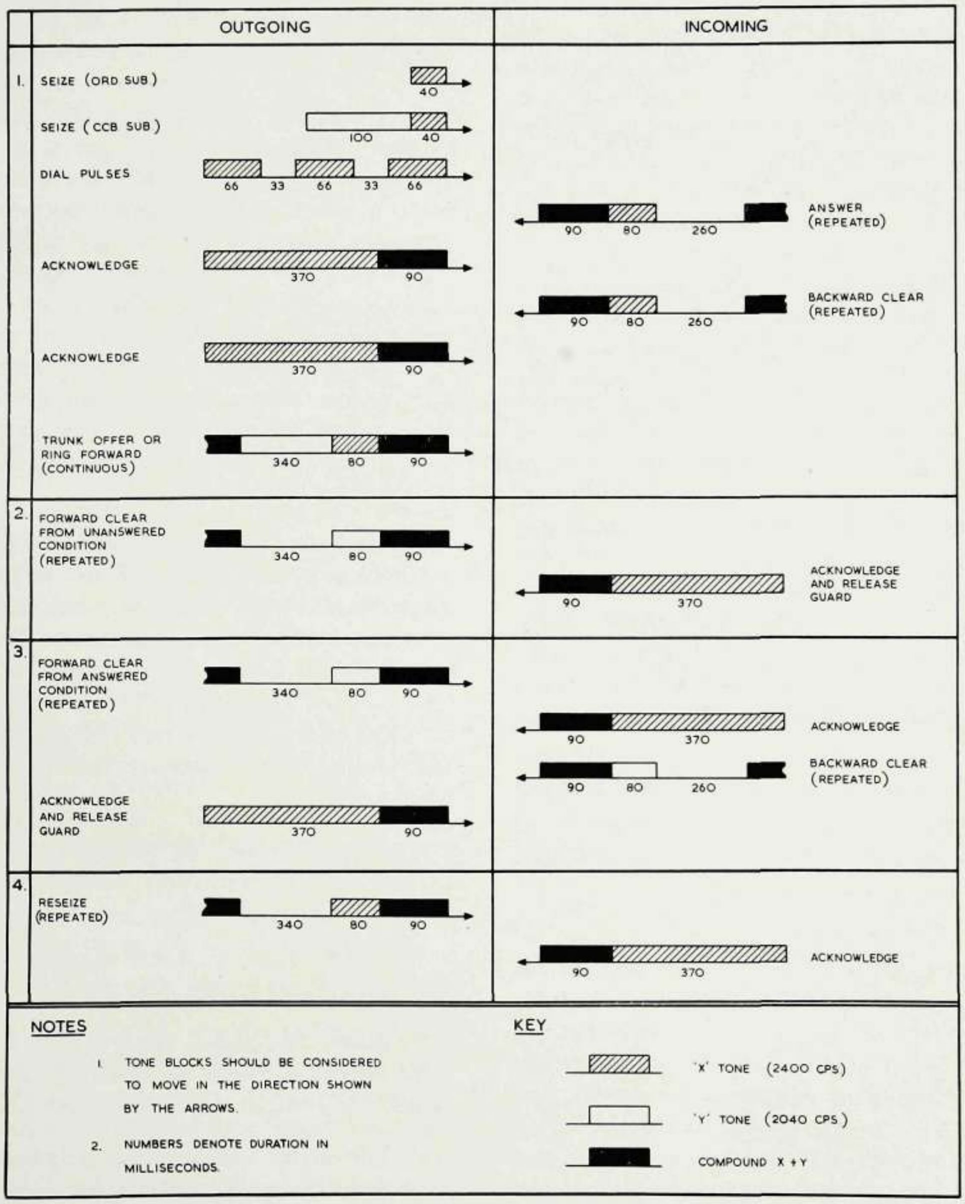


Fig. 1—The PC5A Signalling Code

as no further digits can be accepted from a subscriber. Where there is tandem routing to a parent exchange operator, an additional routing digit, usually " O ", is generated by the outgoing relay set. Seizure time to automatic equipment may be only 40 milliseconds more than that required for a conventional d.c. circuit, since the loop to incoming selectors can be completed on the leading edge of the X pulse. Impulse trains generate pulses of X frequency which correspond to the dial break periods.

The answer signal is the first example of the use of a compound prefix. The prefix, of 90 milliseconds duration, serves both to split the transmission path at the outgoing end and as a synchronizing signal, so that the outgoing relay set starts to time the following simple X or Y signals from the trailing edge of the compound pulse. Any backward X or Y signals which precede the compound are ignored. Every signal used from this point throughout the progress of the call comprises a minimum of two elements, a prefix requiring a minimum duration of 30 milliseconds before recognition, and the following simple suffix, requiring a minimum of 20 milliseconds.

Thus, in the case of the answer signal, the 80-millisecond X element registers in the O/G relay set and prepares it for transmission of an acknowledge signal. This consists of a compound prefix followed by 370 milliseconds of X signal. Meanwhile, the signal recognition time for an X signal in the incoming relay set is increased to 160 milliseconds. This ensures that a short X pulse, such as occurs in the trunk offer signal, cannot acknowledge in the event of a collision.

Backward clear results in a similar signalling sequence, except that the operative signal is 80 milliseconds of Y tone instead of X. Both signals are repeated until acknowledged.

