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Editorial

Although world conditions in recent years have hindered to a considerable extent the telephone development programme planned by the British Post Office, a noteworthy advance was made in February of this year when the new Cardiff telephone exchange was brought into service. This non-director zone centre equipped for sixteen thousand multiple numbers and with over one hundred and fifty operators' positions, has the distinction of being the largest single unit of automatic telephone plant in the British Isles. The engineering, production and installation of the equipment have proved of great interest to the Company's staff.

A hypothetical satellite exchange of three thousand lines included in the Cardiff numbering scheme is accommodated with the main equipment and serves Roath, one of the city's suburbs.

The switching equipment is of British Post Office "2000" type and, in the main, the exchange follows orthodox lines, as will be apparent from the relevant article in this issue, but reference is also made to innovations with respect to manual switchboard finishes and the method of cabling subscribers' circuits from the main to the intermediate distribution frame.

Cardiff's conversion to automatic working was scheduled for the year 1932 but for various reasons which are explained in the article, the project was postponed, with the result that the equipment in the old common battery manual exchange had to be maintained in working condition for a period greatly in excess of the average life of telephone plant. The fact that it was so maintained reflects great credit on those responsible.

Cardiff Telephone Exchange

CARDIFF, the commercial centre of South Wales, is considered by many Welsh people to be the capital of the Principality.

In contrast to its present virile life, the city experienced a particularly lean period during the industrial depression of the early " thirties ", and this hindered normal development ; a fact which is reflected in the history of its telephone system.

In November 1910, a Helsby 24-volt central battery exchange designed for an ultimate of 10,000 lines and equipped for 4,200 lines was opened at the Head Post Office building, Park Street. It provided service for subscribers formerly connected to the original New Street, Roath and Cathays exchanges, in addition to new subscribers in the area. The exchange was destined to have a life span far beyond that visualized by its originators, for, while plans were made for its supersession by automatic equipment in 1932, the project was deemed uneconomic owing to the industrial depression and it was not until 1939 that the Post Office Engineering Group proceeded with the development work.

The outbreak of war caused further postponement, so that it was 1947 before a contract was placed with the Company for a new 16,000-line non-director zone centre exchange to replace the existing subscriber and trunk exchanges in Park Street and the Relief exchange in Newport Road.

At the time of the recent cut-over, the Relief exchange catered for 2,400 multiple lines, although only about half of these were working.

The old Trunk exchange, housed in the same premises as the original subscribers' positions and brought into service in 1934, was one of the first sleeve control switchboards manufactured and installed by the Company.

It seemed that Cardiff's telephone development was fated to be deferred, for after the contract for the new exchange was placed, the shortage of building materials disrupted the programme, with the result that the main installation did not commence until March, 1950, although the main distribution frames and subscribers' I.D.F. were completed a few months earlier.

When finally cut out of service, the old subscriber exchange at Park Street had been working for a period of over forty-one years—surely a record and undoubtedly a tribute to the patience and ingenuity of the Post Office maintenance engineers, for the years of incessant wear could not but cause appreciable deterioration of the equipment.

The city now has the distinction of possessing the largest single unit of exchange equipment ever installed in Britain.

The equipment is housed in a new six-floor building in the same street as the original subscriber and trunk exchanges. The building is rectangular, with wings at each end, and is of massive proportions, more than three million bricks having been used in the steel-framed walls.

The interior decoration is perhaps seen to the best advantage in the manual switch-room where special finishes on the equipment add to the pleasing impression created by the general colour scheme. The

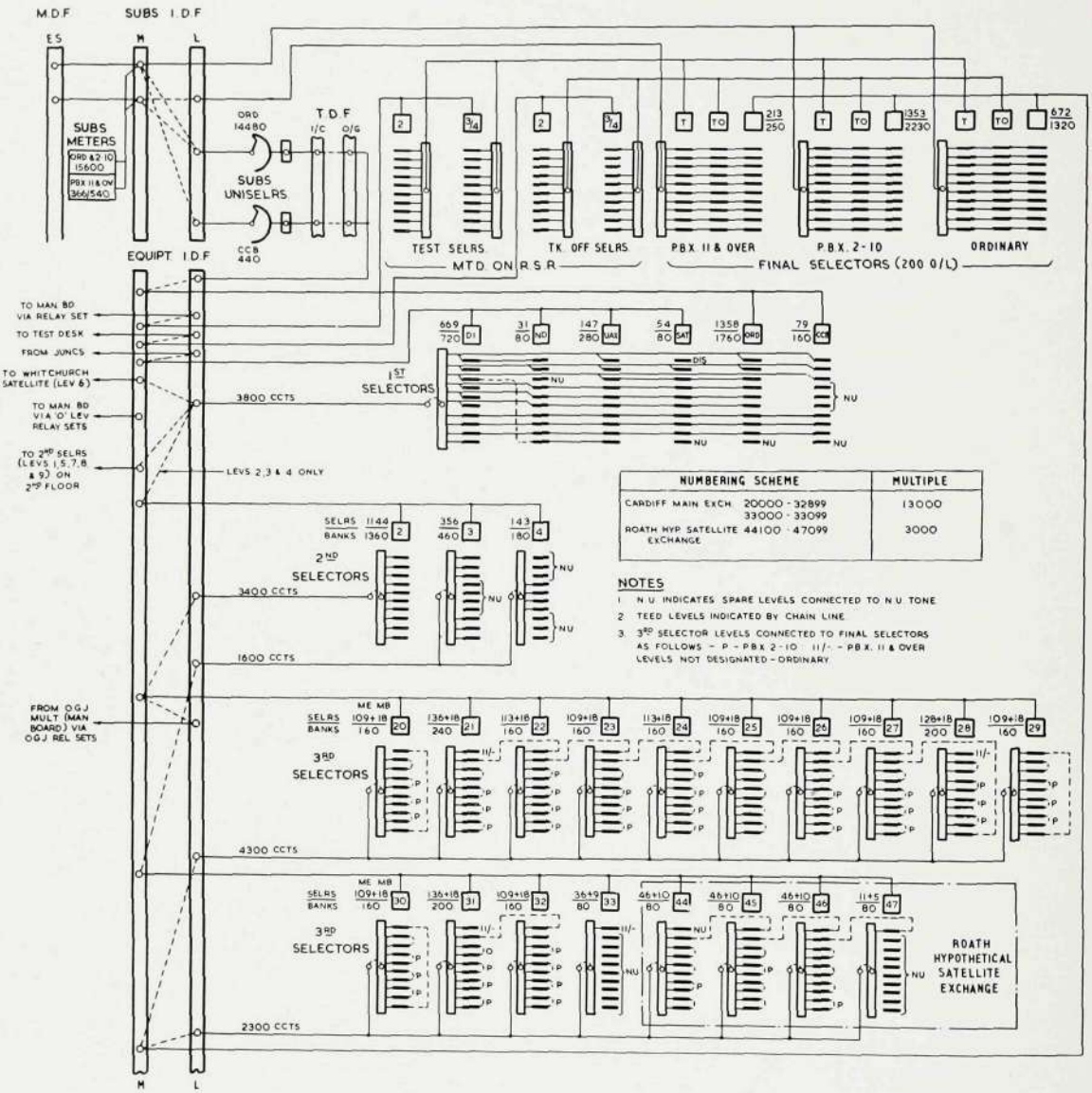


Fig. 1—Trunking—First Floor

natural light from the many windows in this room is augmented by three rows of fluorescent tubes fixed directly on the ceiling, so that, all things considered, working conditions for the operators approach the ideal.

Trunking Arrangements and Type of Equipment.

Before referring to the trunking arrangements it is necessary to state that Roath, a mainly residential suburb of Cardiff, is served by a hypothetical satellite exchange accommodated with the main exchange equipment and included in the Cardiff 5-digit numbering scheme, as indicated in the trunking diagram, Fig. 1. It will be observed that Cardiff has 13,000 multiple numbers, and Roath 3,000, there being a total of 14,920 calling equipments. Other details of the main trunking are shown in Fig. 1A (Page 37).

The Standard British Post Office system employing subscribers' uniselectors and "2000" type selectors is used, and, in general, the trunking and equipment follow conventional lines ; there are, however, innovations appertaining to cabling methods and switchboard construction which will be described later and should be of interest to telephone engineers.

The services and facilities provided are the same as those at other exchanges of similar type. They include voice frequency signalling, multi-metering, emergency, speaking clock, directory enquiries, service observation, automatic routine testing, traffic recording, and a comprehensive fault alarm system.

Group selector racks are of the latest type incorporating grading facilities, therefore separate trunk distribution frames are employed only for the uniselector outlet gradings.

Manufacture of the equipment had been completed prior to the introduction of the new standard light-duty uniselector ; accordingly, the possibility of using the new switch for the subscribers' circuits on this contract was never contemplated ; however, the P.O. No. 2 general duty uniselector, which was standardized at an earlier date, was available in time for use on the voice frequency relay set racks.

Layout

In any large exchange it is of supreme importance that the layout should not only be convenient for installation and maintenance, but should also provide for an economic cabling scheme. These objectives are successfully attained at Cardiff, where the equipment is disposed as indicated below. In addition there is a repeater station on the ground floor. The fourth (top) floor is used for personnel services.

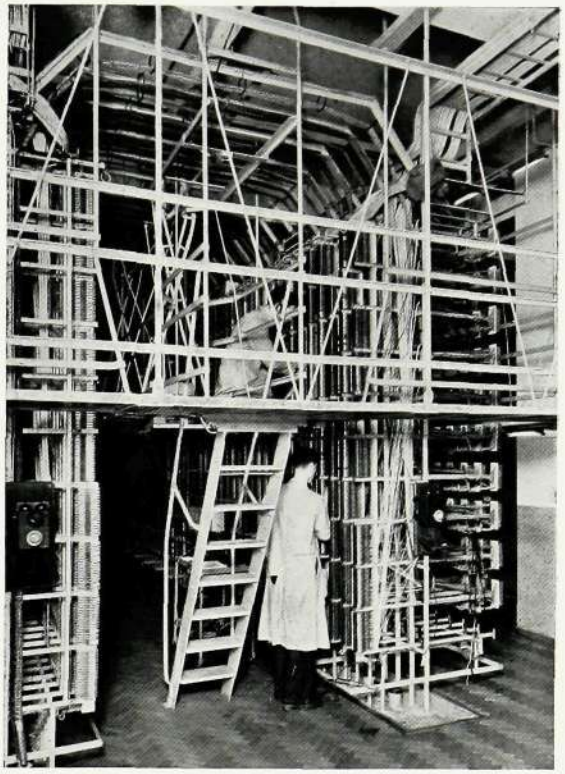


Fig. 2—Testing at the M.D.F.

Basement :	Diesel-driven standby generator, h.t. and l.t. switchgear, cable chamber, stores, etc.
Ground Floor :	Line terminating and testing equipment. Batteries.
First Floor :	Power plant, and subscribers' switching equipment.
Second Floor :	Tandem and junction switching equipment, meter room, and service observation room.
Third Floor :	Manual switchboards.

