THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

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THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

PERNAX

SHEATHING OF LEAD-COVERED CABLES, ETC. (Patent No. 318361)

THIS METHOD has now been in practical use long enough, and extensively enough, to enable us to claim that it

IS THE MOST EFFICIENT MEANS OF PREVENTING CORROSION OF ALL KINDS

THE LARGE CABLE, which is PERNAX SHEATHED over both Lead and Armour, is working at 6,600 volts in a severely corrosive situation (a Sewage Farm), where not less than three other types of Cables have previously been supplied, and each one has failed from lack of effective protection. These three Cables had an average life of under five months (viz., 3 months, 5 months and 6 months respectively).

THIS PERNAX SHEATHED CABLE, however, has been in use to date, for a period of two and a half years, without any visible deterioration, though tested frequently.

THE SMALL CABLE is a Dry Core Telephone Cable, of which a considerable quantity has been PERNAX SHEATHED, for use in conduits and direct in ground, under severe conditions of chemical corrosion.

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TOUGHNESS

and the simplicity of its application as a protective sheathing, without the need of further manufacturing processes, such as vulcanizing, has found much needed uses in regard to—

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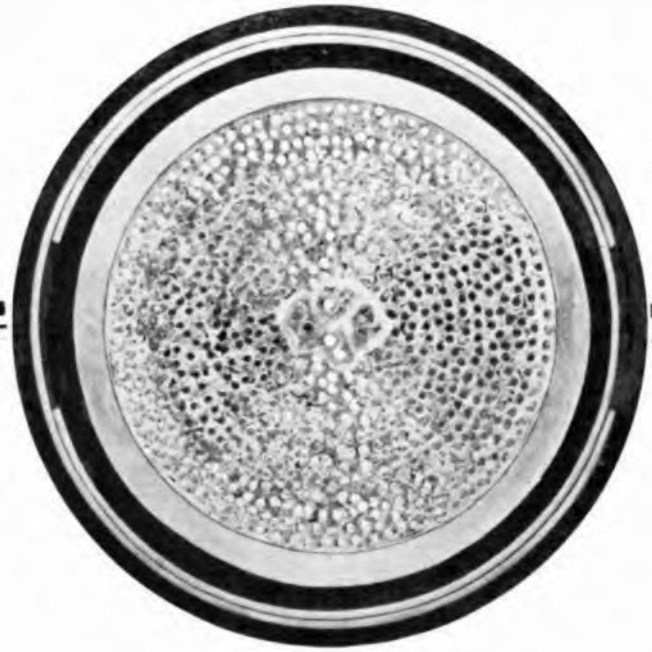


THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

Vol. XXVII July, 1934 Part 2

The Mersey Tunnel

A. J. PRATT, M.I.E.E., and
F. T. CHANY

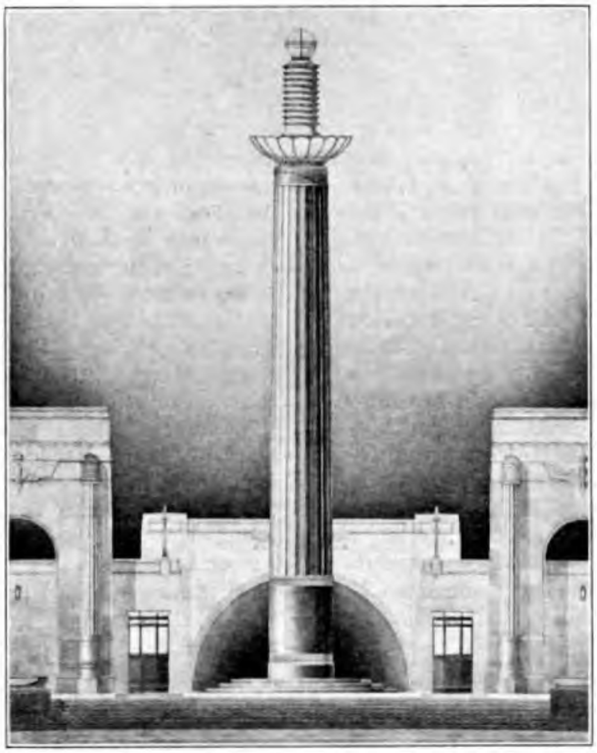
His Majesty the King will formally open the Mersey Tunnel in July

Inception and Purpose.

THE construction of the Tunnel was commenced in December, 1925, when compressed air was turned into the drills at the working shaft at George's Dock by H.R.H. Princess Mary, Viscountess Lascelles.

The Tunnel connects Liverpool and Birkenhead, and forms a link not only between these two Boroughs, but also with the general highways systems in Lancashire and Cheshire, and eliminates for all time the delay to cross - river vehicular traffic.

The construction of the Tunnel is authorized by the Mersey Tunnel Act of 1925, subsequently modified after further detailed study by the Mersey Tunnel Acts of 1927, 1928, and 1933 respectively. The Statutory Committee, known as the Mersey Tunnel Joint Committee, consists of ten members appointed by the Liverpool Corporation, and seven by the Birkenhead Corporation, with a Chairman and Vice-Chairman appointed by and from the members of the Joint Committee, but not both from the same Corporation.



The Mersey Tunnel.
The Old Haymarket Entrance, Liverpool.

Design.

The Tunnel is unique in conception and design. It may rightly be considered one of the outstanding engineering feats of the present century. It is not practicable in the space available to give an adequate and detailed description of the work or to do justice to those responsible for the organization and technical detail of this stupendous undertaking.

Fig. 1 shows the plan and sections of the tunnel. At the Liverpool end the main entrance to the tunnel is at Old Haymarket. The Birkenhead main entrance is at Chester Street. There are two subsidiary dockside entrances, one at New Quay, Liverpool, and the other at Rendel Street, Birkenhead. The ruling gradient is 1 in 30 with a gradient of 1 in 300 for approximately 560 yards under the river. The length of roadway from end to end of the through traffic line is 2.13 miles, and of the dockside line 2.08 miles. The combined length of the through roadway and dock lines together is 2.87 miles. The main portion of the tunnel is 46 feet 3 inches external and 44 feet internal diameter, with a roadway 36 feet wide sufficient for 4 lines of traffic, and is the largest subaqueous tunnel in the world. The width of the roadway in each of the dockside branches is 19 feet, sufficient for two lines of traffic.

Pilot Headings.

The first operation was to sink shafts about 200 feet in depth at George's Dock, Liverpool, and at Morpeth Dock, Birkenhead, and to drive from these

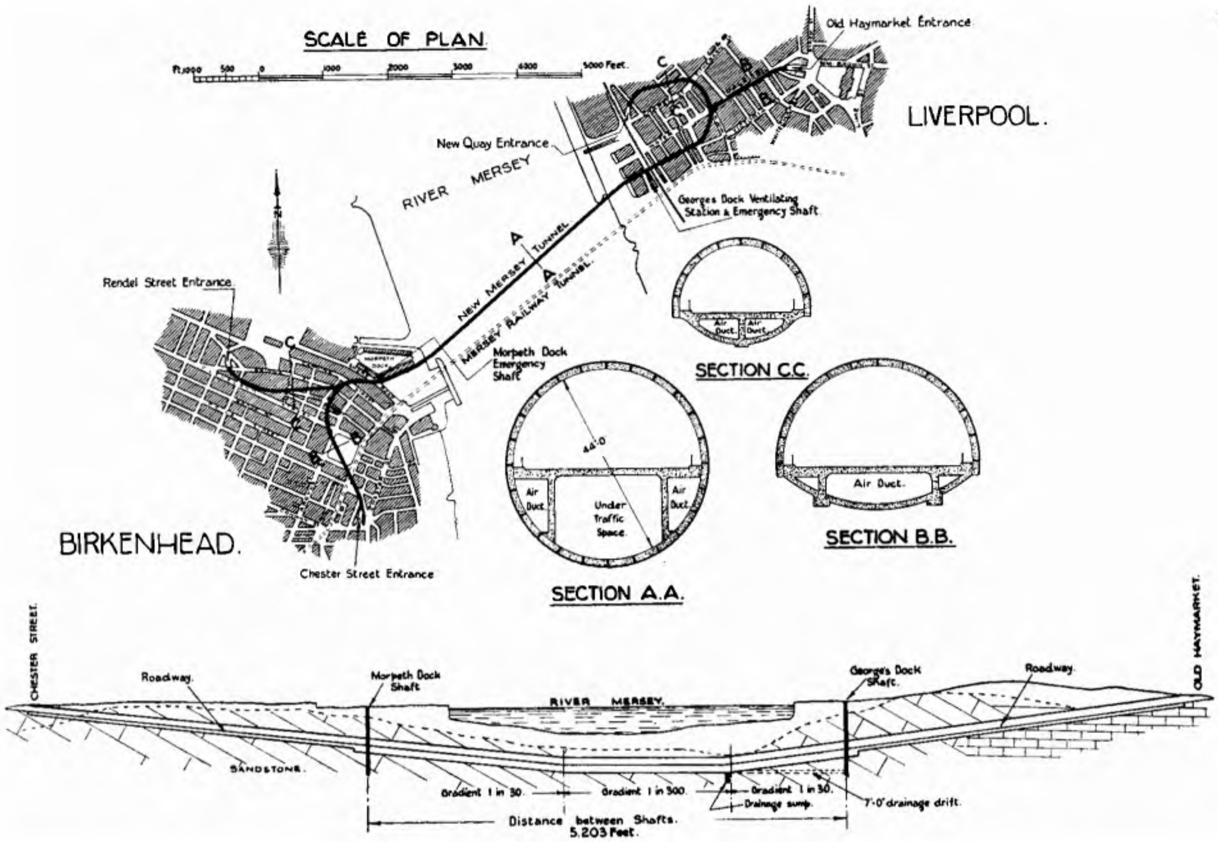


FIG. 1.—MERSEY TUNNEL, PLAN AND SECTIONS.

shafts, which are about a mile apart, small preliminary or pilot headings along the line of the future main tunnel in order to explore and prepare the ground prior to the execution of the full size tunnel. One of these pilot headings is shown in the centre of Fig. **2**. Its diameter approximates to that of the London Tubes. On April 3rd, 1928, the heading from Liverpool met that from Birkenhead almost exactly under the middle of the river. The accuracy of the survey work was such that the top headings met with a divergence of line, level, and length of $\frac{5}{8}$ inch, $\frac{1}{2}$ inch, and 1 inch, respectively; while for the bottom heading these divergences were $\frac{5}{8}$ inch, $1\frac{1}{2}$ inch, and 1 inch respectively.