Ring forward or trunk offering consists of an uninterrupted sequence of compound, 80-millisecond X and approximately 340 milliseconds of Y tone, continued as long as the " Ring " key is operated, or unbalanced conditions persist in the O/G relay set. When ring forward conditions are removed, the signalling sequence can only be disconnected during transmission of the simple Y. In the case of sleeve control relay sets, separate relays are used to prepare dialling conditions and to ring forward, thus ensuring that a second inadvertent operation of a position dial key will not cause unnecessary line signals.

In applications to sleeve control or, in fact, any type of switchboard, provision is made for operators to listen for tones between impulse trains. Dial tone or verbal announcements indicating the progress of a call through tandem switching stages can be applied to incoming selectors if required.

It will be seen that the forward clear signal is the same as the backward clear. When the circuit is in the unanswered condition, the acknowledge in reply to a forward clear signal serves as the release guard, release occurring on the trailing edge of the X element. A further arbitrary guard of 400 milliseconds is provided for the outgoing section of both-way relay sets, to allow for propagation time and small variations in relay release times. From the time the compound prefix of the forward clear is recognized by the incoming relay set, the audio path is protected from extraneous noises in both two-wire ends, so that the chances of the operative signal registering and the acknowledge failing are very remote indeed. Nevertheless, provision is made for the return of an acknowledge signal, even if the incoming end has been released by a previous pulse.

Forward clear from the answered condition produces the same initial forward signal, and an acknowledge is returned ; but, since relays in both relay sets are operated to mark the fact that the call has been answered, this does not produce release conditions immediately. However, it does open the loop to the incoming selector for forward supervisory purposes, and offers a high resistance earthed relay, MH, to the positive wire.

When manual hold conditions do not exist, relay MH is de-energized and a backward clear is transmitted.

The release sequence is then a replica of Sect. 2 of Fig. 1, but in the reverse direction.

Similarly, the re-seize signal and its acknowledgment operate in much the same way as the answer signal, but again in the opposite direction.

Re-seize signals can, however, only be transmitted from the outgoing relay set when it is marked in the answered state.

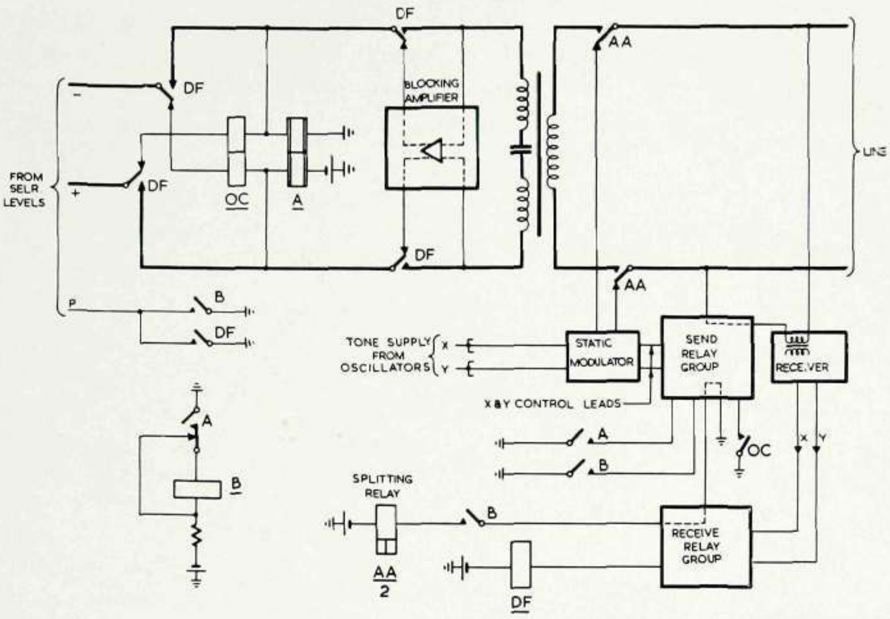


Fig. 2—O/G Relay Set, Simplified Schematic

Outgoing Circuit Principles

Relay sets for bothway or unidirectional traffic over auto-to-auto and auto-to-manual links all operate in a similar manner. A simplified schematic diagram for a relay set outgoing from selector levels is shown in Fig. 2. It includes provision for trunk offering and manual hold facilities, but these can readily be omitted when not required.

When the circuit of Fig. 2 is seized by a selector, relay A operates to the loop and energizes B, a contact of the latter earthing the private to hold preceding equipment. One further contact of relay A extends earth to the "send" relay group, causing a control pulse to be forwarded to the static modulator, which in turn transmits a seizure v.f. pulse to line, in order to prepare the distant incoming relay set for the reception of dialled impulses.

When the seizure signal has been transmitted, relay AA is allowed to operate, and the caller may then listen for dial tone or any other supervisory tones which may be returned. Such tones are heard via, and are amplified by, a blocking amplifier. Similar amplifiers are used in all O/G relay sets and have several functions to perform. Firstly, they prevent the forward transmission of voice frequencies which might cause false operation of receivers ; secondly, they isolate the transmission equipment from 50 volt surges during dialling ; and thirdly, they prevent " spill-over " on v.f.-to-v.f. tandem links during the establishment of a call. Spill-over would otherwise result, due to the initial v.f. pulse of a dial train operating the receiver of a subsequent link before the d.c. break pulse had had sufficient time to release relay AA at the receiving end of the previous link.