Ground Floor

M.D.F. and Line Testing Equipment

The external lines are brought into the building through a cable chamber in the basement and are fed in the conventional

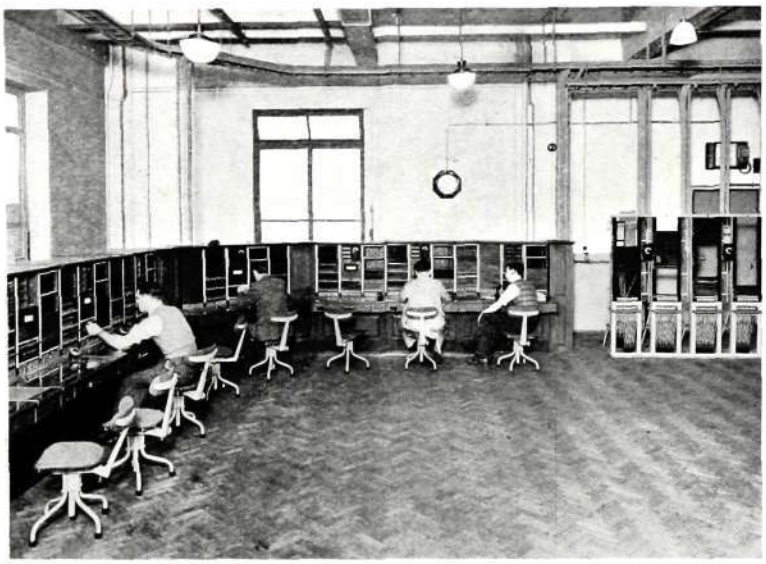


Fig. 3—The Test Desk

manner through pipes up to the ground floor where they are terminated on two main distribution frames (" A " and " B ") each of 65 verticals. The frames are adjacent and parallel to each other—the respective exchange sides being on the inner faces—and complete flexibility for inter-connections is given by a jumpering field overhead, while ready accessibility to the equipment beyond reach from the floor is provided by mezzanine platforms.

The junction circuits are confined to one frame (" B ") but as they are relatively few in number compared with the subscribers' circuits, the junction M.D.F. is also used to accommodate protectors for about 6000 subs' lines. The total quantities of the principal circuits terminating on protectors are as follows :—

Subs lines, ordinary and PBX 2/10	15,600
Subs lines, PBX 11 and over ..	540
O/G and B/W selector level junctions	860
O/G and B/W manual junctions	100
O/G and B/W trunks	380
I/C junctions ..	860
I/C trunks	240
Private wires ..	480
Through circuits ..	40

Facilities for line testing are provided by a test desk (Fig. 3) consisting of twelve subscribers, one junction and two A/N positions ; two " trunk " and two " toll " test racks ; a 4-bay test jack frame, and an automatic routiner for junctions outgoing from selector levels.

Batteries

The exchange batteries are accommodated in a wing of the building and are arranged for a divided battery float scheme. They comprise :—two 25-cell main batteries each having an initial capacity of 5160 ampere-hours and an ultimate capacity of 6450 ampere-hours at the 9-hour rate of discharge ; a 30-volt counter e.m.f. battery of 93 ampere-hours capacity for P.B.X. power supplies ; and the necessary cells provided by the Department for positive battery metering requirements.

The floor supports a considerable load, as each cell of the main batteries weighs approximately 25 cwts., making a total weight of 63 tons for these batteries alone.

First Floor

Power Plant

The power plant, that is, the machines, power board and ringer equipment, is located in the same wing as, and immediately over, the battery room. A general view of the layout is shown in Fig. 4.

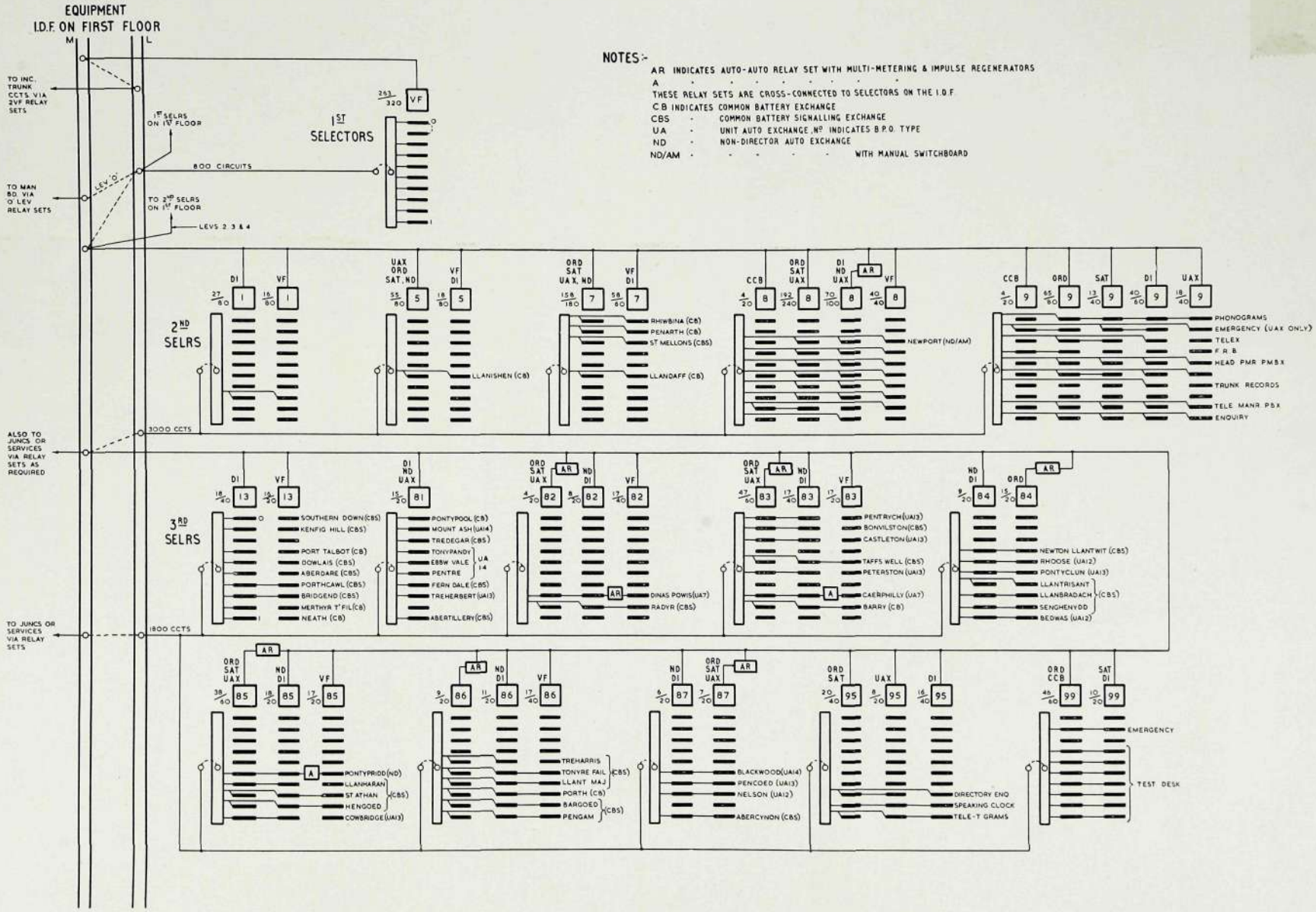
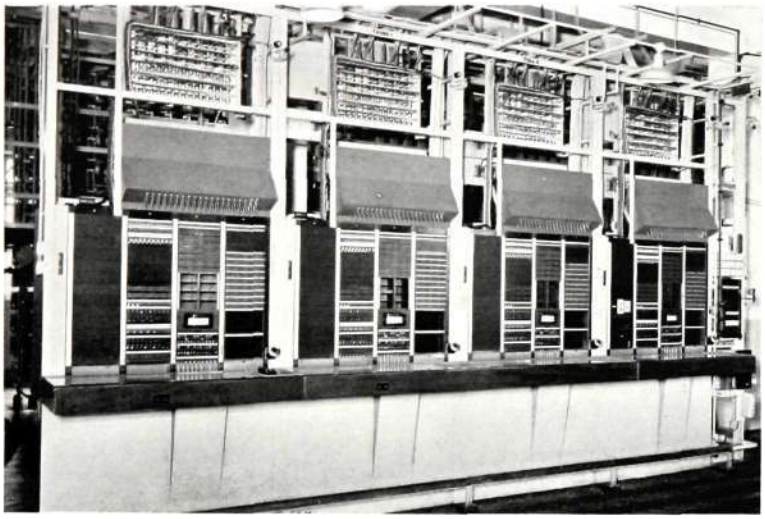
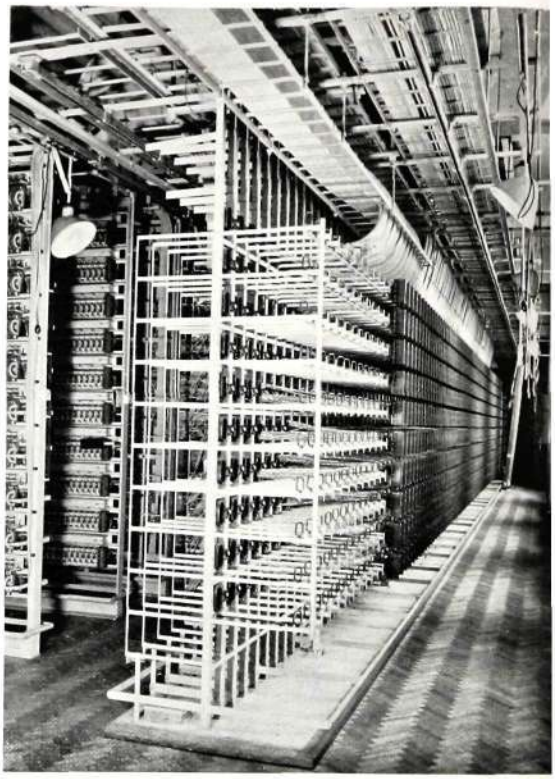