Following the completion of the pilot headings, the work of enlarging the full size tunnel was commenced. This consisted of excavating the ground, mainly rock, and erecting the lining for supporting the ground.

Operation and Methods.

Fig. **3** illustrates this work in progress. The aggregate capacity of the excavation was approximately 800,000 cubic yards, representing a total weight of 1,200,000 tons of excavated material. The whole of the tunnel is lined with cast-iron segments bolted together and caulked. Between the cast-iron lining and the rock face, concrete was injected under air pressure. 82,000 tons of cast-iron were used in connexion with the tunnel lining and approximately one million bolts were used to connect the segments. Some idea of the difficult nature of the work can be formed from the fact that the maximum quantity of water pumped from the excavation during construction was no less than 4,300 gallons per minute, and that the total amount of water pumped from the commencement of the work to October, 1932, was 7,482,000,000 gallons, representing a total weight of water of 33,400,000 tons. For each ton of rock displaced and raised to the surface 26 tons of water had to be pumped to a height of some 200 feet. Despite the difficulties the average rate of excavation during the period of tunnel driving was over one ton of rock every two minutes during the period from June, 1926, to August, 1931.

The interior finish consists of cement rendering applied under pressure, waterproofed by bituminous emulsion, and finished with cream-coloured gypsum and plaster and transparent polish. To a height of seven feet above the footpaths, a dado of black glass outlined with steel strips is provided.

The permanent roadway consists of square cast-iron setts, the traffic lines being marked by amber-coloured rubber blocks set in the cast-iron.

Fig. **4** shows a portion of the Main Tunnel in perspective.

Fig. **5** shows the Old Haymarket portal during construction.

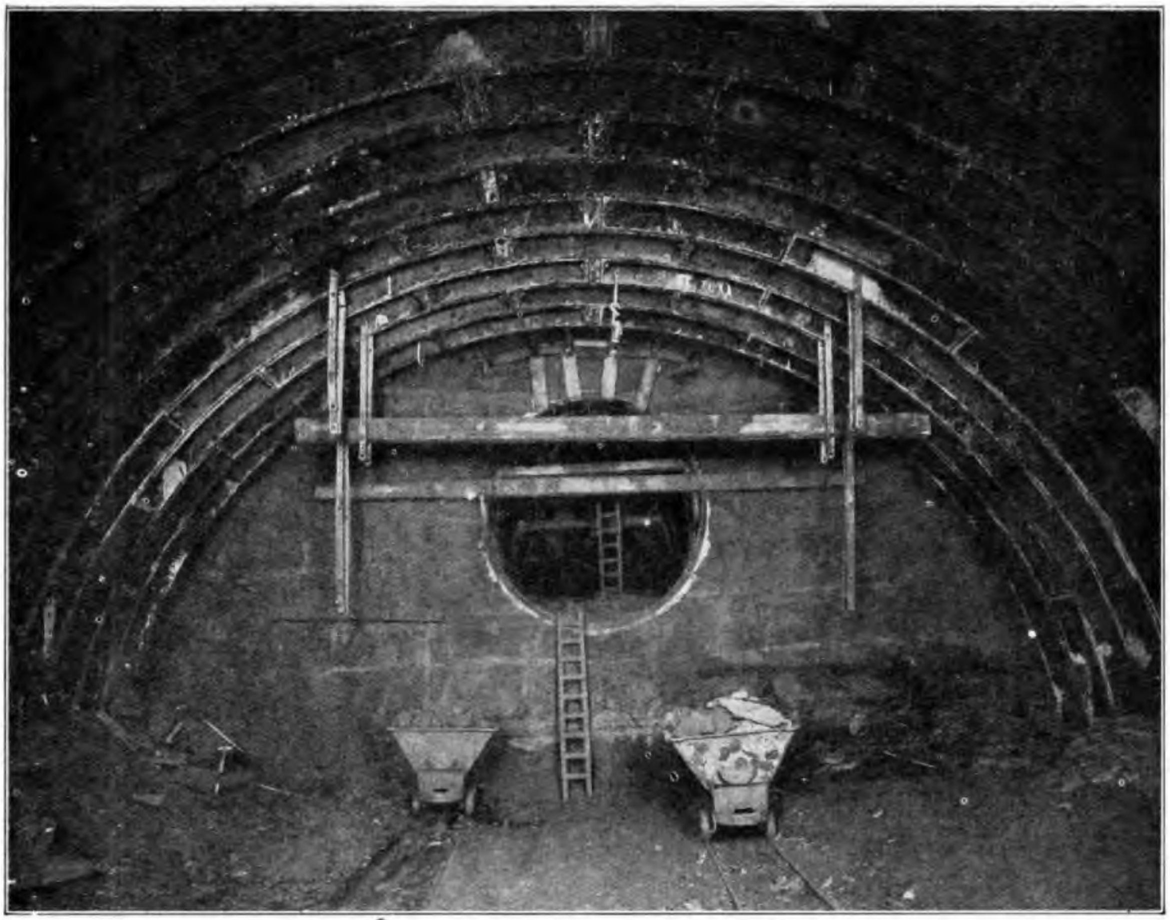


Fig. 2.—44-Foot Break-up, showing Pilot Heading.

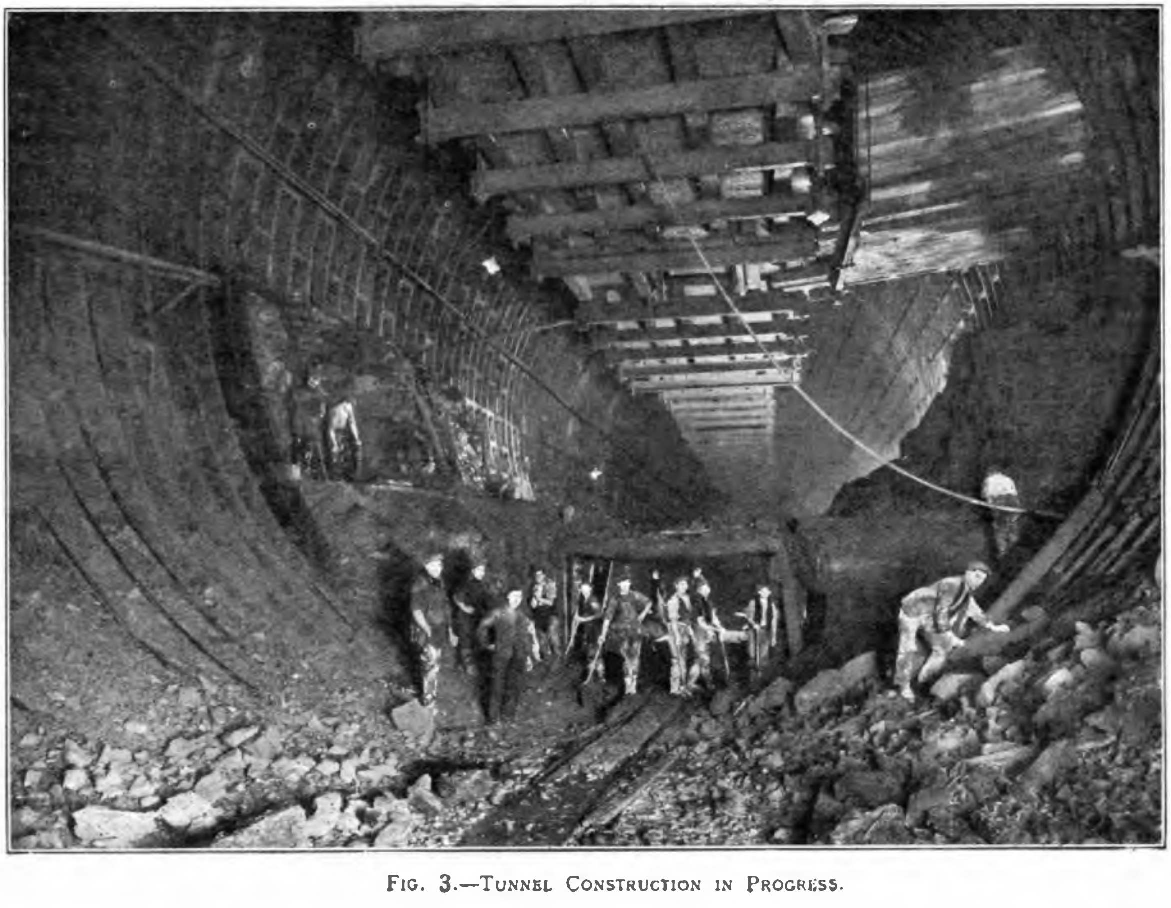


Fig. 3.—Tunnel Construction in Progress.

FIG. 4.—PORTION OF MAIN TUNNEL, IN PERSPECTIVE.

Ventilation.

Ventilation is provided by six surface stations, three on each side of the river, connected with the tunnel by means of vertical shafts and horizontal air ducts.

Fig. 6 is a photograph of the George's Dock Ventilating Station, Liverpool. The air ducts can be seen in Fig. 1, Section AA, BB, and CC. From these air ducts, the air is diffused by an ingenious arrangement of ports 18 inches apart and is expelled into the carriageway from a bell-mouthed expansion chamber immediately behind the kerb of each footway. By this means, an unbroken stream of fresh air is delivered into the tunnel at roadway level along its entire length. The vitiated air is exhausted through openings formed in the tunnel roof at each of the six stations. Fig. 7 shows one of the exhaust ducts in course of construction.

Blowing and exhausting are carried out at the six ventilating stations. The capacity of the six ventilation plants with all fans at work is 2,500,000 cubic feet of fresh air per minute delivered to the tunnel, and an equal volume of vitiated air is extracted. This will ensure that under normal conditions the proportion of carbon monoxide to air will not exceed 2½ parts in 10,000. The control of all the ventilating plant is in the hands of a single operator in a control room at the George's Dock Ventilating Station, Liverpool, and this operator is able, by means of various instruments, to vary the input of air in accordance with traffic requirements. To guard against any possibility of breakdown, the whole of the ventilating plant is duplicated.

Electrical energy for the operation of the Fan Stations is supplied by the Corporations of Liverpool and Birkenhead through four sub-stations, two in Liverpool and two in Birkenhead. These sub-stations are incorporated in the Ventilation Building, and are equipped with H.T. switchgear of the metal-clad type by which the 6,000 volts supply is controlled and distributed to the various driving equipments. Before use in the motors, the H.T. supply is transformed to 400 volts, at which pressure the driving units operate.