An alternative solution to spill-over difficulties is to employ rapid splitting arrangements so that on the leading edge of a v.f. pulse the subsequent transmission path is disconnected before a break pulse can be registered. Such rapid splitting devices inevitably introduce some pulsing difficulties, and must be rendered slower to operate for normal conversation, by means of the answer signal. Excessive clipping of speech would otherwise occur, though some mutilation can be tolerated on calls to non-metering services, which do not, of course, return an answer signal. With a blocking amplifier it is necessary to rely on the answer signal to remove the amplifier before bothway speech is possible. However, this causes surprisingly little inconvenience in practice when appropriate operating procedures are adopted. Furthermore, only an amplifier can neutralize the loss

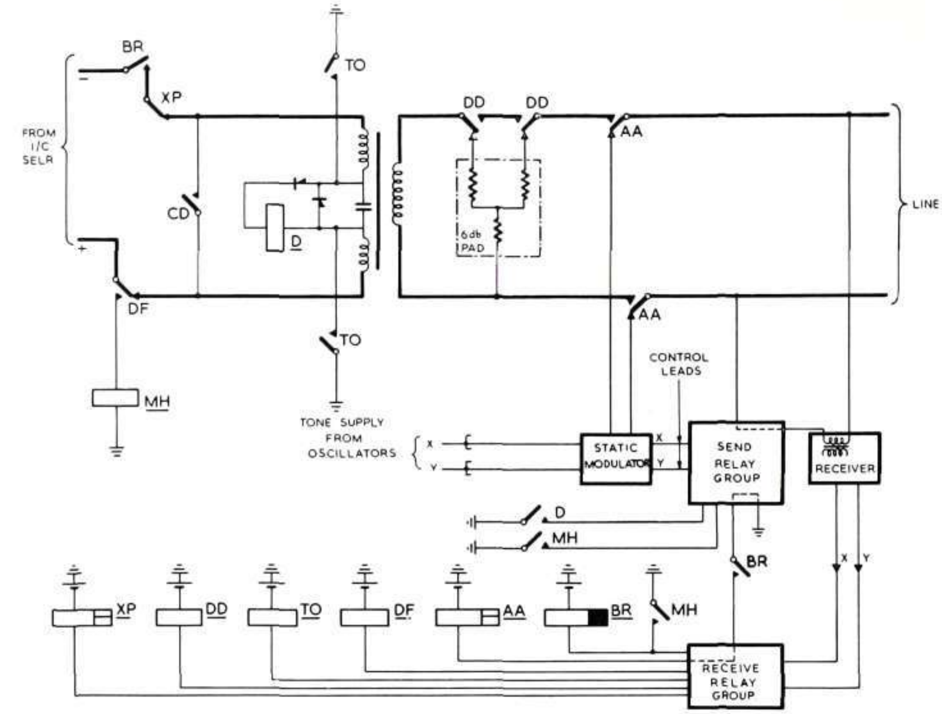


Fig. 3—I/C Relay Set, Simplified Schematic

caused by pads, which are necessary in the incoming relay set, and thus maintain a normal level for supervisory tones.

When relay A responds to dialled impulses, further v.f. signals are transmitted to line via the send relay group and the static modulator.

Relay OC, being differential, operates only to unbalanced conditions on the incoming –ve and +ve lines. The OC contact causes transmission of a pulse code to provide the trunk offering or ring forward signal.

A pulse code, representing the answer signal, actuates relays in the receive relay group and effects operation of relay DF. This relay reverses incoming line potentials and, except in the case of transit switching, earths the private to provide holding conditions on all calls.

When calls are not subjected to manual hold, the forward clear signal, initiated on the release of relay B, causes a backward clear to be returned if answered conditions existed previously. The backward clear signal is then the one which allows release to take place.

Splitting relay, AA, is controlled by both " send " and " receive " relay groups, so that the speech path is completely disconnected when signals are being sent. During receiving the speech path is also disconnected after the initial signal recognition time of 30 milliseconds.

Incoming Circuit Principles

These are illustrated by Fig. 3, which again shows a termination to automatic equipment. The arrangement has many similarities to that of the O/G relay set ; indeed, on bothway circuits many of the same components are used.

On receipt of the initial seize signal, relay BR is operated to pick up the incoming selector. Subsequent dial pulses actuate relay XP, whilst CD provides the usual non-inductive pulsing loop. On tandem calls between incoming and outgoing v.f. circuit groups, the d.c. pulsing paths are of low and uniform resistance. When pulsing relays are designed for optimum performance on tandem calls, more links may be set up without dial pulse regeneration than is possible for normal d.c. junction working.

Forward holding is applied to subsequent d.c. links of the loop/disconnect/reversal type, and is the normal method of holding for v.f.-to-v.f. transit calls. In this way, release of one link is only dependent on succeeding links in the case of manual holding routes where the calling party clears first.

Trunk offering signals are recognized by the receive relay group and operate relay TO, which extends earthed conditions forward to the incoming selector to operate subsequent differential OC relays. At this stage there are inserted between the receiver and incoming selector a 6 db pad and noise limiter. These protect the receiver from surges in the d.c. circuit and provide 6 db discrimination between line signals and supervisory tones at the receiver. When the called subscriber answers, relay D operates to the battery reversal, and the answer signal code is transmitted to line via the send relay group. The subsequent acknowledge signal operates relay DD via the receive relay group and short circuits the pad. At the same time, the blocking amplifier is removed in the O/G relay set to provide a normal speech level.

Relay DF operates on receipt of the forward clear signal code, disconnects the d.c. loop for supervisory purposes and applies test relay, MH, to the positive line. Under manual hold conditions, MH operates, holds BR relay and prevents transmission of a backward clear signal.