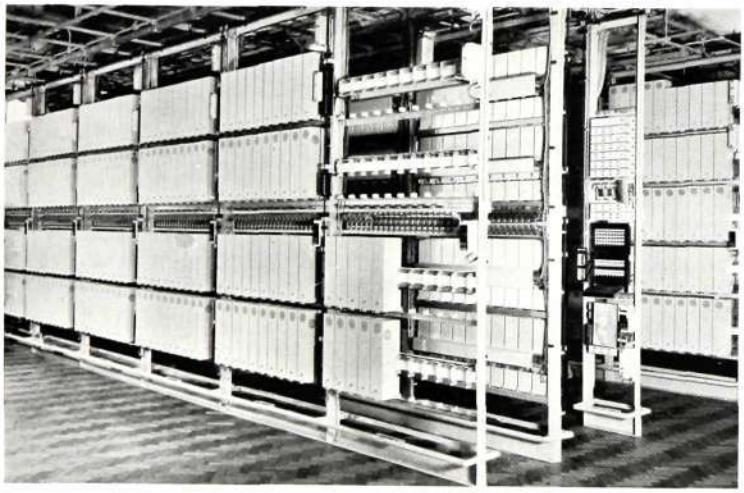
Fig. 1A — Trunking. Second Floor



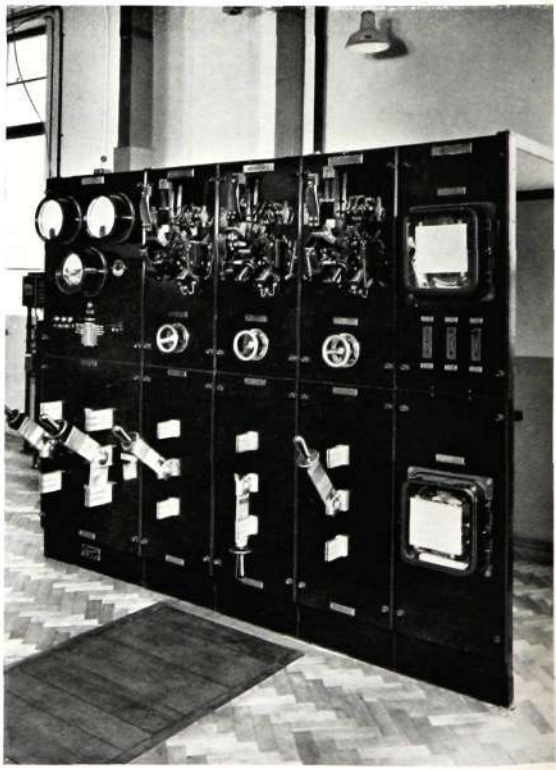
Trunk Test Racks



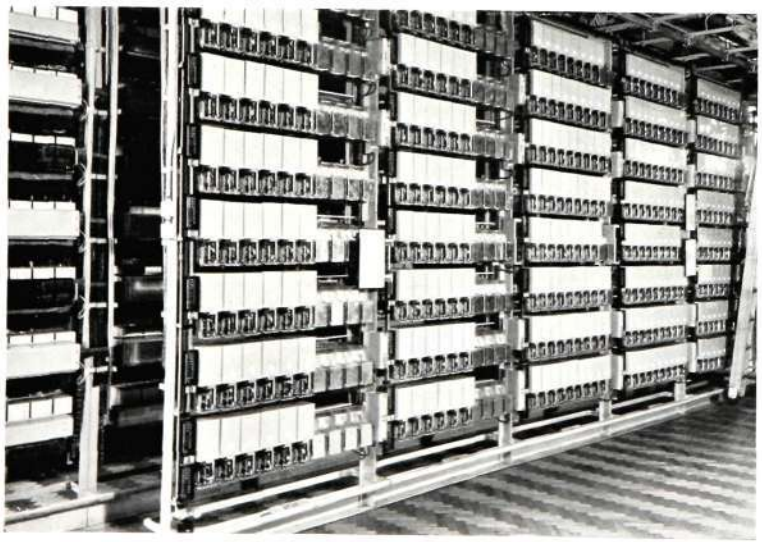
The Subscriber I.D.F. with Uniselector Racks on left



Voice Frequency Relay Set Racks



The Power Board



A few of the Group Selector Racks—2nd Floor

There are three motor-generator sets, each with a protected type auto-synchronous induction motor (operating from 415 volts, 50 cycles, 3-phase supply mains) coupled to an open, protected type shunt generator giving an output of 51 volts at 700 amperes, the output being passed through a smoothing unit consisting of two choke coils in series, with a bank of condensers connected at the junction.

Fig. 4—The Power Room

Each motor-generator set has a motor control panel equipped with a starter, an exciter field regulator, a mains supply circuit breaker, and ammeters for measuring the exciter and motor currents.

The power board has five panels, three of which are for the motor generators, one for battery control and one for voltage regulation equipment. Each generator panel carries a 700-ampere circuit breaker arranged for release on overload or reverse current, a 700-ampere s.p. double-throw switch for connecting the generator to the batteries, and a field current regulator. The battery control panel is equipped with two 2000-ampere knife switches for bringing the batteries into service, ordinary and contact voltmeters, an ammeter, and apparatus associated with various alarm circuits including high and low volts, positive battery failure and circuit breaker. The remaining panel carries two automatic voltage regulators and three d.p. changeover switches. One regulator is connected to the No. 3 generator, while the other can be used with either No. 1 or No. 2 although it is normally associated with the latter.

The main battery trickle charge rectifiers were supplied by the Department.

The ringing equipment comprises one mains and one battery-driven machine, each of 2-amperes output, a ringer panel and a starter for the No. 1 ringer.

Automatic Equipment

The design of the building makes it possible to arrange the automatic equipment in a very convenient manner, as, broadly speaking, the first floor accommodates all the switching equipment necessary for local calls, while the second floor accommodates junction switching and miscellaneous equipment.

Almost the complete 200-feet length of the first floor is occupied on the front side of the building by the subscriber and equipment I.D.F.'s which comprise 102 and 137 verticals respectively, the former being used for line circuit and final selector multiple terminations and for the connection of servicing circuits such as interception and changed number tapping, N.U. tone for ceased and t.o.s. lines, night service, etc.

The larger frame provides facilities for cross-connections between the selector, junction, trunk and miscellaneous circuits, and the associated relay sets.

The switching equipment on this floor includes uniselectors, local first, second and third group selectors (Fig. 5) and final selectors ; the third selectors allocated to the Roath hypothetical exchange being included. As the total numbers of switches and banks provided for the various levels and also the numbers of circuits cabled to the I.D.F. are specified in Fig. 1, their repetition here is unnecessary, but reference to some of the groupings may be of interest.

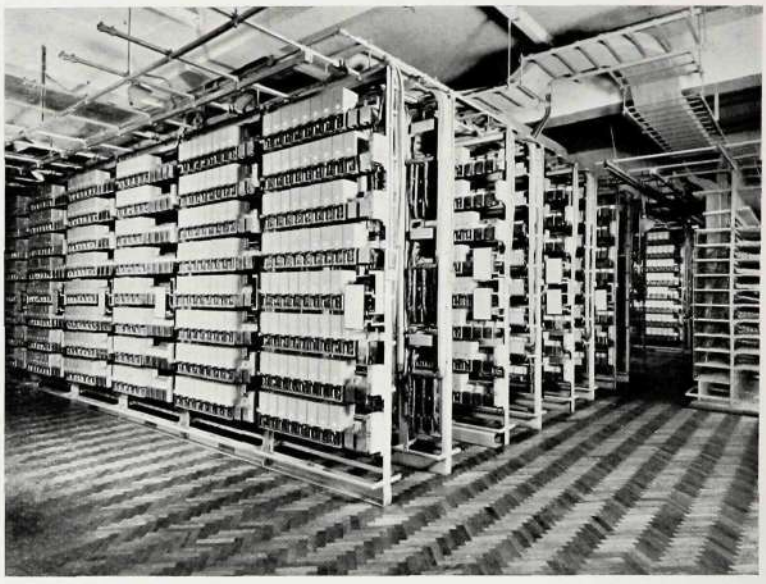


Fig. 5—Third Selector Racks. First Floor

There are four P.B.X. 11 and over subscriber groups, as follows :—

Group	*No. of Subs.*	*Total Meters*	*Total F.S. Sws.*	*Banks*
210	4	96	57	60
280	5	84	53	70
310	5	79	58	70
330	3	52	45	50

The ordinary and PBX 2/10 final selectors are accommodated on 60 racks, providing for a multiple of 15,600 lines, and are grouped as follows :

Type of F.S.	*No. of Groups*	*F.S. Per Group Sws.*	*Banks*
Ordinary (Cardiff)	21	24	40
PBX 2/10 (Cardiff)	42	31	50
Ordinary (Roath)	12	14	40
PBX 2/10 (Roath)	1	17	50
PBX 2/10 (Roath)	2	17	40

The high proportion of Cardiff PBX 2/10 subscribers is largely accounted for by the variety of industries in the area.

The circuits between the group selector racks and the I.D.F. are provided on the standard basis of 100 from each rack of first selectors and 200 from each rack of subsequent rank, making a total of 15,400, 3-wire circuits for the racks on the first floor.

To assist the maintenance staff in keeping the switching equipment in first-class functional condition, two group selector and three final selector routiners (one for large P.B.X. F.S.) have been installed, access to the individual circuits being obtained via 100-outlet selectors mounted on access racks in the conventional manner. Traffic recording equipment also is provided on the standard basis.

Second Floor

The junction switching equipment on the second floor (Fig. 1A) includes : first selectors terminating the incoming voice frequency trunks ; second selectors which are accessible from levels of the first selectors on the floor below ; and third

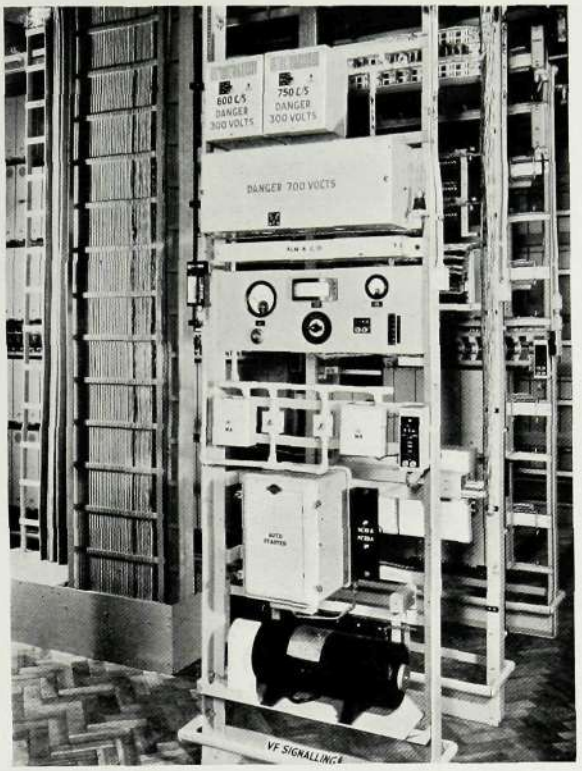


Fig. 6—Generating Equipment for 2 VF Signals

selectors. It will be seen from Fig. 1 that level 1 of the U.A.X. and ND first selectors is teed to level 8 of the DI group. These circuits are wired, via auto relay sets with regenerator and multi-metering facilities, to the DI, U.A.X. and ND second selectors. Similar relay sets are used in the level 82-87 circuits to ordinary, satellite and U.A.X. third selectors.

The test desk faultsmen's lines terminate levels 991-997, while standard subscriber services such as speaking clock, emergency, etc. are allocated to levels as indicated. Immediate attention to " 999 " emergency calls is ensured by the operation of a Klaxon hooter and the flashing of special lamps in the manual switchroom.

Miscellaneous equipment on the second floor includes 60 racks of relay sets, most of which are required for junction traffic, 25 racks of 2 VF relay sets, lamp relay and fuse panel racks associated with the switchboard, and miscellaneous apparatus racks.

The rack shown in Fig. 6 carries equipment for the generation of the 600 c/s and 750 c/s signalling frequencies required for the receivers of the 2 VF relay sets. These frequencies originate from mains operated valve oscillators in the normal way, but provision is made for changeover to a standby machine driven from the exchange battery, in the event of a variation in periodicity or a mains failure. The machine is governor controlled and can be checked for a speed of 3000 r.p.m. by observing the stroboscopic effect of a banded wheel on the machine through a slit in a tuning fork vibrating at 102.78 c/s. The speed can be varied by manually adjusting the resistance of the field circuit.