Two of the sub-stations, one at North John Street, Liverpool, and one at Sidney Street, Birkenhead, house transformer gear for supplying energy at 400 volts through cables laid in the tunnel to the ventilating plants at New Quay, Liverpool, and Taylor Street, Birkenhead, respectively.

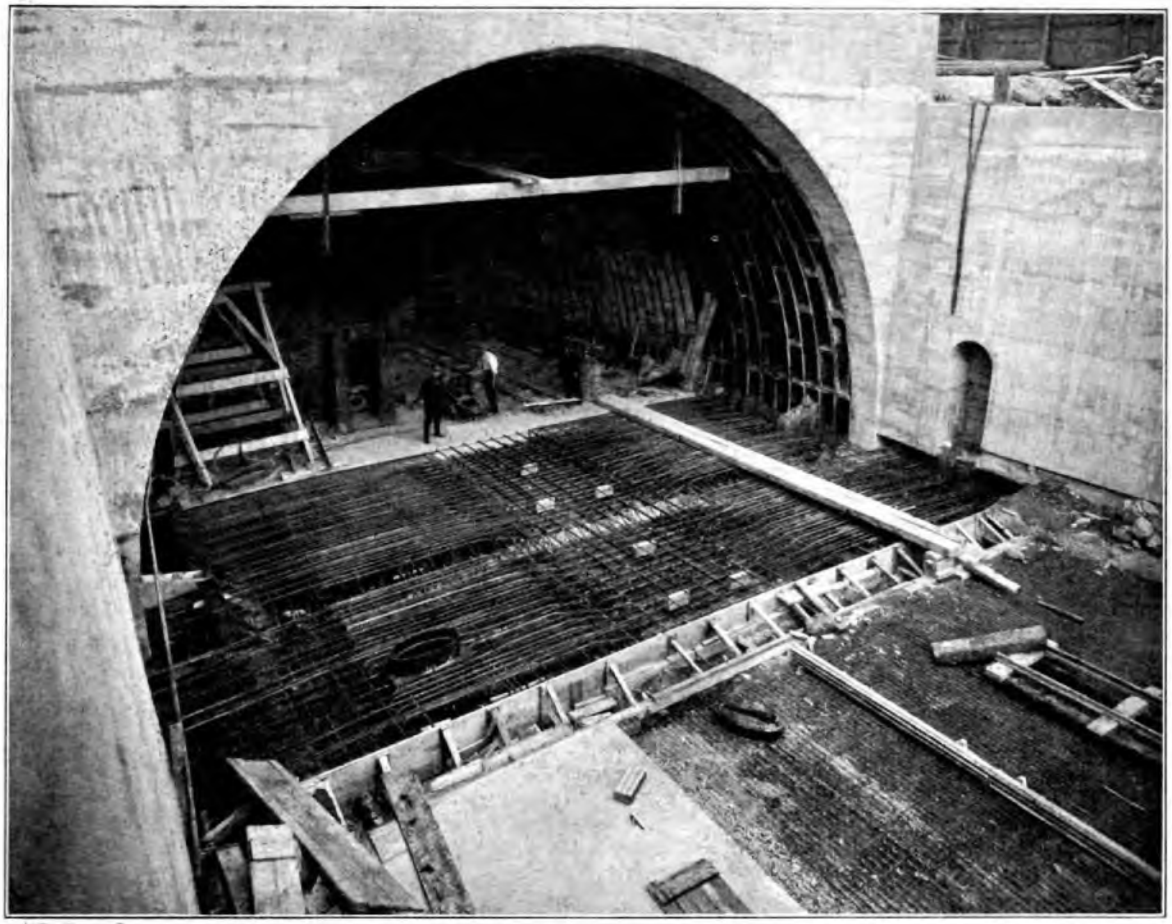


Fig. 5.—Old Haymarket Portal during Construction.

Fig. 6.—George's Dock Ventilation Station, Liverpool.

Lighting.

Lights are placed at 20 feet spacing on each side and the lighting system is so arranged that the total failure of illumination is practically impossible. Every tenth light on the Birkenhead side of the river is fed from the Liverpool Corporation supply, and a similar arrangement ensures that certain lights on the Liverpool side are fed from Birkenhead. Approaching the entrances from inside the tunnel, the spacing of the lights is reduced in several steps, so that the lighting may be adjusted, both day and night, to suit the external light and so obviate the blinding effect to drivers of vehicles which might result from the sudden change in the amount of illumination when emerging from or entering the tunnel.

Traffic and Emergency Arrangements.

At regular intervals of 150 feet spacing, staggered on each side of the tunnel, fire stations are placed, each containing a hydrant, extinguishers, sand bins, a fire alarm and telephone. In the event of a fire, the fire alarm is used to notify the control room, and also automatically to put into operation traffic signals placed at convenient points to control the traffic in such cases of emergency. The telephone is used by the patrol man to explain the nature of the fire to the control room operator, who, if necessary,

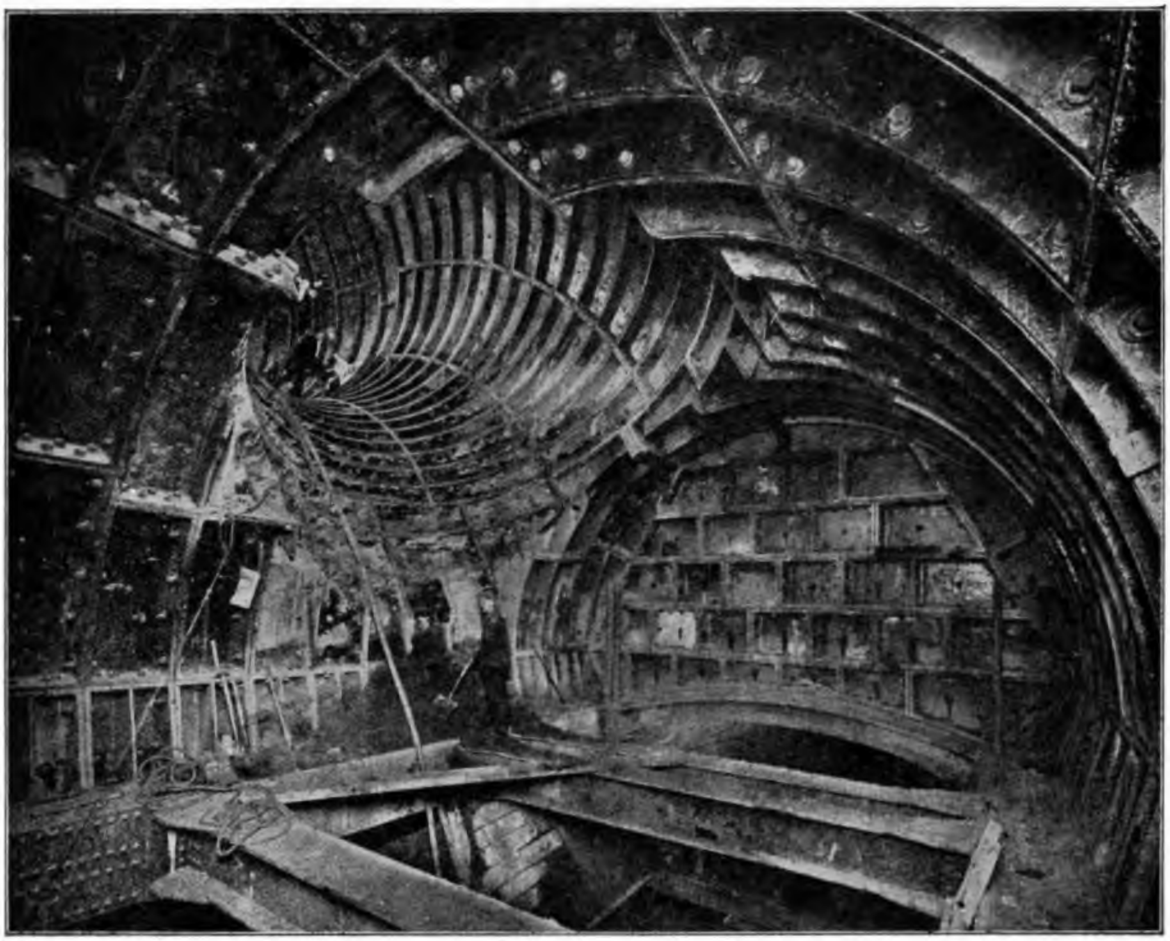


Fig. 7.—North John Street Exhaust Duct, during Construction.

calls in the Fire Brigade. The other apparatus is to be used in extinguishing the fire or controlling it, until the Brigade is able to reach the point.

Signs are also placed above these stations so that, should traffic be brought to a standstill, drivers of cars will be told to stop their engines and thus avoid emitting harmful gases. Further, at each junction chamber traffic will be controlled by automatic signals of the electromatic type now used at important crossings in many parts of the country. Should an occasion occur where it is necessary for people to leave the tunnel quickly, emergency exits have been provided at George's Dock, Liverpool, and at Morpeth Dock, Birkenhead.

Post Office Plant.

Accommodation.

The Corporations of Liverpool and Birkenhead were required by Act of Parliament to provide, when constructing the tunnel, such reasonable accommodation for the telegraphic lines of the Postmaster-General as shall be sufficient for twenty-five lead covered cables each with an external diameter of three inches.

It was essential to secure accommodation throughout for the full complement of cables, although new cables are not being provided immediately. The several circumstances associated with each point were carefully considered, however, to determine to what extent the provision of bearers and/or pipes should be made in the initial stage; the determining factors being economy in first cost and the security of the route for all time.

The scheme under review was unique in that problems associated with the accommodation offered, the arrangement and disposition of the cables, and the provision of adequate jointing facilities had to be considered as and when the constructional work of the tunnel progressed.

Although the construction of the tunnel commenced in 1925, it was not until 1928 that the first question involving essential constructional detail in respect of accommodation for the Post Office requirements could be discussed. At this stage, the construction of the subaqueous section of the tunnel was sufficiently advanced to permit of survey. The considerations involved in the selection of the cable route and the constructional details in this section are referred to later.

Lay-out.