Relay AA is controlled by the send and receive relay groups in exactly the same manner as that described for the O/G relay set.

Signal Reception

Probably one of the most interesting circuit elements is that concerned with signal recognition

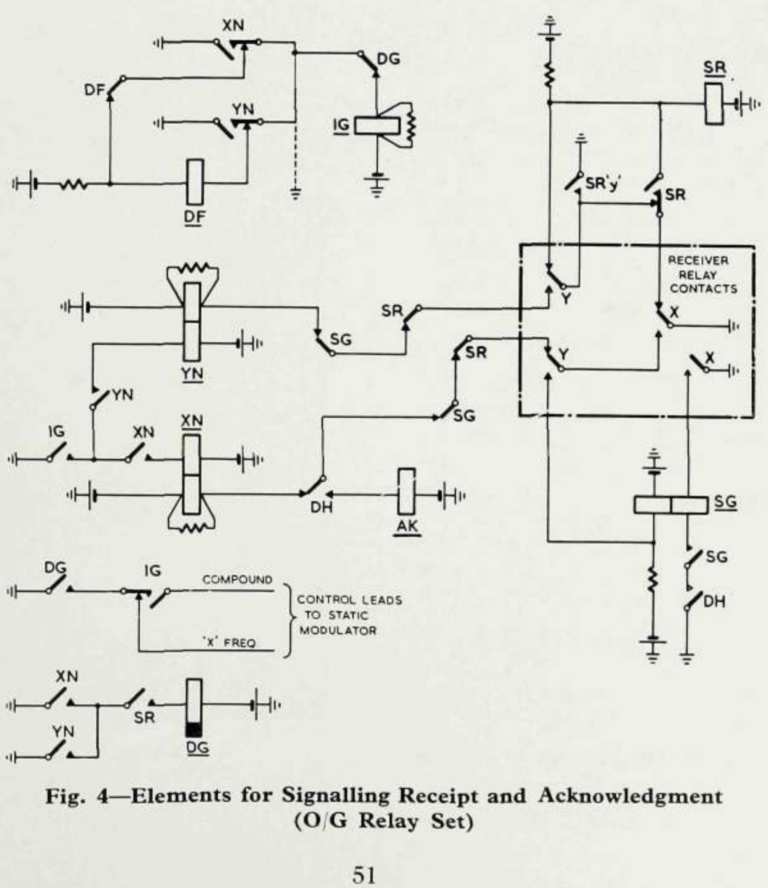


Fig. 4—Elements for Signalling Receipt and Acknowledgment (O/G Relay Set)

and acknowledgment ; a brief description of Fig. 4 follows.

Relay SR is normally operated, releases about 30 milliseconds after relays X and Y have both operated, and remains released until X and Y have both restored. When the circuit is seized, relay IG operates to the main holding earth.

Thus, when an answer signal is received, the compound prefix releases SR and operates relay SG. Receiver relay, Y, releases on the following simple X signal and disconnects the circuit of relay SG, which has a release lag of 20 milliseconds minimum to provide a guard period before any simple signal can register. XN relay operates when X is operated and both SG and SR are normal. It locks on a second winding and disconnects the short circuit on relay DF, which operates. The transmission of the acknowledge signal commences when the incoming signal is disconnected, but may be delayed if necessary to cover short echo suppressor hang-over times. Relay X then releases, reoperating SR, which in turn operates relay DG. DG starts the release of IG and, via the static modulator, transmits a compound pulse to line, the pulse length being determined by the release lag of IG. When IG has released, X tone is transmitted during the release lags of relays XN and DG, a minimum of 300 milliseconds.

A backward clear signal functions in a similar manner, but operates relay YN and releases relay DF. Should the relay set be itself expecting an " acknowledge ", relay DH, of which only two contacts are shown, is operated. The release lag of relay SG on an X pulse is increased by virtue of a short-circuited second winding, and the acknowledge relay, AK, is applied in lieu of relay XN to the X signal lead.

The illustration, Fig. 5, shows a small " Rurax " exchange wired for 20 lines with bothway junction facilities for combined " 9 " and " 0 " services over a radio link. Covers are removed from the PC5 equipment, which in this instance is mounted on Rurax type jack-in relay sets and operates in conjunction with standard multi-metering relay sets.

Equipment for the parent terminal can be seen in greater detail in Fig. 6. The twin relays of the central relay set are merely convenient space saving items, and may be replaced by the more conventional type if desired. At the top of the illustration is shown the receiver, which, incidentally, operates on 50-volt h.t. supplies ; the lower mounting plate contains common X and Y mains-driven oscillators and a 6.3 volts transformer for normal receiver filament supplies.

PC5 electronic equipment will be the subject of a future article.