Three automatic routiners are supplied for the second floor equipment, one for group selectors and two for auto/auto relay sets.

A separate room is provided for the subscribers' meters, and another for a service observation desk which is constructed of beech with a semi-matt finish. The desk has two 8-digit number display units, and two observation panels each with capacity for ten and equipment for five incoming observation circuits.

THIRD FLOOR.

The imposing appearance of the manual switchroom may be seen in Fig. 7. The boards occupy the whole length of the building, the " A " suite of 88 joint trunk positions (numbered 1-88) backing on to the front windows, left, while the joint trunk " B " suite of 27 positions (101-127) and the 24 incoming positions of the " C " suite (201-224) back on to the opposite wall.

Fig. 7—The Manual Switchroom

In the centre are 20 enquiry positions numbered 501-520, and beyond them is the directory enquiry bureau, while supervisor's desk No. 1 is in the foreground. At the far end the room extends into the wing of the building, providing ample space for additional sections.

The quantities of main circuits on the four manual suites are :—

	Suites		
	A & B (each)	*C*	*Enq.*
OGJ mult. with F.L.S. (4-panel repetition)	1920	1920	80
OGJ mult. w/out F.L.S. (ditto)	—	—	80
Ans. mult ..	1200	720	160
Ans. mult. repetition ..	12 pan	6/12 pan	4 pan
Cord circuits wired	15	16	7
Cord circuits equipped ..	12	16	6
Time clocks ..	7	—	—
Delay indicator cords	1	1	—

The O.G.J. with F.L.S. circuits on suites "A", "B" and "C" are commoned at the I.D.F. to give a continuous multiple, as are also the answering multiples on "A" and "B". The effective multiple answering circuits on the "C" suite total 360 in a six-panel repetition.

Opportunity was taken to incorporate several new features in the construction and finish of the boards which are to the latest P.O. design. The sectional outline diagram, Fig. 8 shows the general arrangement of equipment and cables in the base of the large type section which is 6′—4½″ high, the enquiry positions being 4′—8½″ high. Light steel angle-iron replaces the channel formerly used and allows considerable weight reduction without detriment to stability. The base assemblies of the large and small sections have been standardized so that only two types are used—one for the one-position and the other for the three-position section ; also, the removable kicking panels are increased in size by adopting panel-to-panel fitting, thus giving greater accessibility to the cables on the floor of the section when the panel is removed and simplifying construction by eliminating the pilasters and fillets formerly used. Further improvements are effected by using cross battens in place of longitudinal ones for levelling purposes, and by a different arrangement of the cord pulleys, while the rear equipment framework is a separate unit which can be equipped and wired before it is fixed in the board ; a facility of considerable value in production.

Whilst the manufacturing specifications were being prepared, the Post Office Trunk Mechanization Steering Sub-Committee recommended that lighter colour schemes be used in manual switchrooms, and the Company was approached to adopt this recommendation on the Cardiff contract. After considerable research it was mutually agreed that beech with a shellac cellulose semi-matt finish be used for the exterior of the switchboards, in place of the traditional dark polished mahogany, and that the fibre on the keyshelf and below the main panel equipment should be mid-Brunswick green. Other parts were toned to suit ; for example, the steel work visible to the operator, and the bakelite front plate of the operator's jack are coloured deep cream, while the spacing strips in the panels are faced with green plastic, and docket distributors and Kardex files are enamelled green.

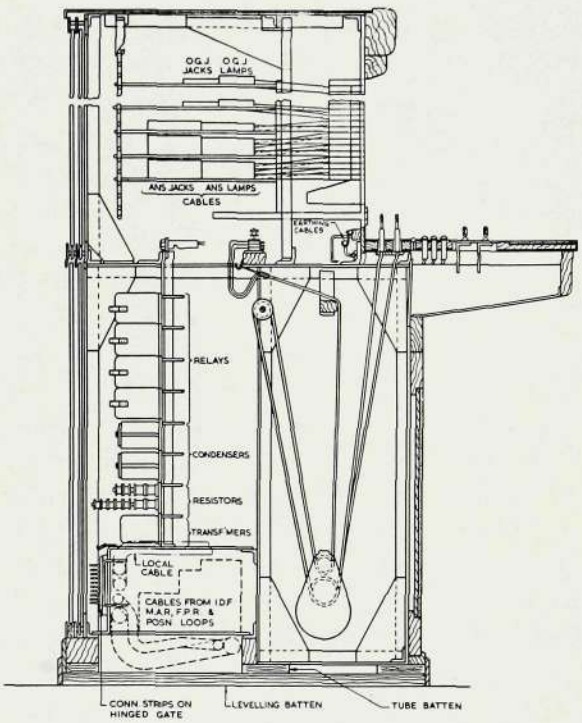


Fig. 8—Sectional View of a Switchboard Position Showing Construction and Interior Equipment Layout

Supervisors' Desks

Three desks of the conventional type, i.e. based on the design originated by the National Telephone Co. before 1912, were specified in the contract, therefore the deferment of the ready-for-service date which enabled desks of modern type to be installed was fortuitous, as the new design (described in our July 1950 issue) is much more in keeping with the general appearance of the room.

The timber used is beech and the tops of the desks are inlaid with green linoleum.

In the article mentioned above, reference was made to the new method of establishing listening-in connections by means of three Yaxley switches which are set by the supervisor at, respectively, the " hundreds ", " tens " and " units " digits of the number of the position concerned. This arrangement necessitated a revision of the numbering of certain positions at Cardiff, where the allocation for supervision is as follows :—

Supervisor		*Positions*
No. 1	(*a*) 1–27	joint trunk
	(*b*) 501–520	enquiry
	(*c*) 601–606	directory enquiry
	(*d*) 621–622	directory monitorial
No. 2	28–87	joint trunk
No. 3	201–226	joint trunk
	301–324	incoming.

Positions (*c*) and (*d*), above, are not *en suite*, and in conformity with P.O. practice were originally numbered in different " hundreds " groups, i.e. (*d*) was numbered 701-702. As, however, the P.O. limit the number of arcs on the Yaxley switch to ten, thereby restricting to three the number of

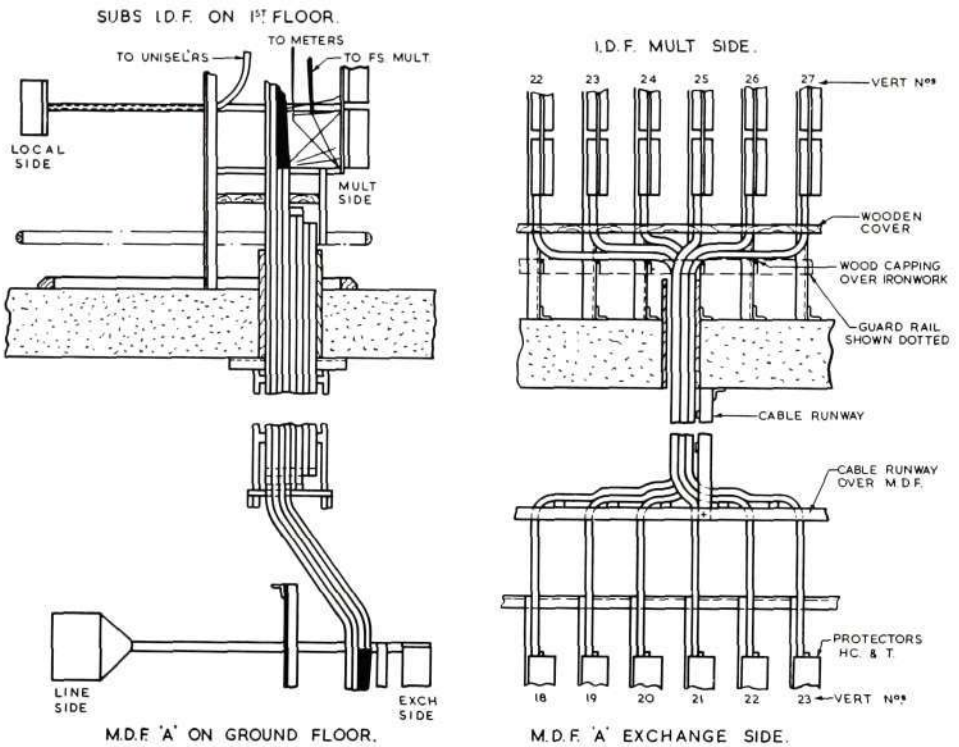


Fig. 9—Cabling Scheme, M.D.F. to I.D.F., for Subscribers' Line Circuits

suites accessible from the "tens" switch, it was necessary to re-number the directory monitorial positions in a "hundreds" group already terminating on the No. 1 desk.

Directory Enquiry Positions

By dialling 953, a local subscriber obtains access to a suite of six directory enquiry positions. These are single-sided tables with adjustable sloping tops to reduce the strain on the operators, each of whom has a fixed directory rack. Incoming calls are automatically queued and are answered in sequence on a straightforward junction basis. They can be transferred either to the adjacent directory monitorial suite of two positions or to the manual board. The number of waiting calls is registered on an ammeter suitably calibrated on a basis of 5 milliamps per call, and if the queue reaches a pre-determined maximum an alarm is given.

The waiting call meter is mounted on a small panel adjacent to the first position. This panel also accommodates the connecting circuit busy keys (3 per position) which may be operated to allow a faulty connecting circuit to be taken out of use for faulting. Meters are provided to register the calls dealt with at each position.

CABLING (New Schemes)

The cabling of any large exchange is likely to present problems arising from the size of the cross-sections ; Cardiff was no exception, the first problem being due to the amount of cabling necessary between the subscribers' line protectors on the M.D.F. and the connection strips on the multiple

side of the subscribers' I.D.F. on the floor above. In the ordinary way these cables would be taken through a hole at the non-growing ends of the frames, but on the suggestion of the P.O. engineers a different scheme was tried. The first vertical equipped with subscribers' protectors on M.D.F. " A " was aligned with the first I.D.F. vertical terminating the subscribers multiple, and holes were made through the floor along the I.D.F. footings, there being one hole for every six verticals, as shown in Fig. 9.

The cables at the I.D.F. are fanned out across the guard rail supports which are capped with wood to protect the cables from damage resulting from their pressure on the ironwork ; wooden covers are also fitted to prevent wire clippings and solder from falling amongst the fanned cables.

The subscribers' circuits on M.D.F. " B " are cabled above the frame to the growing end and then across to frame " A " where they also are grouped and fed to the I.D.F. in the manner described.

This method of cabling prevented the congestion which otherwise would have resulted above the I.D.F. had the M.D.F. cables been added to those from the 75 uniselector, 65 final selector and 18 meter racks. It also considerably reduced the length of runs.

A second problem was encountered in planning a suitable scheme for the first floor. The original intention was to follow the standard practice of having one subscriber I.D.F. and one equipment I.D.F., but it was found that the congestion caused by bringing the switchboard and associated relay set rack cables down to the equipment I.D.F. on the first floor would make a satisfactory cabling layout impossible. It was therefore proposed to the P.O. engineers that a separate equipment I.D.F. be installed on the second floor for cross-connections between the equipment on that floor and the manual board. Approval was given to the scheme, with the result that congestion was avoided, installation facilitated and economy in cable effected.