It will be observed in Fig. 1, Sections AA and BB, that the cross section of the tunnel varies in shape at different points and is not circular throughout. The cylindrical section extends from George's Dock, Liverpool, to Morpeth Dock, Birkenhead. The extensions from these points to the respective entrances have a semi-circular upper traffic space with an oblate lower section. Had the tunnel been cylindrical throughout its entire length, the provision of cable accommodation would have been comparatively simple, but owing to the change in design in the extensions, and the consequent lack of adequate accommodation therein for the 25—3″ cables, the whole question of accommodation became complex. The position was further complicated owing to the lack of information regarding the constructional detail of the vertical ventilating and emergency shafts which were to be constructed extraneous to the tunnel proper but connected thereto by adits or subways, and through which it would be necessary to lead the cables from the tunnel level to the surface on each side of the river.

A great deal of thought and consideration was necessary and the ultimate condition had to be visualized in order to provide, at all points throughout the scheme, an orderly cable lay-out and a consistent numerical sequence of cables while at the same time securing the utmost economy in initial expenditure and subsequent maintenance. Regard had also to be given to economy in future cabling costs.

Schematic Diagram.

In order to appreciate the details of the arrangements, reference should be made to Fig. 8 which is a key index to the various points involved in the cabling scheme. The diagram shows schematically the changes in cable formation consequent upon the type of accommodation available at the various points.

Manhole, Liverpool.

At A is a line of 30—3″ screwed steel pipes embedded in concrete and terminating in a concrete manhole constructed immediately outside the George's Dock Ventilation Station, Liverpool. The use of steel pipes was rendered necessary owing to the excessive amount of water contained in the subsoil and every precaution had to be taken to prevent the accumulation of water in the manhole. It is, of course, imperative that in no circumstances shall water be allowed to enter the station through the Post Office pipes. Fig. **9** is a section of the manhole, the retaining and the station walls, and shows the arrangements provided at point B, Fig. **8**, to prevent the ingress of water to the station building. A $\frac{1}{4}$ inch steel plate, suitably drilled to accommodate 30 steel pipes, was provided, the pipes being welded externally to the steel plate. The plate was then set vertically in the retaining wall, served with a coat of bitumastic material, and the concrete restored to the full section of the retaining wall. The pipes were ultimately extended to reach the internal face of the building wall. The exposed length of pipe between the retaining wall and the building was embedded in concrete as shown.

During the construction of the manhole, a strip of 12-lb. lead was cast in the wall as shown and the two free ends wiped together. After the completion of the manhole, the protruding edges of the lead strip were securely wiped to an apron of 12-lb. lead placed across the face of the 30 pipes. The lead apron was then carefully dressed against the rims of the steel pipes until a repoussé effect indicating the position

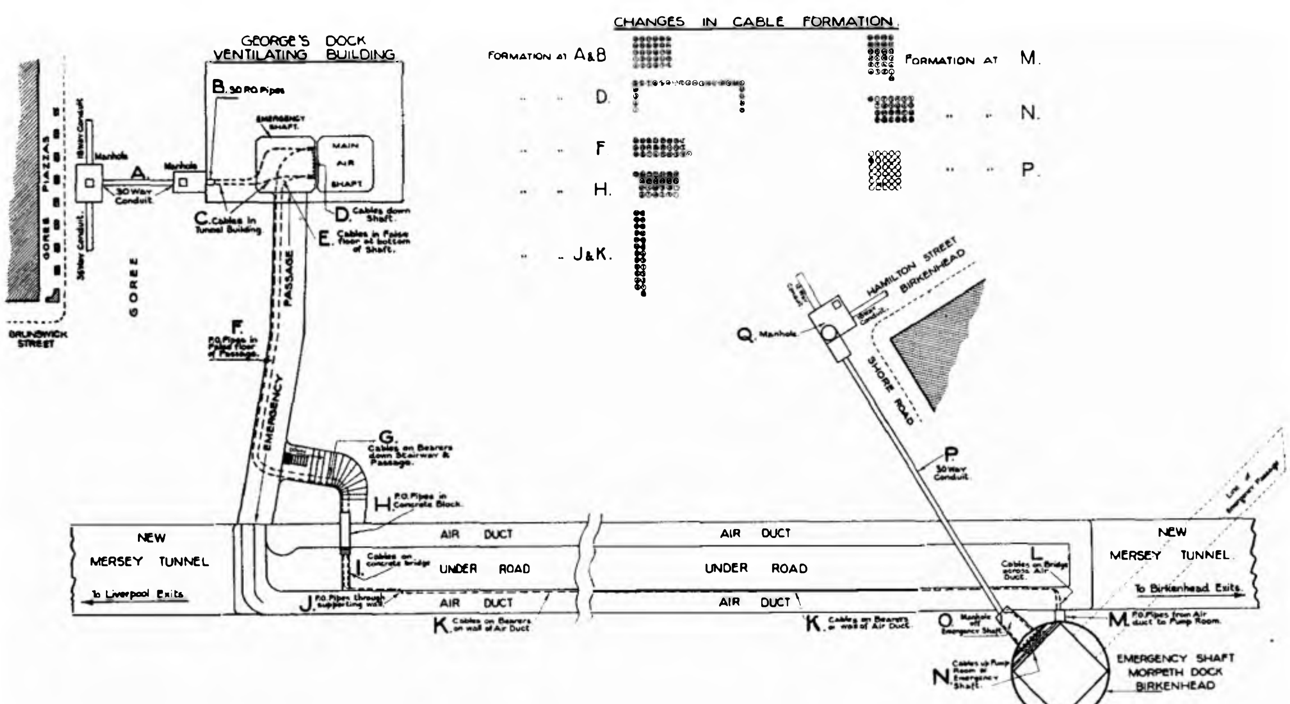


Fig. 8.—Key Index.

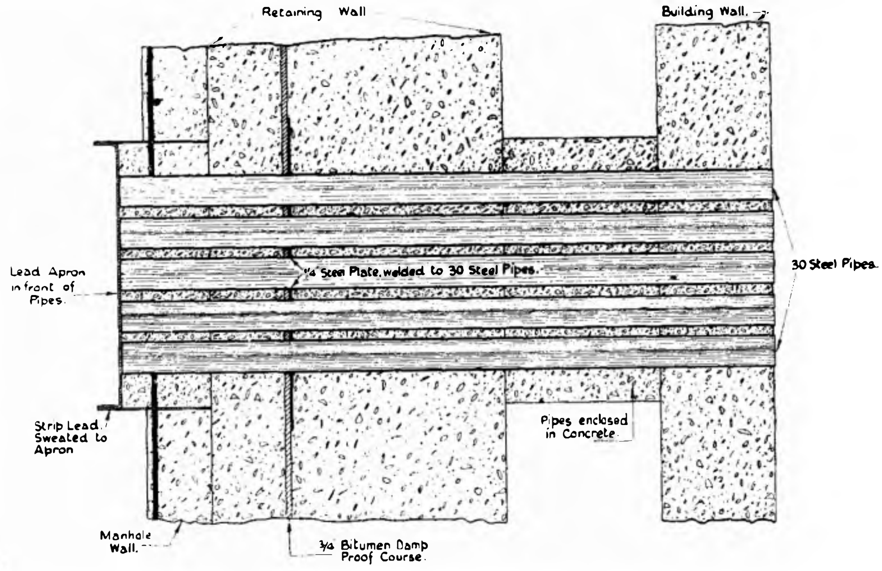


FIG. 9.—RETAINING WALL, GEORGE'S DOCK.

of each pipe was obtained. When cabling operations are in progress, the lead disc approximating in size to the diameter of the cable in front of the appropriate pipe will be cut away and, when drawn in, the cable sheath will be wiped to the apron.

As a further precaution, it was arranged that the thread ends of the pipes entering the manho'e, F'g. **8**, Point A, from the public highway should protrude into the manhole. An iron cap suitably threaded and served with red lead was fitted to each pipe.

Cable Chamber.

Point C, Fig. **8**, is a cable chamber, provided inside the ventilating station, into which the 30 pipes enter from the manhole at B. Here a somewhat radical change in the cable formation is involved owing to the position and shape of the vertical emergency shaft D. The cables will be led from the internal face of the chamber to the top of the vertical shaft by means of bearers consisting of rolled steel stanchions of H section and rolled steel channels suitably drilled to accommodate the bracket bolts and secured to the floor and soffit by steel angles and bolts. Standard cantilever brackets will be used to carry the cables as and when required. Fig. **10** shows the details of this work. Cables 1 to 6 and 20 to 25 will be carried directly to the top of the shaft on bearers, and will occupy the positions shown in the index. The intervening cables which will occupy the wall of the vertical shaft will be carried on the bearers to a point opposite the shaft, where they will fan out in numerical sequence and droop towards the floor on wrought iron stools, thence on hardwood battens and over the concrete bolster.

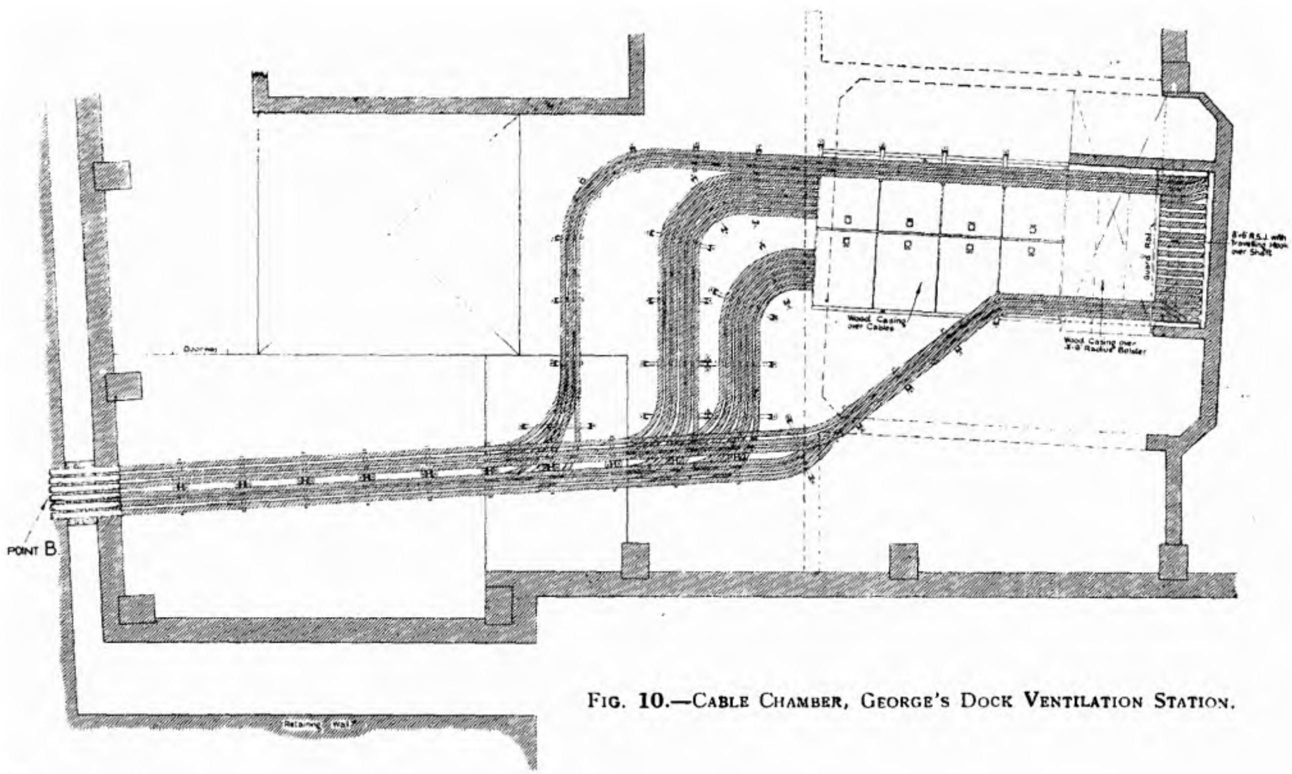


FIG. **10**.—CABLE CHAMBER, GEORGE'S DOCK VENTILATION STATION.