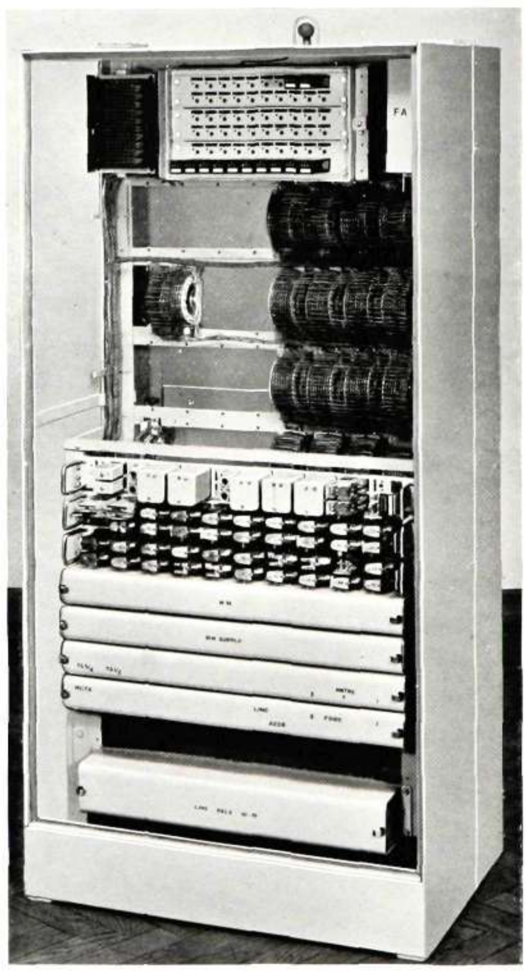


Fig. 5—" Rurax " type Exchange Equipment Unit accommodating PC5 Equipment (shown with covers off)

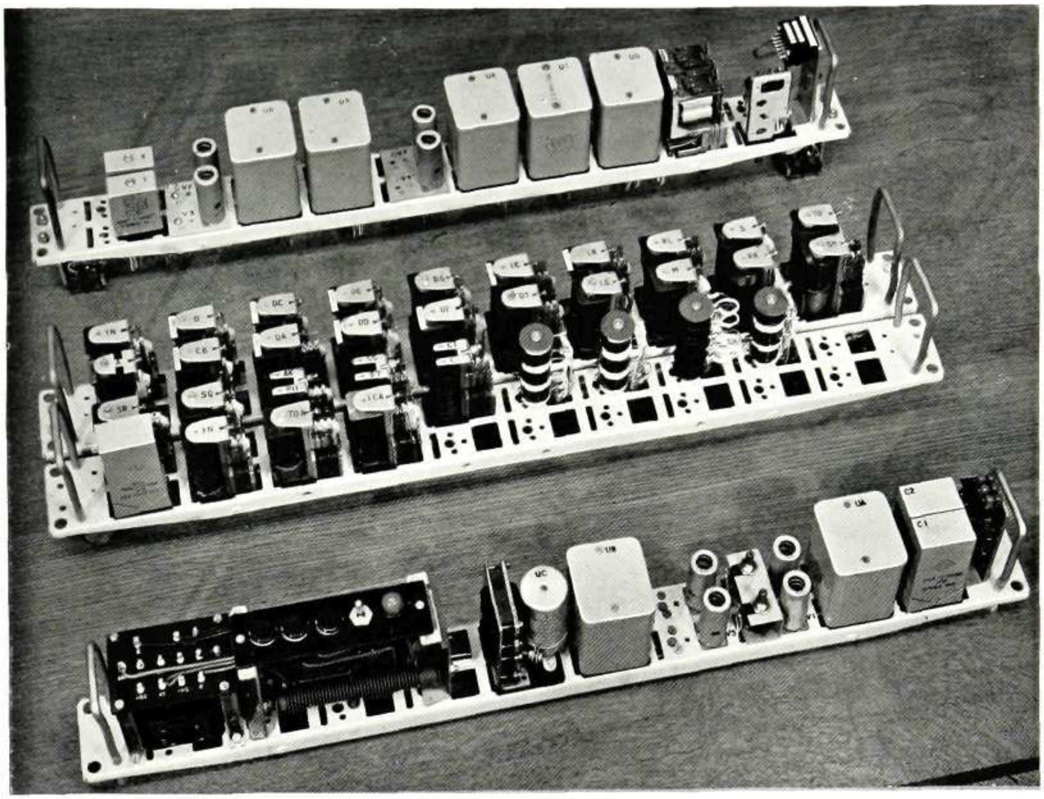


Fig. 6—PC5 Equipment for Parent Termination

AN IMPROVED WALL TELEPHONE

TYPE N1073A

The telephone described has recently been selected by the British Post Office to be their future standard moulded wall instrument, Type No. 333.

The design caters for ordinary, Shared Service or Plan Number working in automatic or manual C.B. systems, Type N.1073A being the straightforward automatic telephone without push buttons. The equivalent manual CB telephone is Type N.1422A.

THE Company's Engineers have recently concentrated on improving the appearance of some of the types of telephones designed many years ago but which, though still in demand, have little aesthetic appeal today. Re-designed table and wall type intercommunication telephones, and a moulded table telephone for general use or adaptation for Plan Number working, have been available for some considerable time and have been described in a previous Bulletin.

Another step in this logical development is marked by the introduction of an improved moulded wall telephone, which is now on the production lines. Both automatic and manual C.B. versions are being made, differing only in the substitution, in the manual set, of a dial dummy for the automatic dial and associated cord in the other.

The automatic telephone, Type N1073A, may be considered a companion to the type N1014B automatic table instrument, for both have similarly curved contours, identical handsets and basically the same construction, with a moulded one-piece case, and a metal base or backplate on which the internal apparatus is mounted.

Old Type (N1071A)

New Type (N1073A)

Fig. 1—The Old and New type Telephones Compared

For purposes of comparison, the new automatic wall telephone is shown in Fig. 1 beside its predecessor. It will be generally agreed that the designers have achieved their principal aim—improved appearance.