The Cut-Over

The cut-over on the 16th February 1952 was made a civic ceremony. Those present included the Postmaster General — the Rt. Hon. the Earl de la Warr, P.C. ; the Lord Mayor of Cardiff—Ald. Robert Bevan, J.P. ; representatives of the Cardiff City Council and Chamber of Trade ; Glamorgan County Council ; Headquarters and local G.P.O. staffs, and many others. The Company was represented by the Works Manager, Air Commodore W. C. Cooper and the Assistant Manager, Mr. F. Limb.

Arrangements were made whereby the operation of a switch by the Lord Mayor at a table on the ground floor gave the signal for cutting out the old exchanges, and the operation of a similar switch by the Postmaster General signalled the introduction into service of the new equipment. The latter ceremony is shown actually taking place in the illustration in which, also, Mr. H. C. Andrews the Cardiff Telephone Manager may be seen reporting the procedure through a microphone connected to a public address system installed throughout the building. The small switchboard beneath the window is one of two used for staff communications during the cutover, the operators having access to the old Park Street and Relief exchanges as well as to key points on each floor of the new building.

The operation of the switch by the Lord Mayor caused red lamps to glow on a

Fig. 10—Civic Ceremony at the Cutover

The Postmaster General (The Rt. Hon. the Earl de la Warr, P.C.) giving the signal to bring the new exchange into service.

(Reproduced by kind permission of Western Mail & Echo Ltd.)

transfer control desk and in a dining room on the fourth floor where the guests were assembled, as well as on the ceremonial table. On completion of the cut-out, a key operated by the engineer-in-charge at the control desk caused the red lamps to be extinguished, whereupon, at 1.36 p.m., the Postmaster General, with the words " I declare the new exchange open ", operated a switch to cause green lamps to glow and give the signal for the new equipment to be brought into service. Incidentally, the manual switchboard portion of this zone centre exchange was brought into operation earlier in February, the trunk and junction circuits being gradually transferred from the old trunk exchange.

The conversion of Cardiff to automatic working will expedite the automatization of the immediate area ; Llandaff, now a C.B. exchange accessible from Cardiff second selector level 75, is scheduled to become a satellite on Cardiff in the near future, the order for this contract having already been placed with the Company.

We are indebted to the Engineer-in-Chief of the British Post Office for permission to publish this article, and for the use of photographs.

Birmingham Science Museum Exhibit

THE City of Birmingham played a vital part in the Industrial Revolution and in 1950 the authorities acquired premises in Newhall Street where specimens of old machinery and craftsmanship could be preserved ; not as mere museum pieces but as an historical background to throw into prominence the products of modern science and industry.

The style of the traditional museum has been replaced by an exhibition display technique which imparts knowledge, without conscious effort from the visitor, by sustaining a high level of interest.

This new Museum of Science and Industry is being opened section by section, and not only will it be a permanent centre of instruction for the general public but one of inspiration and guidance to the younger generation and of introduction to other fields for those already engaged in particular branches of science or industry.

The Company agreed to present an exhibit for the section recently opened to deal with light engineering ; the subject chosen by the museum authorities, to fit into the planned display sequence, being relays and their technicalities.

This is not an easy subject, for a relay is not spectacular in its operation ; its mechanical and electrical design provide little that can be made interesting to the layman and its small size makes an effective display difficult.

With so little to rouse the desired degree of interest, a considerable reliance on display aids was inevitable but these had to be very carefully chosen otherwise the essential balance between the instructional and the spectacular would not be achieved. One of these aids takes the form of a supplementary display which, by entertaining the visitor, produces a lasting impression of the versatility of relays and of the exhibit as a whole, but its form is such that the scientific standard is not lowered.

The apparatus is housed in a T shaped cabinet of modern design with a light oak finish and dark green facings. One side presents the instructional aspect (Fig. 1) and the other the supplementary display (Fig. 2).

The Instructional Side

This consists of three panels behind a single sheet of plate glass which is set at an angle to avoid reflections. A hand rail ensures the correct viewing distance and at

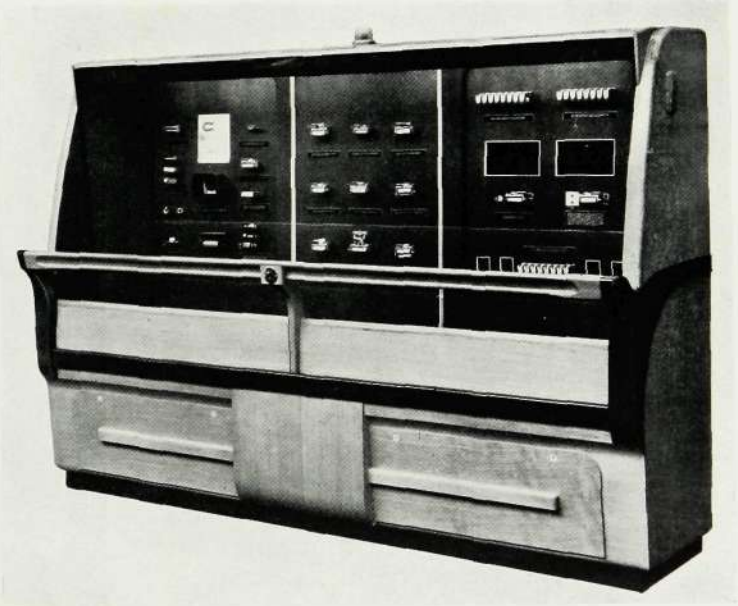


Fig. 1—The Exhibit. Instructional Side

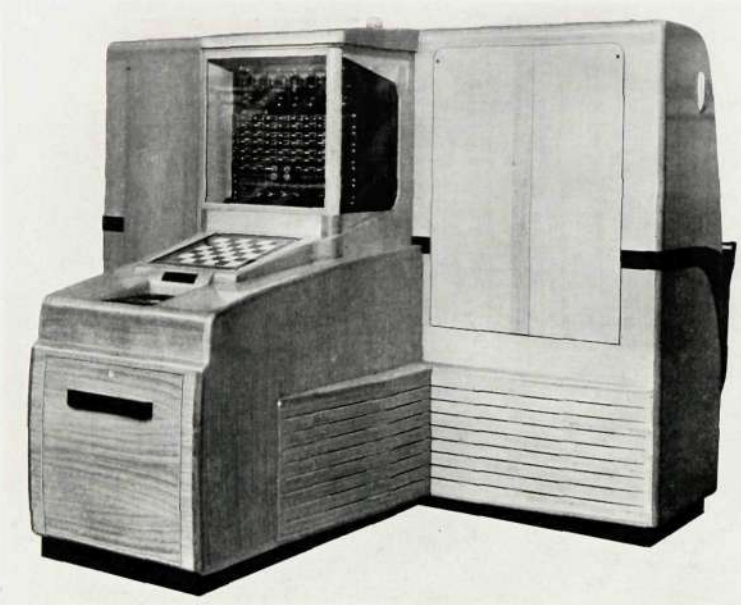


Fig 2—The Exhibit. Supplementary Display Side

its centre a push button is fitted. Momentary operation of the button brings into action equipment mounted in the base of the cabinet and controlling the display, which lasts for a period of two and a half minutes. The left hand panel (Fig. 3) illustrates how the constructional details of a relay are related to its electromagnetic principle.

The viewing sequence starts at the top centre with a brilliantly coloured plaque explaining magnetic flux and continues with a working model of an electro-magnet using the simplest of components, and various units illustrating the gradual build-up of a relay from its component parts. The sequence ends with a complete relay which is operated and released at short intervals and is viewed through a magnifying lens. The relay is mounted on a vertical translucent screen—in such a way that the supporting bracket and the wiring to the coil are not seen—and is illuminated by concealed direct lighting. Coloured light diffused through the screen silhouettes the relay and makes the action of its armature and springs clearly visible. An attractive effect is obtained by the lighting combination, as the relay casts no shadow and appears to be poised in mid-air.

The centre panel (Fig. 4) carries a static display of relays, including those for special purposes. The right hand panel (Fig. 5) deals with the electrical characteristics of a normal relay and illustrates how these are modified by circuit arrangements.

Where the speed of operation or release is demonstrated, a chain of relays is used to amplify the brief time periods. Each relay operates the next, and the last one releases the first, thus a cyclic ripple of operate and release movements passes through the chain. The light-conducting property of perspex is used as a display aid. If a rod of this material is highly polished and a light source such as a glowing lamp is placed at one end,

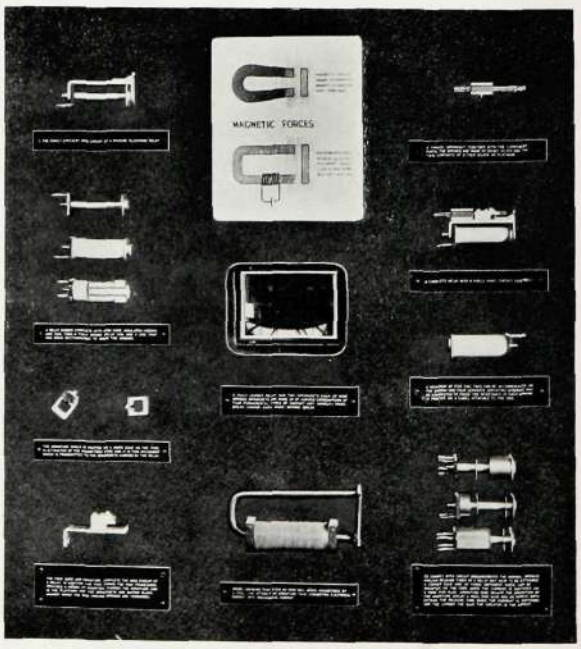


Fig. 3—Left-Hand Panel of Fig. 1

the light is barely discernible along the length of the rod but the other end emits a glow of the nature of fluorescence. One of these rods is fitted under each relay, and coloured lamps, concealed behind the panel, glow at the ends of the respective rods when the relays operate, so that a ripple of light moves along the tips of the rods in phase with the mechanical movement of the chain and allows relative time periods or changes in these periods to be readily discerned.