Vertical Shaft.

The cables will be attached to brackets fitted in the vertical shaft. On the floor space between the bearers carrying cables 1 to 6 and 20 to 25, a hard wood casing with removable covers has been constructed to protect cables 7 to 19 and to allow adequate working space for cabling parties and incidentally to secure the route. The distance apart of the concrete wings in the vertical shaft is 7′ 6″ and the maximum height of the cable chamber approximately 5′ 3″. It is necessary therefore to conserve the maximum amount of working space between the vertical bearers and at the same time provide adequate protection to any existing cables when new cabling work is in progress.

The vertical emergency shaft D, Fig. 8, at George's Dock contains a staircase to provide a ready means of exit in case of emergency. The accommodation for Post Office cables provided by the Tunnel Engineer at this point consists of a portion of the shaft wall flanked by two concrete wings. The wings are 7′ 6″ apart and extend 2′ 6″ outward from the shaft wall. The length of the concrete wings from the bottom of the shaft to the roof of the cable chamber is 85′. The cable bearing arrangements are clearly indicated in Fig. 11, which shows the lower portion of the concrete wings and one complete set of cable bearers. The bearers consist of 3″ × 3″ × ½″ steel angles securely attached to the concrete wall and wings by Lewis bolts. To these bearers, 2½″ × 2½″ × ½″ angles are bolted in the opposite direction. The vertical leg of the top angle contains ½ inch slots which are provided to accommodate the bolts connecting the plumbers tacks or steel binding clips. The main object of the slots is the conservation of space and lateral flexibility. A complete set of bearers fitted on one wing provides immediate accommodation for five cables, and a full

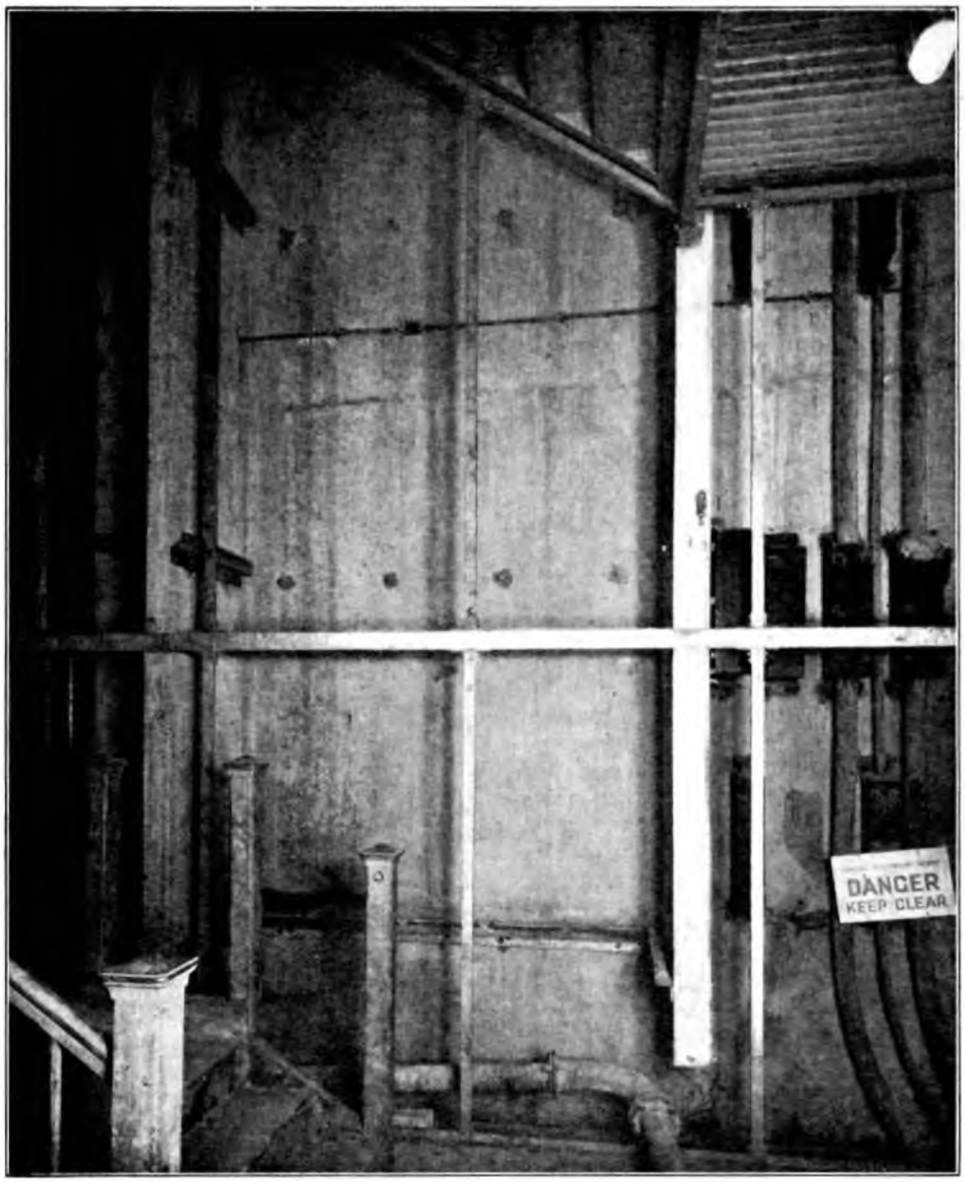


Fig. 11.—Vertical Shaft, George's Dock Ventilation Station.

set of bearers fitted at the top and bottom of the shaft secures the route. Lewis bolts to accommodate the ultimate cable-bearing requirements have been fitted in the full length of the shaft. All the metal is galvanized.

A rolled steel joist carrying a travelling hook is securely seated across the top of the concrete wings to provide facilities in connexion with cabling or maintenance works.

The galvanized steel framing in front of the cable chase is provided with a metallized plywood screen which will enclose all the services on this side of the shaft. The screening panels are capable of removal during the Post Office operations.

The pipe in the foreground is a temporary compressed air service and will be removed in due course.

Emergency Passage.

It will be seen from Fig. **8** that the vertical emergency shaft D is situated some distance from the tunnel, and that it is connected thereto by an emergency passage. This passage connects the tunnel roadway with the stairway in the emergency shaft and provides a ready means of exit for motor drivers and passengers in case of emergency. As the Post Office cables, however, are to be accommodated in the air duct, it was necessary to provide a route from the foot of the vertical shaft to the lower portion of the tunnel. Another passage and stairway G connects the emergency passage with the under portion of the tunnel and advantage was taken of this as a means to the desired end. It is imperative for obvious reasons that the emergency passage shall be free of obstruction at all times, and it was considered that the presence of cable racks or bearers would largely decrease the available width of the passage and interfere with the free passage of pedestrians in emergency. Having regard to the above circumstances, it was ultimately decided to place the Post Office cables in the floor of the emergency passage.

At E, a false floor covers the whole of the shaft bottom and consists of concrete flags sitting on steel cross pieces supported by concrete piers. The whole of the false floor is removable and, at the terminating of cabling operations, will be reinstated in a manner similar to the reinstatement of ordinary footway paving. The depth of the false floor is 18″ and provides ample accommodation for turning the cables into the pipes contained in the floor of the emergency passage. To maintain an orderly lay-out of cables and to prevent direct contact between the concrete and the cable sheaths, wood battens are provided upon which the cables will lie. The battens are slotted and numbered in accordance with the proposed cabling scheme and bolted to the floor proper. Cable accommodation in the emergency passage consists of 25—3¼″ steel pipes embedded in concrete. The formation is as shown in Fig. **8**.

From the emergency passage, the cables will turn in a curved chase in the direction of G, Fig. **8**. The chase is fitted with wood battens slotted and numbered as at E. Concrete flags provide a cover over the chase and can be removed when required.

SOUTH AIR DUCT.

Point G is the stairway and passage leading to the under road and air ducts. This point presented many difficult problems in the provision of suitable cable bearing arrangements, not the least of which was the change in cable formation. A right-angle turn in the passage and a variation in the line of descent further complicated matters, whilst the limitation in available space laterally, by reason of the width of the passage, and vertically, on account of the early arching of the passage roof, provided much material for consideration. Another factor involved at this point was the corrosive effect of the tunnel atmosphere on the material to be employed in the construction of the cable bearers.

Bearers and Brackets.