The primary quality demanded of any telephone is reliability in service, appearance being generally of less moment. Nevertheless, appearance may assume major importance when a telephone suitable for installation in elegant surroundings is being sought. It is a reasonable certainty that, of the two telephones shown in Fig. 1, Type N1073A would be preferred for the hall of a private residence or for a tastefully furnished office. It would also probably be preferred for warehouses and other places where robustness counts more than appearance : the new case, with a moulding free from sharp angles, is, if anything, stronger than its predecessor.

Comparison between the old and new sets on the grounds of reliability in service gives neither the advantage. Both have the same basic circuit and similar components, both utilize the practically frictionless roller-plunger movement which was evolved by the Company some years ago and has since proved highly efficient in service. The new sets are available—as were the old ones—in both standard and tropical versions ; thus the possibility that one type is more reliable than the other in tropical conditions does not arise.

Features of the earlier model that have been discontinued are, firstly, the removable equipment chassis ; secondly, the gate-hinged case. It was considered that the advantage of the chassis design—which permits the removal of the equipment unit for servicing—was largely offset by its extra cost and was one which would be of real value only in the event of a major repair ; a comparatively rare occurrence. Attention was therefore centred on devising a layout of the component parts on the backplate of the new telephone that would leave free access for servicing and obviate the need for a separate chassis. In this connection, one of the difficulties experienced with any type of wall telephone having a hinged case is that the case, when open, is apt to swing and impede access to the interior. The gate-hinged case offers an advantage in this respect, since it can be lifted off ; but if the telephone were located in, say, a corridor, the case would probably have to be left on the floor and might inadvertently be kicked while maintenance was in progress.

Such drawbacks have been overcome in the new design by the attachment of the case to the bottom edge of the backplate by a strong webbing strap, so that it is suspended below and well clear of the apparatus, as shown in Fig. 2.

On the top edge of the case are two metal clips which engage with recesses in the edge of the backplate when the instrument is closed ; a single captive screw at the bottom serves to lock the case in position.

A novel feature of the design is the dial mounting. Normally the dial fits direct into the aperture and is locked in position by one screw, the moulding round the aperture being shaped to form the seating. Improved seating is now achieved by the provision of a metal clamping ring (Fig. 3), which fits into the

Fig. 2—Interior view of the Telephone

aperture and is fixed from the inside by three screws. The form of the ring is such that it is readily adjustable to the dial fixing lugs ; thus the latter need not be bent to fit the aperture, and the risk of damage to the mechanism is eliminated. The ring is also designed to permit extraction of the dial without removal of its fixing screw.

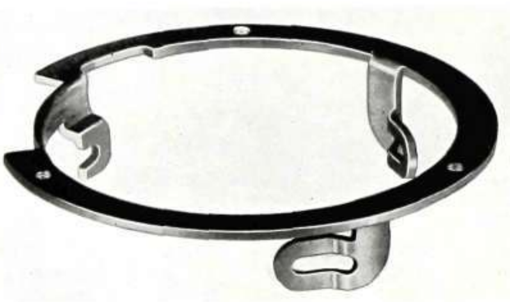
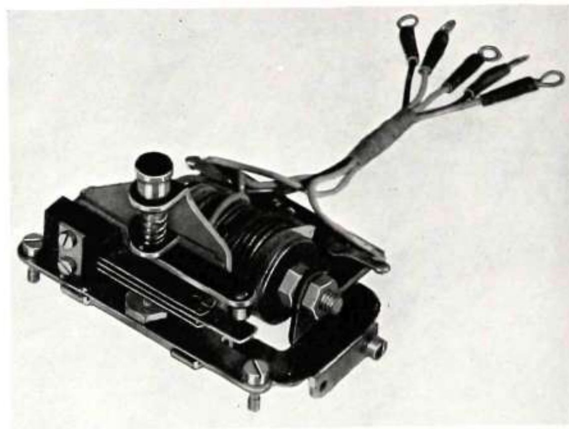


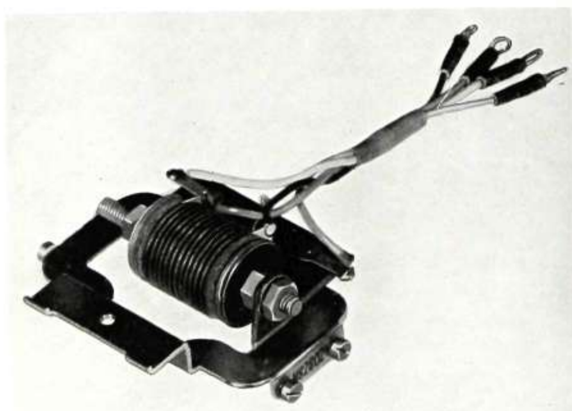
Fig. 3—Dial Clamping Ring

The telephone backplate is a light alloy die casting to which four semi-resilient synthetic rubber feet are attached by tubular metal rivets which also serve to accommodate the telephone fixing screws. The feet are sufficiently flexible to compensate for any reasonable inequality of wall surface, so that distortion is avoided. When the instrument is installed, there is approximately half-an-inch clearance at the back for the issue of sound from the ringer and for the external wires. The latter enter the instrument through a hole in the bottom centre of the backplate. The handset cord is fed in through a synthetic rubber protector fixed in the bottom of the moulded case.

Of interest in the internal arrangement are the two brackets between which the cradleswitch lever is pivoted ; they are formed for the convenient mounting of the additional units required for shared service working. There are two such units, viz. : British Post Office Adapter Shared Service No. 1 and No. 2 (Fig. 4). Each incorporates a flexible cord for connection to the main terminal block in the telephone, the layout of which facilitates this arrangement.