Two chains at the top of the panel show the differences in characteristics brought about by a fore-end slug and a heel-end slug, respectively, while at the bottom of the panel another chain, comprising unslugged relays, is used to demonstrate the change in releasing times when a relay is shunted by a resistor or rectifier. The bottom chain is operated under four circuit conditions, each persisting for a short period. The first is without shunts, the second with a high resistance across each relay, the third with a low resistance, and the fourth with a rectifier. Four slides, two on each side, show these conditions in the conventional circuit symbols and the appropriate slide is

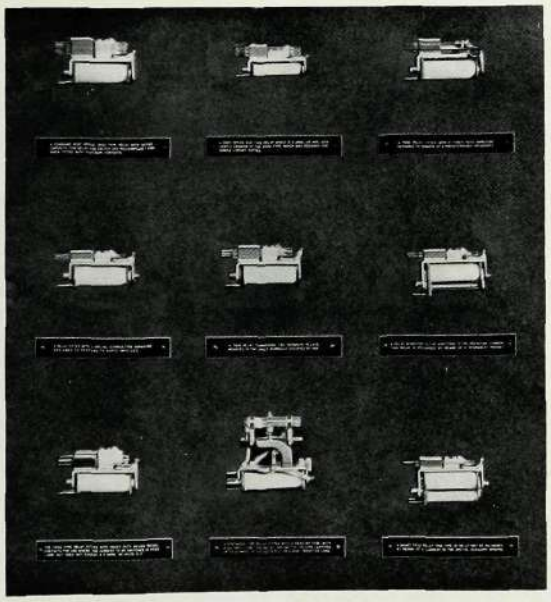


Fig. 4—Centre Panel of Fig. 1

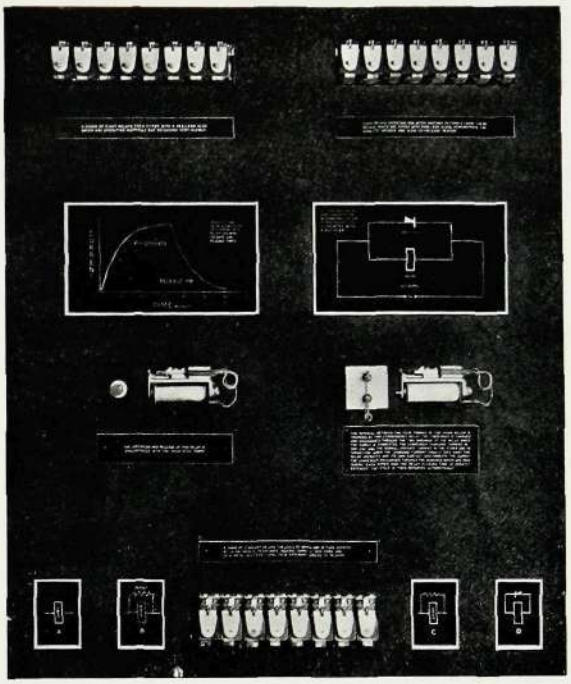


Fig. 5—Right-Hand Panel of Fig. 1

illuminated as the chain operates under the condition depicted.

In the centre of the panel are two diagrams. That on the left hand illustrates the rise and fall of current through a relay coil during operate and release, the diagram being illuminated except for the path of the curve. Then the part indicating the current rise is traced in red light slowly from its origin to the point of maximum current. When fully lit, this part is extinguished and the remainder of the curve is instantaneously outlined in amber light which is then slowly extinguished from the peak downwards. Underneath the diagram is a relay which is synchronized with the display so that it operates and releases when the illumination of the curve reaches the appropriate marked points. The operation of the relay is made more readily apparent by the glowing tip of a column of perspex which is mounted near the armature.

The right-hand diagram shows how a relay can be made to operate satisfactorily on alternating current by means of a

rectifier shunt. The path of the current from the alternating current source is slowly traced by light ; firstly in the direction in which the rectifier conducts, then in the opposite direction when the current passes through the relay.

Underneath this diagram is a circuit element consisting of a relay and capacitor which together control the application of the four circuit conditions to the bottom chain. The associated caption explains how long operate and release times are obtained from a normal relay by such a circuit arrangement.

The panels are finished in green crackle paint and the surrounding frames and sides are " flock " sprayed in dark brown, giving a cloth-like appearance. Concealed overhead fluorescent tubes are used as a general illuminant and every component on the panels is mounted so that its shadow enhances the appearance of the exhibit.

Supplementary Display

This takes the form of a game-playing machine with one of the visitors as the opponent, for nothing is more certain to excite the public interest, providing that the game chosen fulfils the following conditions : It must appeal to all ages ; must not be too protracted ; must have an element of skill and, although the machine plays as an expert, it must be possible for the player to win.

These conditions are met if the familiar draught-board game of " fox and geese " is played on a reduced size of board ; one of six squares each side instead of eight (Fig. 6).

The game is played on the white squares and the machine plays the three pieces representing the geese while the player controls one piece—the fox. A move is one step by one piece along the white diagonals ; the geese can move forward only, but the fox may move in any direction. The player can choose from which of his three starting squares the fox commences, and the game ends in a win for the machine when the fox cannot be moved because the adjacent square, or squares, are occupied by the geese, or in favour of the player when the fox breaks through the line and reaches one of the squares from which the geese started.

The machine operates in such a way that once contact (as it were) is made with the fox, the player is forced on the defensive and his counter-moves are dictated by the machine. This leads to thirteen possible end-games of which one is a win, after thirteen moves, for the player.

The relays and switches of the machine are mounted in a compartment illumined by concealed fluorescent tubes and having a glass front and sides so that the operations can be observed during the course of the game. The equipment is made attractive by a glossy black finish on the mounting plate and switch frames, by highly polished plating on the relay armature and by leaving the relay slugs in their natural copper colour. The moving light reflections from the armatures make the relay operations clearly visible.

Fig. 6—The " Fox and Geese " Game Feature

The draught-board is mounted on a slight slope and the position of a piece is indicated by the appearance of an illuminated disc—of red colour for the fox and green for the geese—in the centre of the square concerned.

Three buttons below the board serve the dual purpose of starting the game and of allowing the player to select the starting square in which the fox shall appear. Conveniently placed for the player's hand is the mechanism by which he controls the fox's movement. It is designed so that the natural action of moving a piece is simulated ; the player can watch the board and make his move without consciously relating the movement of the mechanism to the position of the red disc on the board. The device consists of a mimic piece fixed to a movable sheet of plain glass covering a pattern of five white squares. The piece normally rests over the centre square and can be moved to any of the diagonal positions. The resultant movement of the glass not only enables the illusion of an unattached piece to be achieved, but is also used to operate a robust but simple concealed mechanism which closes a single make contact associated with the square chosen. When the piece is released, it is returned automatically to the centre square and as this occurs the machine responds to move the fox.

The mechanism merely indicates the diagonal along which the fox's move is to be made and the machine relates it to the current position of the red disc. If it is to a square occupied by a goose or is in such a direction that the fox would go off the board—moves which are not permissible—the red disc reappears in its original position. Having moved the fox, the machine makes its own move with one of the geese.

When the game is completed, a " player win " or a " machine win " indication is given by means of glowing lamps behind a stencil recessed into the lower border of the draught-board ; the control mechanism is rendered ineffective and the final positions of the pieces are held illuminated for 15 seconds, after which the equipment returns to normal, ready for the next game.

Should the player take longer than one minute between successive moves, or abandon the game, it is cancelled and the equipment returns to normal, but a " ten seconds " indication is given on the recessed stencil at the beginning of this time interval before cancellation takes place.

Power Supply, Fusing and Alarms.

The exhibit is entirely self-contained and the only external connection necessary is to the mains. The relays in the displays and in the control relay sets are energized from a 10-amp. eliminator fitted in the base of the supplementary display section, while the current for lighting the instructional display aids is from a 12-volt mains transformer.

A fuse panel is mounted in the base on the instructional side, and in the event of a fuse being blown a visual indication is given by a lamp on the top of the cabinet, in addition to an audible alarm.

As uniselector magnets are not self-protecting, should one become energized for an abnormal time its circuit is broken and an alarm is given. Attention has also been paid to the dissipation of heat within the cabinet which is so constructed that an internal air circulation is maintained between the fine louvres seen in the base in Fig. 2, and vents in the top.

The general public has shown great interest in the museum as a whole, and the Company's exhibit has attracted considerable attention, which seems to indicate that the objectives of the authorities and the designers have been achieved.

The Teletone Transmitter

THE distribution of supply services such as electricity, gas, water, etc., often necessitates the installation of some kind of control equipment for which, either because of its location or nature, it is uneconomic to have an engineer in attendance. This equipment is usually concerned with regulating the supply to the demand and, in general, is designed to cover a comparatively short range below and above the average requirements, so that the size and cost of the plant can be kept within economic limits ; storage being arranged wherever possible to cater for short periods of exceptional demand.

A natural concern over these isolated units must always be felt by the staff responsible for maintaining the particular service, especially when heavy demands are

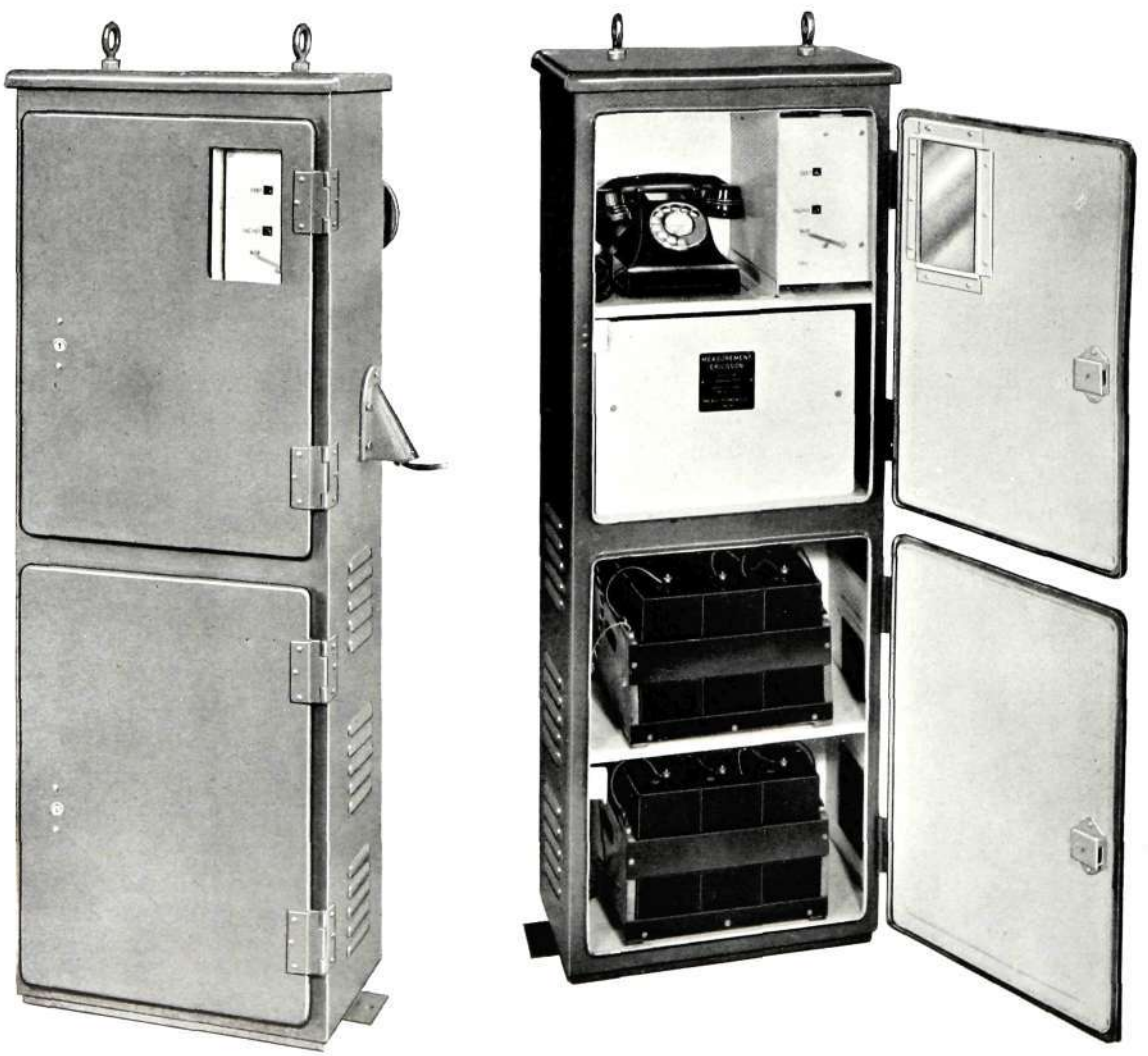


Fig. 1—Water Level Indicating Unit Incorporating the Teletone Transmitter

expected, and in consequence various schemes for automatic supervision in the form of tele-metering and remote control apparatus have been evolved. Apparatus of this nature has been produced by the Company in collaboration with Messrs. Measurement Ltd., of Terminal House, Grosvenor Gardens, London, S.W.1., over a period of several years, and the facilities which have been asked for cover a very wide range, but analysis shows that a large degree of standardization can be achieved, with the result that most, if not all, of the requirements of a particular application can be met by one of a limited series of standard equipments.