Fig. **12** shows the method adopted to provide for the change in formation between points F and H. The necessity for this change ruled out the possibility of the provision of any system of uniform racking owing to the variation in the number of brackets required on the separate bearers, and the change in elevation of the various cables. In the circumstances, it was decided to provide wall bearers on one side, and to support the near end of

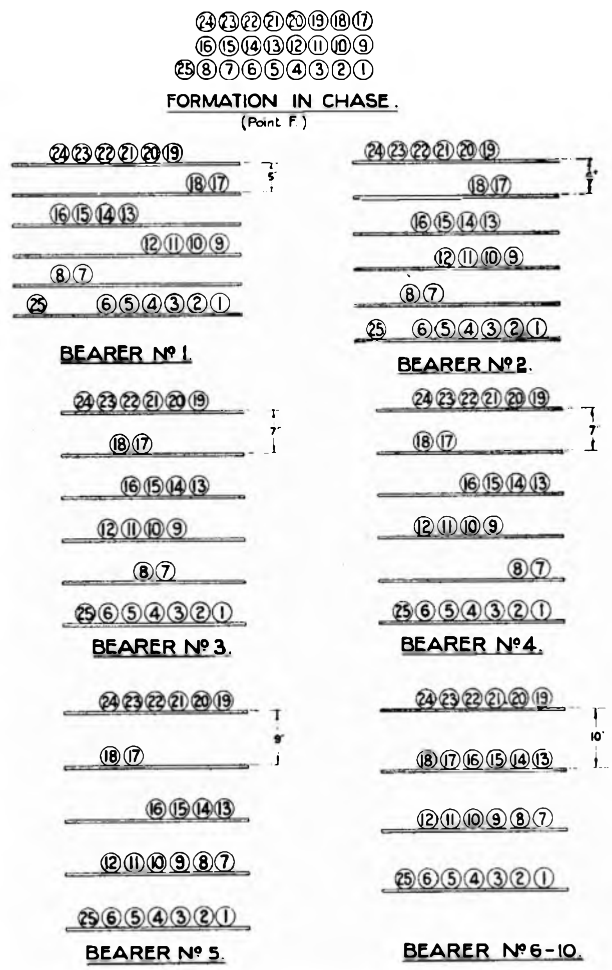


FIG. **12**.—CHANGE IN CABLE FORMATION, POINT G.

the brackets on stanchion bearers fitted to the steps and floor by means of angles and bolts. The steep descent of the cables from point F reducing gradually to point H required that the plane of the bearer brackets should be off the horizontal and should coincide with the plane in which the cables will descend. Two methods of setting the brackets in the required planes were possible; the first was to fix the bearers to the wall at such an angle as would result in the brackets lying at the required angle. The second method was to fit the bearers vertically and design the brackets to meet the case. A scale drawing was prepared in which the 25 cables were shown in their appropriate positions on cable brackets, and it was found that the line of descent of the cables necessitated a variation in the degree of deflection from the horizontal at each bearer. It was also apparent that the right-angle bend in the passage Point G could not be negotiated by means of the method first mentioned. It was therefore decided to adopt the alternative method, and fix the bearers in a vertical position on the wall and to provide a supporting bearer opposite each wall bearer to carry the free end of the brackets. The simplest method of adjusting the plane of the brackets to the line of the cables would have been to twist the flat of the bracket to the desired angle, but here another problem presented itself. The amount of space in a lateral direction allocated for Post Office plant was limited, and the disposition of the cables involved in the change in formation demanded the availability of the full width between the bearers and the associated stanchions. To obtain the desired angle on the bracket by means of a twist would involve a loss of effective seating accommodation of approximately 6″ per bracket—a loss which could not be afforded.

Fig. 13 illustrates the method finally decided upon. The bearers consist of angles fitted to the

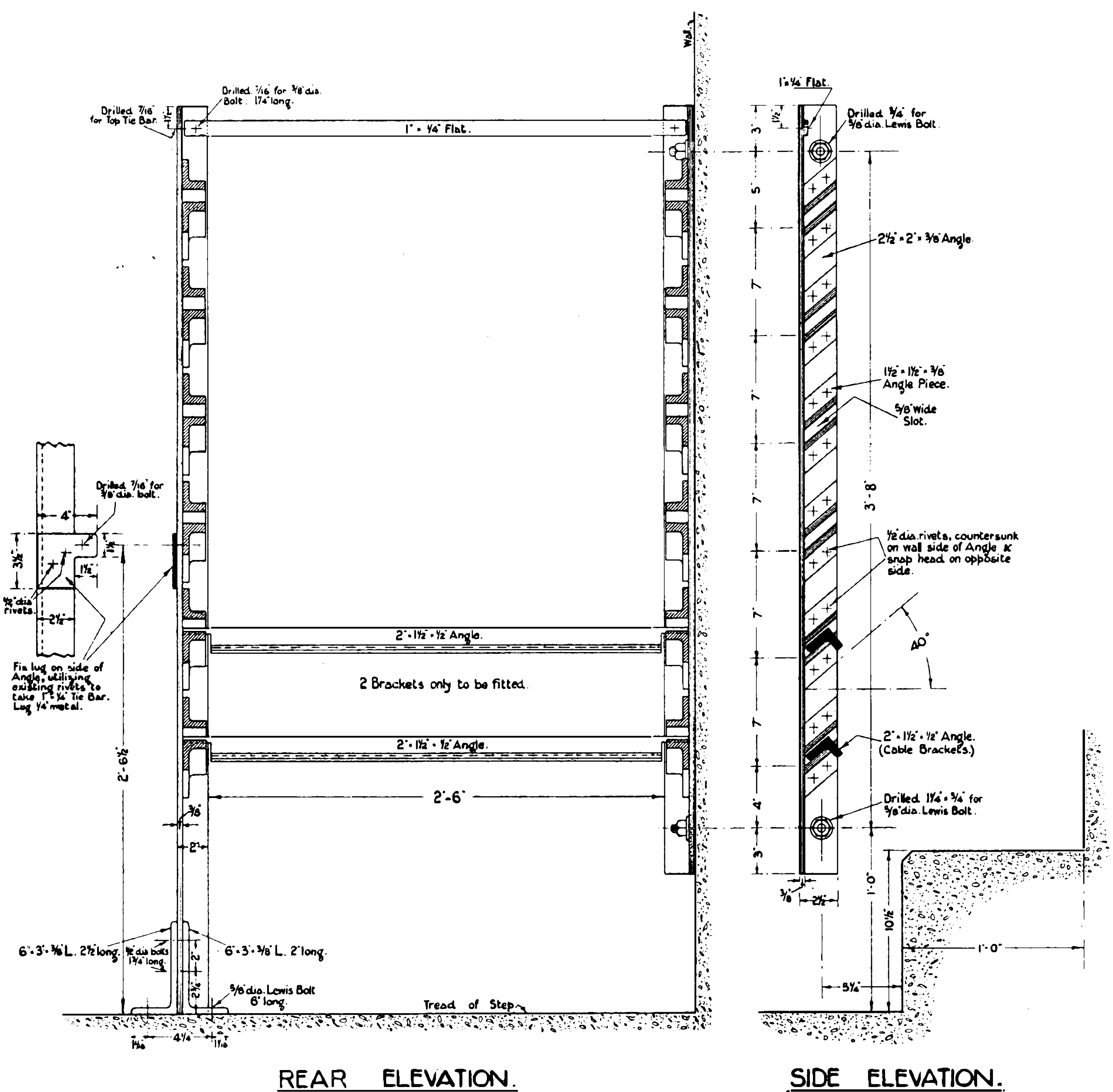


Fig. 13.—Cable Bearers, Point G.

wall and steps in the passage. On the inside of the angle leg lying in the direction of the cables a number of small angle pieces are rivetted, each pair being arranged to form a slot which admits the free insertion of a 2" × ½" metal flat at the prescribed angle. The other leg of the angle bearer retains the bracket in position. Owing to the possibility of cable creepage resulting from the sharp descent of the cables at this point, brackets of angle section have been provided in lieu of the usual rectangular section. The object of the angle bracket is to provide sufficient area against which a stopper, lead-wiped on to the cable sheath, can react.

Material.

Each end of the passage is fitted with an airtight stainless steel door. The lower door opens directly into the south air duct. The upper door when closed shuts off the emergency passage and this door must always be closed before the lower door is opened, otherwise the ventilating air stream would be released. Should the upper door be closed and the lower door remain open, the atmospheric conditions in the passage G, Fig. 8, would be similar to those in the main air duct except that the air would be pocketed to some extent. When both doors are closed the atmosphere in the passage will be humid and more or less stagnant and will exert a decidedly corrosive effect on iron or ordinary steel, thus involving abnormal expenditure in subsequent maintenance. After the installation of a number of cables, the wall bearers and brackets will be difficult of access for maintenance purposes and accessibility to these points will diminish as further cables are installed. Having regard to these circumstances, it was decided that stainless steel should be employed in the construction of the bearers and brackets.

Crossing Under Road.

The emergency shaft, D, Fig. 8, at George's Dock is on the side of the tunnel remote from the north air duct, and it was therefore necessary to cross the south air duct and the under road to gain access to the north air duct in which the Post Office cable bearers are installed. For obvious reasons the Tunnel Engineer would not permit an obstruction such as 25 steel pipes to cross inside the south air duct and the pipes were therefore laid under the air duct and so enter the under road. Point H, Fig. 8, shows the pipes laid accordingly. Both ends of all the pipes are plugged and numbered.

Concrete Bridge.