Adapter Shared Service: BPO No. 1



Adapter Shared Service, BPO No. 2

Typical 3-Plunger Plan No. Key Unit as used with Unit No. 2 above

Fig. 4—Typical " Shared Service " and " Plan No. " Key Units

Adapter No. 1, comprising a thermistor, copper oxide rectifier and a single plunger key with a make-before-break springset, is used for normal two-party conditions, the thermistor being included to prevent bell tinkle during dialling, and the key to permit the recording on separate meters of the calls initiated by each party.

Adapter No. 2 is provided when plan number working under shared service conditions is required. It is similar in most respects to Adapter No. 1, but as individual requirements differ, the key is replaced by a separate plunger key unit of appropriate type, such as that shown in Fig 4 ; the front of the telephone is drilled for one, two or three plungers as necessary ; any unused holes can be filled with an unobtrusive plastic dummy.

Fig. 5 is a schematic of the basic circuit. A slightly different arrangement obtains when shared service or plan number working is envisaged, the cradleswitch springset then having an additional contact and the wires being terminated to provide convenient " break in " points for the leads from the key units, should these be required.

The internal connecting wires in both the standard and tropical models are insulated with p.v.c., as are the conductors in the handset cord, which is laid up circular and covered with a nylon cordonet braiding.

The new telephones are being produced in the usual range of colours, namely, black, ivory, chinese red and jade green ; it is expected that this variety of finishes, combined with their pleasing appearance, will tend to make them more popular than the conventional wall telephones of more austere design that have long been the accepted standard.

A prototype of the new telephone was submitted to the British Post Office, which had for some time been contemplating the standardization of a moulded wall set and selected it from a number of designs as their future standard. Its further development was therefore carried out in collaboration with the Post Office Engineers, who have allocated to it the P.O. Type No. 333.

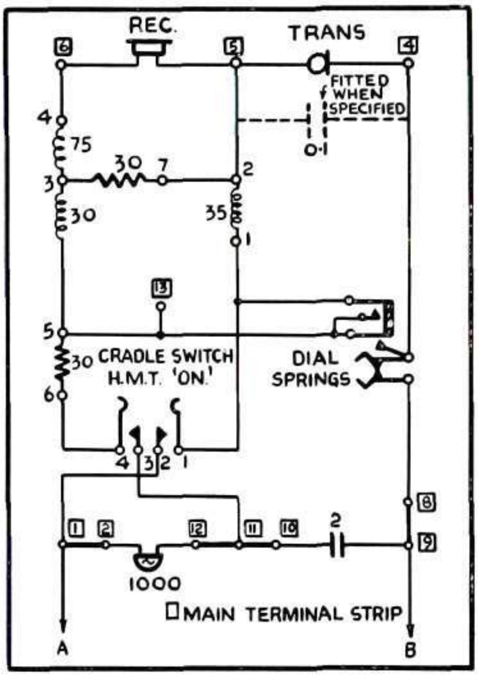


Fig. 5—Schematic of the Basic Circuit

THE 39th PHYSICAL SOCIETY EXHIBITION, 1955

FOR many years the Physical Society has held its Annual Exhibition in the Imperial College of Science and Technology, South Kensington. This year, owing to an increase in the number of exhibitors and a decrease in the space available for the Exhibition in the Imperial College, the long-established tradition had to be broken and other accommodation found. The Exhibition Committee was fortunate in securing the use of the Royal Horticultural Society's New Hall, Westminster, and, on 25th April, the 39th Physical Society Exhibition was opened there by Professor R. Whiddington, C.B.E., M.A., D.Sc., F.R.S.

The exhibits covered almost every branch of research as well as certain industrial applications. Many of the latest developments in equipment and techniques were demonstrated, and some of the exhibits showed great ingenuity both in the application of physical principles and in the design and production of the apparatus used. Several manufacturers of scientific instruments displayed equipment of well-known aspect and proven design which has found a place in many laboratories and workshops.

The increasing importance of the Dekatron and the transistor in electronic and nucleonic apparatus and communication equipment was indicated by the large number of instruments incorporating these devices. The Dekatron could be seen in scaling, counting, and timing equipments, and the transistor was demonstrated in analogue and digital computers, telephone repeaters, and many other kinds of electronic apparatus. The next Physical Society Exhibition will no doubt reveal more applications of these two new and interesting devices.

A large number of visitors from home and overseas was welcomed at the Company's stand, where keen interest was shown in the latest developments in electronic and nucleonic instruments, as well as in the increasing range of cold-cathode tubes and miniature relays.

The Add-On Counting Equipment Type 101A, including several new units, caused much favourable comment, both for the compactness of its layout and the diversity of its applications. The new units shown were the Electronic Gate, Type 101A/A6, and the Register Unit, Type 101A/A33. The gate unit is particularly useful for timing and frequency counting, when it is desired to gate the input to the add-on equipment electronically, thus substantially reducing the time errors associated with electro-mechanical switching methods. The unit may be operated by single or dual channel pulses of at least 40V peak amplitude and a minimum duration of 100 micro-seconds. The "gate" opens in approximately 400 micro-seconds and closes in approximately 100 micro-seconds. The unit can also be operated by d.c. methods.

The Register Unit comprises a non-resettable P.O. type register with associated trigger triode circuitry and is useful where low count rates and large maximum counts are required.