A recent addition to the series is the teletone transmitter, developed in the first instance to indicate to a remote control point the level of water in a reservoir, although it can equally well be used for other purposes. Connected to any line capable of being used for the transmission of speech, this equipment gives supervision at minimum cost.

Briefly, the *modus operandi* is as follows :

When the officer responsible wishes to check the water level at the reservoir he initiates a telephone call to the site. The line terminates at the teletone transmitter equipment which is arranged to respond by returning pulses of tones of two different frequencies to indicate the level of the water in feet and inches.

EQUIPMENT.

As most unattended sites are rather exposed, it is necessary for the equipment to be housed in a robust, weather-proof container such as that shown in Fig. 1. The metal cabinet has two doors, the lower one giving access to the power equipment and the upper one, which has a small glass panel, giving access to the main equipment.

Power, in the particular case concerned, is obtained from a battery of modern type dry cells which it is estimated will have a life of seven or eight years, based on the reasonable assumption that an average of two calls per day would be made. However, the battery compartment is suitable for the accommodation of secondary cells should these be preferred.

In the upper compartment are housed the teletone transmitter made by the Company for Messrs. Measurement Ltd., a telephone instrument, and a position indicator switch displaying behind the glass panel of the door, not only the water level in feet and inches but also a pointer which indicates whether the level is rising or falling.

The position indicator switch comprises a cyclometer type of mechanism operating two rotary switches and driven by a flexible coupling connecting it to the spindle of a four-inch main-drive pulley located outside the cabinet and directly above the water. The pulley and spindle revolve in response to the rising or falling of a float attached to one end of a stranded steel cable which passes over the pulley and is suitably counterweighted at the other end. This action operates the two rotary switches which have, respectively, rings of 25 and 12 contacts numbered 0–24 representing " feet " and 0–11 representing " inches ", to provide a visual indication, as previously mentioned, for the convenience of the engineer when visiting the site.

Although the equipment is normally unattended there are occasions during the periodic visits of the engineer when it may be necessary for him to receive or make a

telephone call. The telephone in the cabinet is provided for this eventuality. Calls which are made in the ordinary way for the purpose of checking the water level can be answered by an engineer in the vicinity if an extension bell is installed to warn him of the call, in which case, when the handset is removed the automatic transmitter is released and the instrument is connected to the caller.

signals, a high tone (400 c.p.s.) being used for " feet " and a low tone (133 c.p.s.) for " inches ". The number of pulses of each transmitted to line depends upon the water level registered by the indicator switch mechanism, and as it was not considered desirable to transmit two-digit numbers in " tens " and " units " form, the complete number is counted out in units, a zero reading being indicated by a prolonged

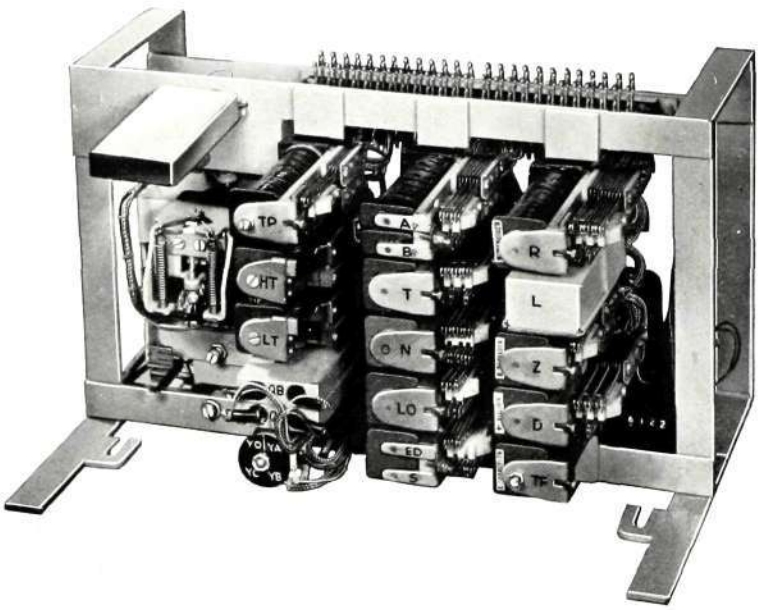


Fig. 2—Teletone Transmitter Unit. Relay Side.

The teletone transmitter, views of which are shown in Figs. 2 and 3, is very compact and is composed of standard telephone-type equipment. The wiring terminates on multi-point jacks which mate with plugs attached to the flexible cable tails from the position indicator switch and enable the teletone transmitter to be easily removed so that maintenance can be carried out in any convenient place.

Two relays are included in the transmitter unit to provide tones for the pulse

pulse—in this case, two seconds as compared with the normal pulse of 250 milliseconds.

A satisfactory transmission speed for accurate counting was found to be two pulses per second with a two-seconds pause between feet and inches, and to preclude the possibility of error, the complete indication of the water level is repeated twice, with intervening pauses of five-and-a-half seconds, after which the apparatus automatically releases.

Circuit Principles

The transmitter basically consists of a uniselector stepped by a pulsing circuit which is capable of two pulsing rates i.e. one per half-second or one per two seconds. In the former case a " pip " of tone is transmitted to line each time the uniselector wiper moves over a contact in either the feet or inches group until the position indicator switch marking condition is encountered. The pulsing is then reduced to the slower rate so that there is an interval of two seconds during which the uniselector self drives over the remaining contacts in the group, in preparation for the receipt of further half-second pulses. The interval is adequate, as a uniselector can normally drive over about 66 contacts in two seconds.

When the first complete feet-and-inches indication has been transmitted the switch steps over seven contacts before re-starting the cycle, and this, at two steps a second, increases the pause period to $5\frac{1}{2}$ seconds. The relevant tone relay is operated continuously during the period in which the uniselector is stepping from the first to the marked contact in each group, and the use of the pulsing circuit to control the tone transmission as well as the uniselector stepping enables the pulse length to be easily increased to two seconds for zero indications.

As far as possible it is arranged that the apparatus releases automatically should the caller clear before the three complete cycles have been transmitted, though in practice it is found that the need for this rarely arises. Provision is also made for the registration of all calls incoming to the transmitter and this feature should be of use in determining how often batteries at particular installations need to be replaced. The Company's teletone transmitter circuits have been the subject of considerable development over a number of years and it is obvious that they have quite a wide sphere of application. They are covered by British Patent No. 661,103.

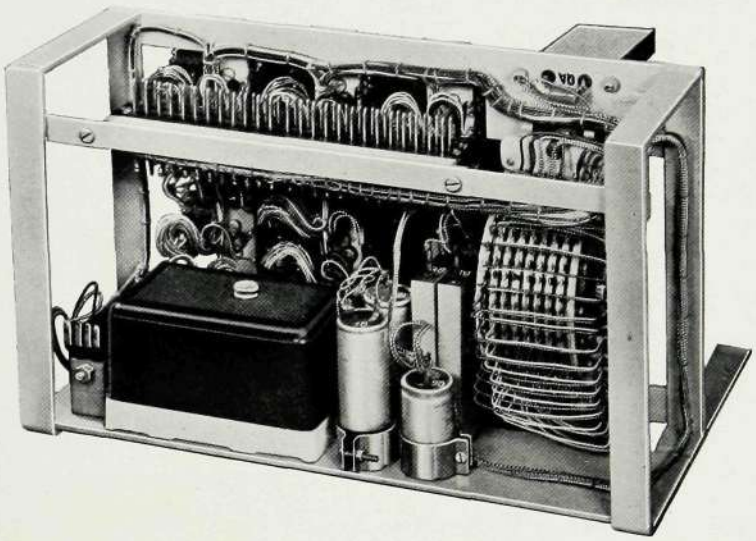


Fig. 3—Another View of Fig. 2 Showing Wiring Arrangement and Terminations

Automatic Telephone Exchanges for Cable and Wireless Ltd., Cyprus

DURING the present century there has been a marked rise in the level of education of the population in territories which, in comparison with western standards, are undeveloped. Contributory factors in this rise have been the gradual influence of personnel sent into the territories to supervise industrial or commercial interests, improved communications which have gradually eliminated physical and cultural barriers, and the impact of two world wars on the economic life of the communities.

At the same time there has been an acceleration in the rate of scientific progress in the world generally, and a higher standard of technical education has become necessary. The problem of training local technicians to maintain modern equipment still exists in territories where facilities for the more advanced forms of education are not available.

Cable and Wireless Ltd. operate the telecommunications in Cyprus and their arrangements for training local personnel to maintain their B.P.O. "2000-type" automatic exchanges are briefly described below. We have been favoured with the contracts for the exchanges at Nicosia, Limassol and Famagusta, and the Government P.A.B.X. at Nicosia. At the time of publication these exchanges will have been handed over to Cable and Wireless.

The island of Cyprus, 35° north of the equator, is at its nearest point only about forty miles from Asia Minor and about two hundred from Port Said, consequently the principal languages are Turkish and Greek, but English and French are also spoken by the educated classes. Education, although Government controlled, is provided by the various religious denominations at elementary and secondary schools, and some eighty thousand of the island's population of nearly half-a-million are attending these schools.