Fig. 14 is a photograph taken in the under road,

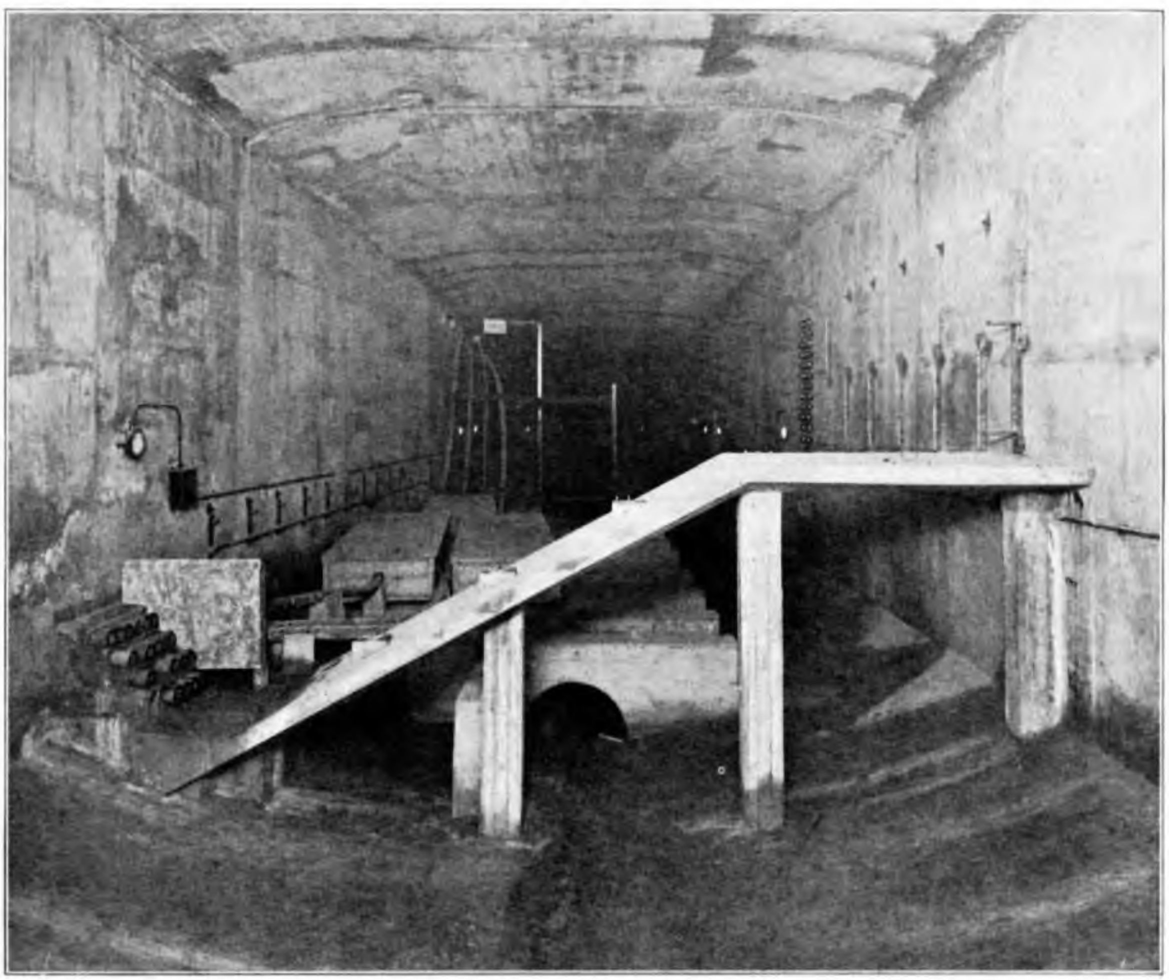


FIG. 14.—CONCRETE BRIDGE, PIPES, AND BEARERS IN UNDER-ROAD AT GEORGE'S DOCK, POINT I.

Point I Fig. 8, and shows the arrangements made to effect the crossing, and to gain access to the north air duct. Many considerations were involved at this point, chief of which was the Tunnel Engineer's requirement that sufficient head room should be provided under the cables to ensure the free passage of workmen engaged in the subsequent maintenance of the tunnel. The numbered pipes seen on the left of the photograph are the ends of the pipes referred to under H, Fig. 8. It will be observed that the horizontal layers of pipes are arranged in stepped formation. This arrangement provides increased flexibility in connexion with cabling operations at this point. The concrete slab shown at the side of the 25 conduits is a physical barrier erected between the power cables of the Central Electricity Board and the Post Office pipes to prevent the possibility of contact between the respective plants. The bridge is designed to carry the whole of the cables to be provided ultimately. Cables 1 to 6 will lie flat on the bridge surface, which has an overall width of 3′ 7″ and will turn at a right angle in sets of two on to the stainless steel wall bearers seen on the right of the photograph, and thence through the pipes set in the vertical wall, and so enter the north air duct. Subsequent cables will be carried on the bridge by means of stainless steel centre bearers, which will be erected as required. Stainless steel bolts to secure the future bearers to the bridge have been set in the bridge concrete and can be seen in the photograph.

Protection.

It is realized that some provision is necessary to prevent direct contact between the cable sheaths and the concrete bridge, and it is intended that suitable provision shall be made in this direction either by means of hardwood battens or low metal stools bolted to the upper surface of the bridge. The fitting of these supports, however, has been deferred pending the installation of the first cable in order that the correct alignment may be obtained. A change in formation occurs between the two sets of pipes passing through the vertical walls. The consequent change in cable formation will be made on the bearers which will be fitted to the bridge. Cables 1-6 are not affected in this respect.

North Air Duct.

The internal diameter of the pipes passing through the vertical wall, Point J, Fig. 8, of the north air duct is 4 inches. This increased diameter was provided to take up a portion of the curve in the cables as they pass through the wall. The pipes are set in the wall at an angle of 30 degrees.

As stated previously, the cylindrical portion of the tunnel was the first portion available for survey and consideration in connexion with the Post Office cabling requirements. Accommodation in the upper traffic space was definitely not available and it became necessary, therefore, to consider the advantages and disadvantages of cable accommodation in the lower half of the tunnel, which consists of the air ducts and the under road. This under road is reserved for future traffic requirements, and may in due time be required for this purpose. Although the Joint Committee have no immediate proposals in this direction, the availability of the space and the accommodation for traffic contained therein obviously suggests the possibility of such development. In view of this possibility and having regard to the heavy cost that would be involved in an enforced removal and the distinct danger that the present available alternative accommodation might be lost if removal were demanded, it was considered more economical to accept the accommodation offered in the north air duct.

At this time, the Central Electricity Board was negotiating with the Joint Committee regarding the accommodation for power cables, and it was decided finally to accommodate Post Office cables in the north air duct and Central Electricity Board cables in the south air duct.

The system to be employed in the ventilation of the tunnel had not been decided and it could not be ascertained whether the ducts would be used for the purpose of fresh air input or, alternatively, whether the vitiated air in the tunnel would flow in the air ducts during the process of extraction. It was necessary, therefore, to consider the effect of the air duct content on the material to be used in the manufacture of the cable bearers and brackets, which would be erected in the north air duct. In the event of the air ducts being used as extraction channels, the air would be charged with gases such as carbon monoxide and carbon dioxide.

Another aspect of the case was the obstructive and disturbing effect the Post Office cable bearers and cables would have on the air stream in the air duct, and obviously the main ventilating system of the tunnel had first claim to consideration. Decision was made finally to erect the cable bearers on the vertical wall, and to provide as flat a formation as possible.

Bearers and Brackets.

This object was secured by arranging the bearers and brackets to accommodate twelve sets of two cables in vertical formation; the 25th cable to be accommodated on the bottom row by substituting a longer bracket when required. The cable bearers in the air duct are of cast iron of approximately standard section and protected by bitumastic compound. The cantilever brackets are of malleable cast iron and are similarly treated.

Fig. 15 is a photograph of the north air duct, Point K Fig. 8, and shows the disposition of the cable bearers and the gradual fall to the level at which the steel pipes pass through the vertical wall into the under road. The high elevation of the bearers was necessary in order to pass over several doors which are formed at intervals between the under road and the air duct. The bearers are arranged in two tiers. A full complement of bearers has been provided in the bottom tier with one bracket to each bearer. The upper tier consists of bearers spaced at approximate intervals of 50 feet.

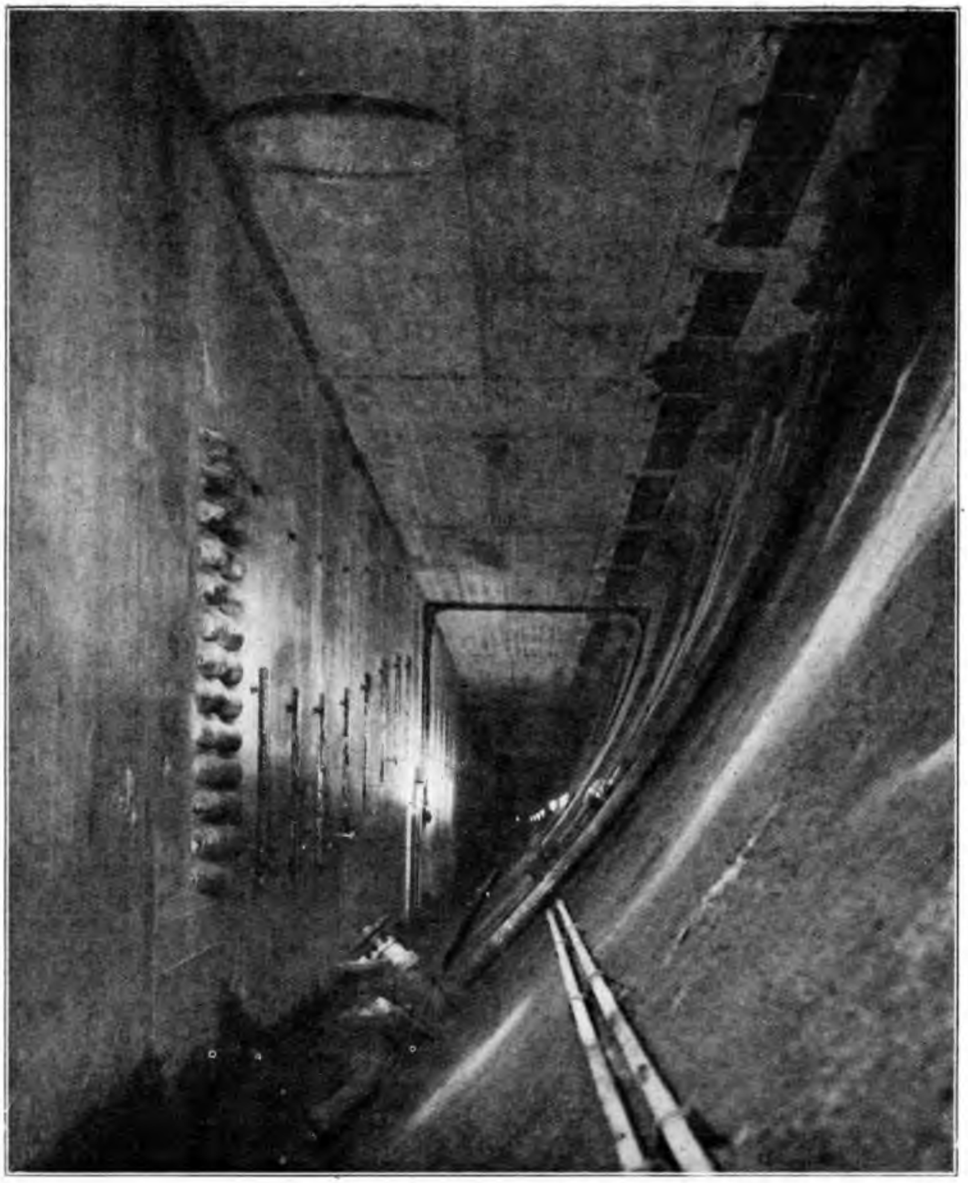


Fig. 15.—North Air Duct, Point *K*.