The add-on counting equipment was also shown in combination with an E.H.T. Power Supply Unit, Type 105A. (See enlarged view). This combination constitutes an economic and compact scaling equipment for use with Geiger-Müller counters. The 105A E.H.T. Unit is capable of supplying power at voltages from 300 to 3,300 for GM tubes, scintillation counters and proportional counters, in addition to power supplies for a GM probe unit such as the A.E.R.E. Probe Unit, Type 1014A, and the E.T.L. Probe Units 109A and 110A.

The range of new equipment in the nuclear instrument field was further augmented by the battery operated Radiation Monitor, Type 1320, which has been developed in conjunction with A.E.R.E. Harwell as a general purpose alpha-beta-gamma monitor for use where mains supplies are not available. The equipment, which can be carried in a canvas haversack, comprises a main indicator and power unit together with an alpha probe unit, a beta-gamma probe unit, and associated cables, headphones, etc.

Two other new instruments for more general use were shown ; thus all the Company's exhibits were completely new. The Pulse Generator, Type 104A, though primarily designed for use in the nucleonic

View of the Company's Stand at the Physical Society Exhibition.

On the left :

An enlarged view of the combined Add-On Counting and E.H.T. Power Supply Equipment Unit connected to a Probe Unit.

field, has many general laboratory applications. This versatile generator has either internal or external triggering facilities and either a positive or negative rectangular pulse output variable in 100 micro-volt steps up to 51 volts. Duration of the pulse can be varied continuously from 4 micro-seconds to 500 micro-seconds.

The second general purpose instrument was the Interval Timer, Type 103A, with Relay Adaptor Unit, Type 103A. The interval timer will measure times within the range 100 micro-seconds to 10 seconds to an accuracy of approximately 10 micro-seconds. Control of the timing sequence is extremely versatile and very simple means of timing various relay characteristics are provided by the relay adaptor unit.

The 1955 Exhibition was, no doubt, regarded by visitors and exhibitors alike as a first class exhibition and the Company were proud to show their new commercial products in the field of physics at this extremely successful show.

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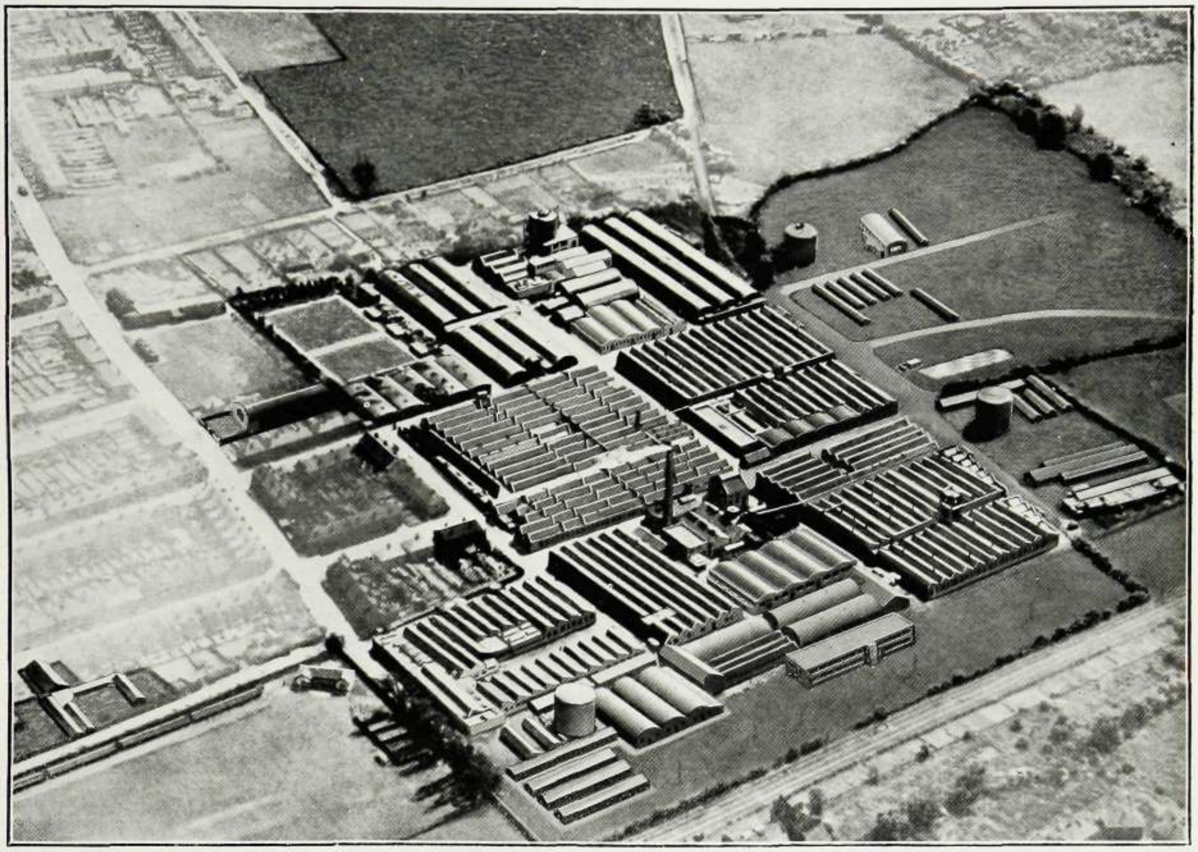

Aerial View of The Telephone Works, Beeston, Nottingham