Nicosia, the capital, is increasing in importance with the development of air transport. It is becoming one of the main junctions for middle east traffic ; a circumstance that has made efficient telecommunication imperative. The new exchange caters for 2,300 multiple lines, while the town of Limassol and the main seaport, Famagusta are each provided with a new

Fig. 1—Nicosia Auto Exchange Building

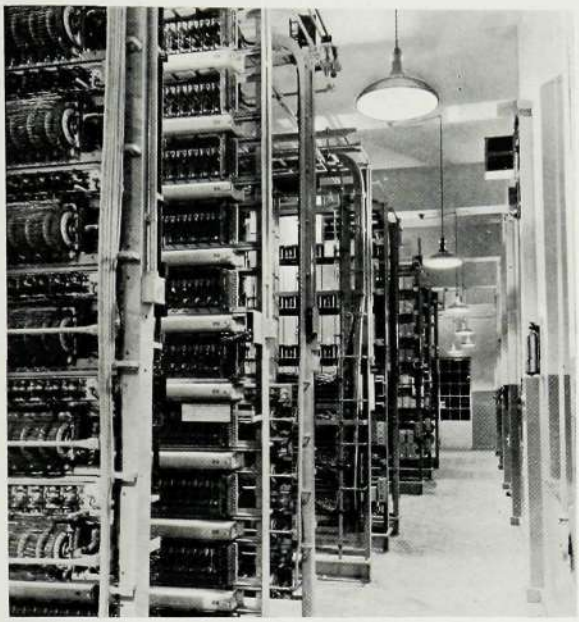


Fig. 2—Auto Equipment at Nicosia Exchange

1000-line exchange. The Government P.A.B.X. in Nicosia is equipped for 400 multiple lines.

TECHNICAL DETAILS.

As the principles of the standard B.P.O. " 2000-type " system are familiar, it is unnecessary to describe the equipments in detail, more especially as the three larger exchanges are basically the same, excepting the number of lines. A summary of the Nicosia equipment will therefore suffice.

Trunking provides for an initial equipment of 2,050 working lines, including 20 coin box, and for an ultimate of 3,700 lines.

The system is based on the use of 25-point uniselectors with 200-outlet first, second and final selectors, excepting the 100-outlet second selectors for special services which comprise enquiry (level 91) faultsmen (level 96) test desk (level 97) and emergency (level 99).

Subscribers' meters are provided and there are at present one large P.B.X., two 2/10 P.B.X. and nine ordinary final selector groups with banks multipled in sets of 25, 30 and 40, respectively ; however, space for the extension of the ordinary and P.B.X. 2/10 multiples has been allowed, to cater for possible development.

Contrary to modern practice, grading facilities are provided on separate frames and not on the group selector racks, but while this allows less flexibility for dealing with unexpected alterations in traffic and involves greater labour costs when extension equipment is being installed, it has the merit of presenting a clear picture of the grouping and grading ; an asset of particular value where local maintenance staff has to be trained from first principles.

Subscribers dial " O " to obtain access to the switchboard for trunk or toll calls, all of which are operator controlled as there

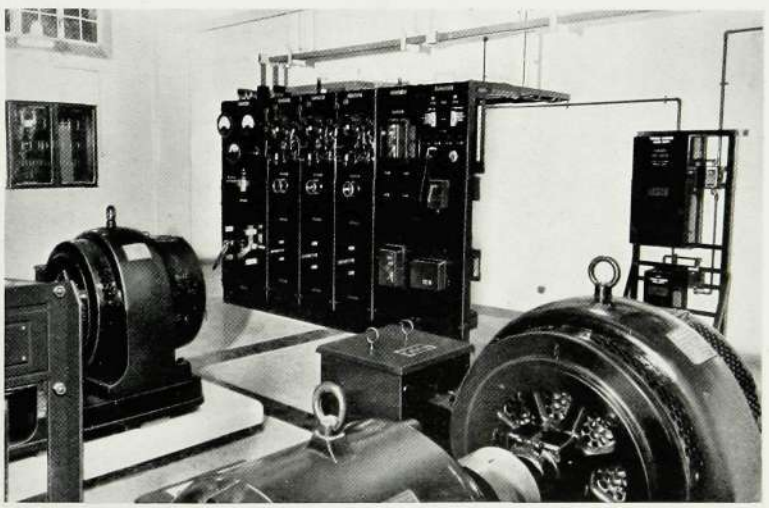


Fig. 3—Part of the Power Room—Nicosia

Fig. 4—Manual Switchroom—Nicosia

is no provision for direct dialling to other exchanges. The seven-position board is of the standard British Post Office sleeve-control type, with time check facilities on seven of the fifteen cord circuits equipped on each operator's position, and a multiple consisting of 120 answering and 140 outgoing junction F.L.S. circuits, both in a four-panel appearance, the first answering jack in each panel being allocated for delay transfer purposes. Forty bothway generator signalling trunks are available for the external traffic, but extension to sixty circuits can be easily arranged, as extra line protectors and T.J.F. jacks are already fitted and wired.

Operator access to the subscribers is obtained through manual board second selectors, and service efficiency can be checked at an observation desk in a partitioned corner of the manual room. The desk equipment includes a panel containing lamps which illuminate stencilled figures corresponding to the digits being dialled by the caller, and facilities for holding the connection if it is desired to trace back. Connections for observation are established by means of flexible cords and plugs at the M.D.F. in the usual manner.

Other items of exchange equipment include a standard one-position test desk and four portable sets for routine testing, respectively, group selectors, final selectors, subscribers' meters, and M.D.F. heat coils fuses and cords. Traffic recording and fault alarm equipments are also provided in accordance with standard practice.

The exchange is powered by a divided battery float system with automatic voltage control. The capacity of each main battery is 800 a.h.—ultimately 1500 a.h.—whilst the motor generator output is 51 volts at 200 amps in the case of the two larger machines and 100 amps for the smaller one.

To prevent the breakdown of communications in the event of the failure of the mains supply, standby equipment is provided in the form of an alternator set which is driven by a six-cylinder, 56 b.h.p. diesel engine. The alternator output of 37 k.v.a., 380/400 volts is controlled by an Isenthal automatic voltage regulator flexibly coupled to the exciter.

Installation, and Training of Personnel

The exchange building has a prominent site close to the historic Paphos Gate in the ancient walls surrounding the old town. The basement and ground floors accommodate the power and automatic plant, also carrier equipment, while the trunk switchroom is on the second floor.

It was arranged that local labour should be employed for the installation and testing of the various equipments, under the supervision of our representatives. Sixteen youths-in-training were provided by Cable

and Wireless Ltd. with the object of giving them experience to enable them ultimately to carry out maintenance duties, while other (unskilled) labour was made available as the circumstances required, for unloading, erecting, cable running etc. The youths-in-training have a good knowledge of English and were instructed by Cable and Wireless officers in the principles of magnetism and electricity, manual telephony and automatic switching systems, but there had previously been no opportunity for practical experience in installing, testing or adjusting equipment in a modern automatic exchange. This experience was gradually imparted by four, later increased to six, of our staff as installation proceeded. The trainees were eager and hard-working and had obviously assimilated their earlier tuition, for they mastered the technicalities of every phase of the work in the exchange very satisfactorily, although not all of them could be employed at Nicosia right through to the transfer, owing to their services being required at the Limassol and Government P.A.B.X. installations which began within a period of a few months of the start at Nicosia.

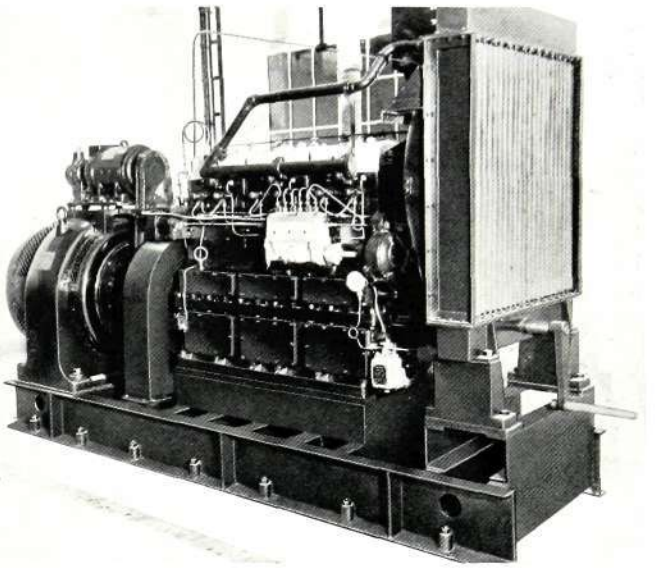


Fig. 5—Stand-By Alternator Set—Nicosia

While this may have caused the young enthusiasts disappointment, it did not curtail the period of tuition, as some of our men also were diverted to supervise these installations.

With regard to the unskilled labour, a certain amount of difficulty resulted from the fact that their knowledge of the English tongue was as rudimentary as our own staff's knowledge of modern Greek and Turkish, nevertheless progress was generally satisfactory.

The equipment was transported by road from Famagusta to Nicosia, and, despite the aids of baksheesh and repeated objurgation, both essential to most middle-east negotiations, it was with the greatest difficulty that dockers and drivers were persuaded to deliver cases in the stated sequence so that congestion at the site could be avoided. Fortunately, although the normal average yearly rainfall for the district is thirteen inches, and some of the work was done during the monsoon period, the weather was exceptionally dry and did not hinder unloading, as it often does in the tropics.

The external line distribution, and the installation of equipment at the subscribers' premises were carried out by Cable and Wireless staff. This entailed considerable work, as the existing system was magneto, but all difficulties were overcome and the new exchange was brought into service at 6.0 a.m. on Saturday, the 8th December, 1951. Much of the responsibility for the successful conclusion of this contract attaches to the staff of Cable and Wireless, Cyprus, whose co-operation and hospitality were invaluable. There is every indication that their careful instruction of the local trainees, augmented by the tuition from our staff, will ensure a high standard of maintenance at the various exchanges and good service for the subscribers.

We are indebted to Cable and Wireless Ltd. for permission to publish this article.

Physical Society Exhibition

OUR Research Laboratories showed several new instruments at the thirty-sixth Physical Society Exhibition which was held recently in London. This exhibition, which is held annually, includes instruments and apparatus representative of many fields of research and development, drawn from Universities, commercial organizations and Government Departments.

The equipment on our stand included apparatus making use of the recently-developed series of Dekatron valves, and a new polarized relay having unusually high sensitivity.

Fig. 1—All-Cold-Cathode Scaler

Among the instruments which were demonstrated may be mentioned an interval timer for measuring times between 1 milli-second and 10 seconds to an accuracy of $\pm$ 0.1 milli-second ; an add-on counter unit to which may be added as many counting decades as are needed for the particular application ; and an all-cold-cathode scaling unit developed in conjunction with the Atomic Energy Research Establishment, Harwell, and which is intended for routine application to particle counting problems.

Fig. 2—Interval Timer

Photographs of these instruments are shown, together with an illustration of the polarized relay, the performance and sensitivity of which are better than any similar relay previously available. The operating power required is less than 1 milliwatt, and two changeover contacts are fitted as standard. The relay is available in side-stable or centre-stable versions, for either plug-in or wired-in applications.

Fig. 3—Add-On Counter

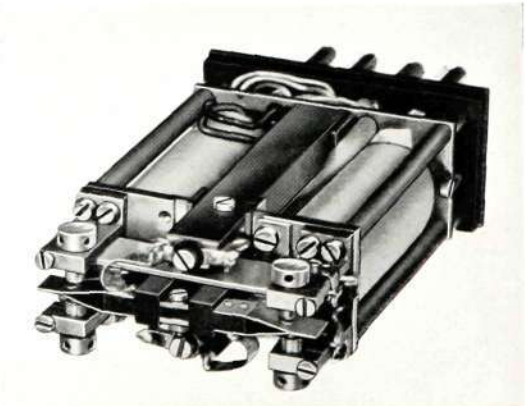


Fig. 4—Polarized Relay