This arrangement secures economy in initial expenditure and protects the route.

Openings spaced at 300-yard intervals and fitted with manhole covers, have been provided in the tunnel roadway directly over the north air duct. A cover can be seen in the upper portion of Fig. 15.

Cable Exit.

Point L, Fig. 8, is the point at which the cables will leave the air duct and enter the vertical emergency shaft at Morpeth Dock. Fig. 16 is a photograph of a stainless steel bridge erected in order to carry the cables across the air duct to a group of 25 steel pipes embedded in concrete, Point M. Stanchion supports were not permitted by the Tunnel Engineer, and recourse had to be made to a semi-hanging arrangement in order to secure the necessary rigidity of the structure. Stainless steel was chosen owing to the susceptibility to corrosion of rolled steel. The use of cast iron was considered but rejected owing to the fact that a similar construction in cast iron of sufficient strength and rigidity would be too bulky and would not allow the requisite latitude for subsequent cabling operations in a somewhat restricted space. Another factor considered in this connexion was the difficulty of subsequent maintenance and/or replacement at this point.

Vertical Shaft.

At N, Fig. 8, is the vertical emergency shaft at Morpeth Dock, Birkenhead, which consists of a 21′ diameter circular shaft constructed of cast-iron segments and lined with concrete. Inside the circle of the shaft is a stairway of square formation leading upward to the emergency passage. The whole

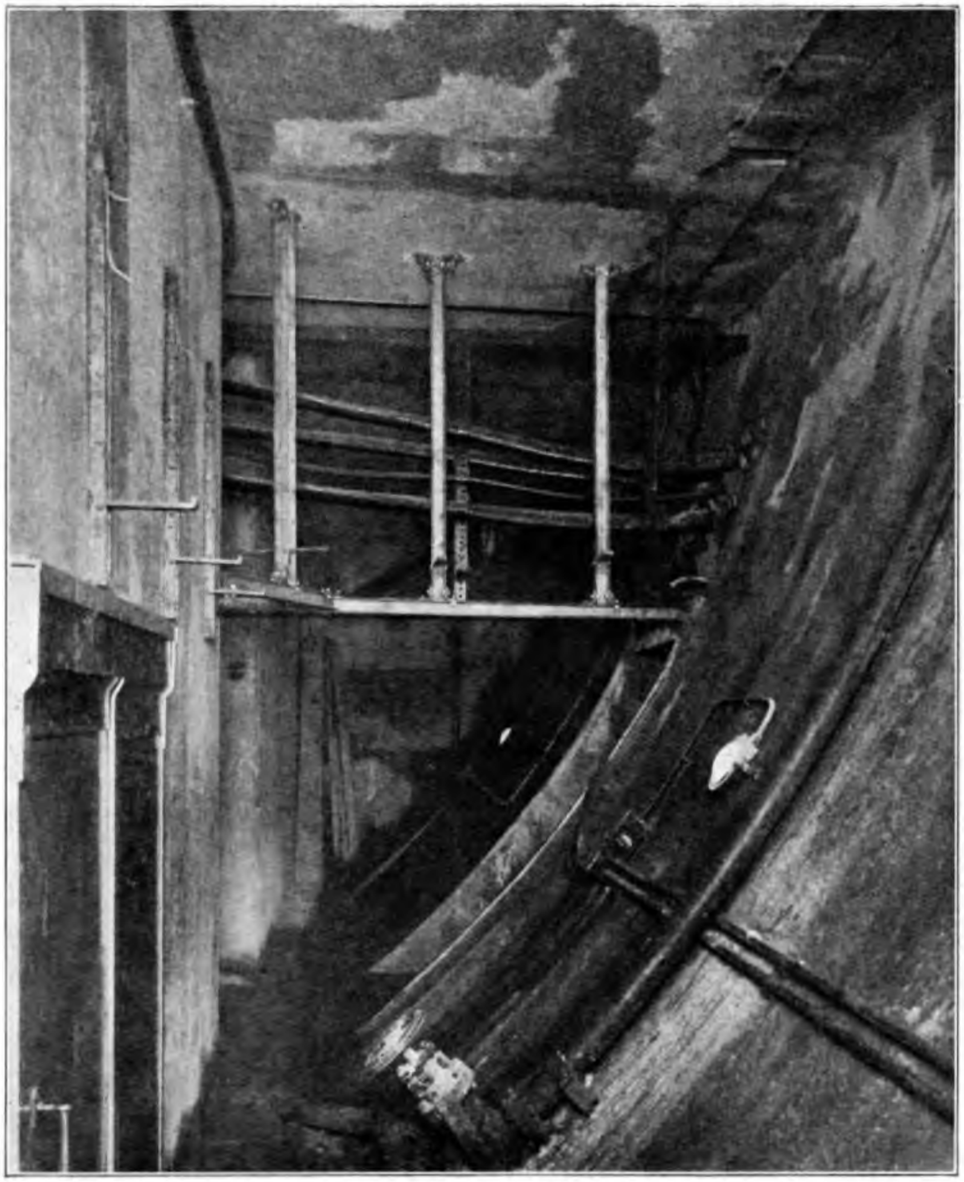


FIG. 16.—NORTH AIR DUCT, POINT L.

of the stairway is enclosed in metallized plywood thus describing in plan a square within a circle. One of the four segments thus formed has been allocated to the Post Office for the accommodation of the 25 cables. Fig. 17 shows the method adopted to carry the cables up the vertical shaft. 8″ × 4″ rolled steel joists were erected as shown. Seated on the upper side of the joists and secured thereto by set screws are steel channels, the legs of which are slotted in a similar manner to the angle bearers described under D. The whole of the steel work is heavily coated with bitumen as a preservative.

At O, Fig. 8, is a concrete manhole constructed off the vertical shaft and connected thereto. An aperture cut in the cast-iron lining of the shaft provides an entrance to the manhole. The manhole is approximately 35 feet below ground level and was constructed at this level owing to wayleave considerations.

WAYLEAVE CONSIDERATIONS.

The vertical emergency shaft is sunk in land which is under the jurisdiction of the Mersey Docks and Harbour Board, and although for constructional purposes the whole of the shaft was in use as a working shaft, at the conclusion of the constructional work in the tunnel the upper portion was dismantled, roofed over, and filled in to a depth of approximately 23′ 6″. The terms of the agreement between the Mersey Docks and Harbour Board and the Tunnel Joint Committee provided that the Joint Committee should not permanently occupy the surface of the ground at this point. A subway constructed off the vertical shaft at a level of approxi-

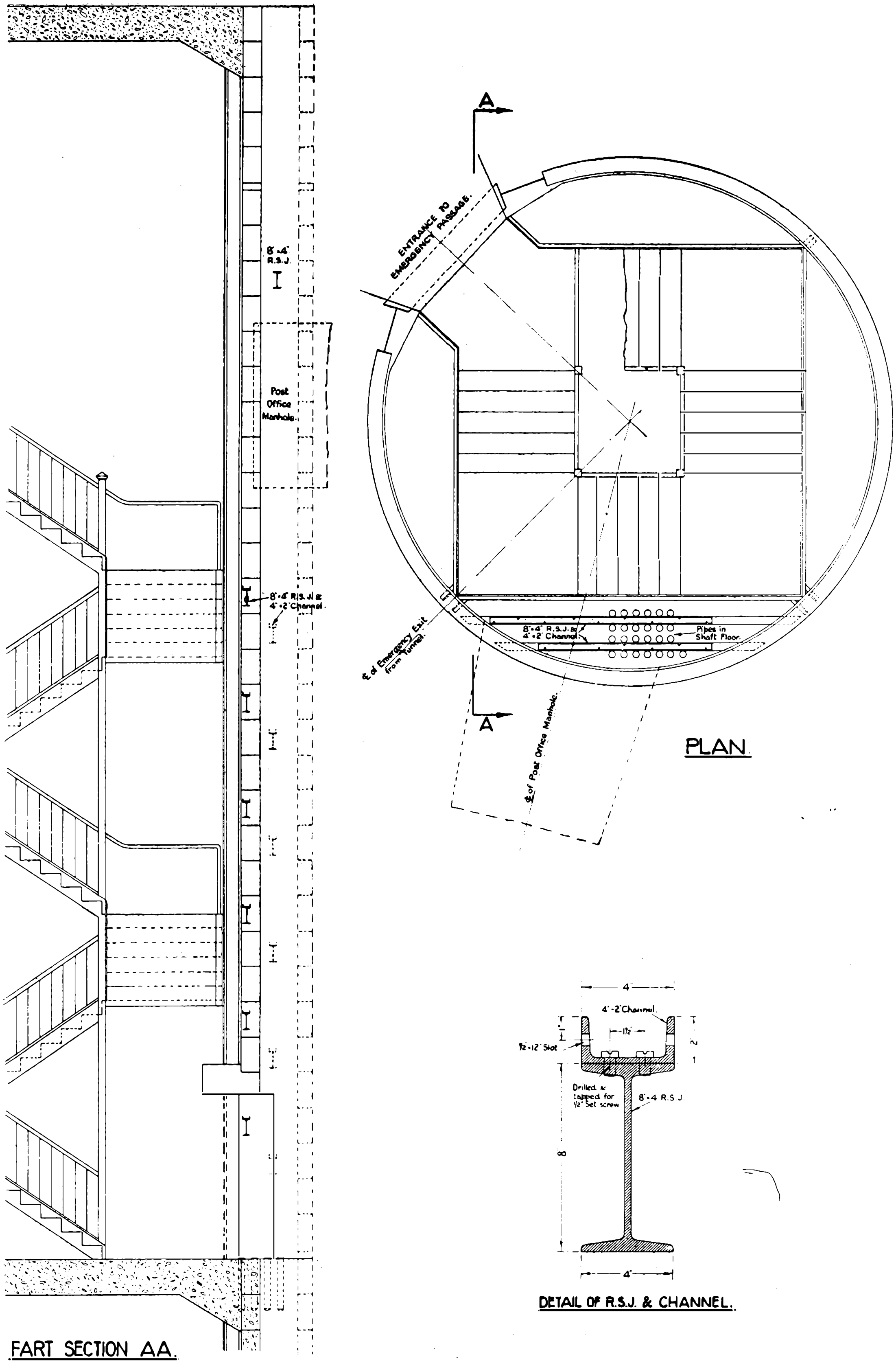


Fig. 17.—Cable Bearers, Point N.

mately 35 feet below surface and terminating at a point remote from the shaft provides an exit from the Tunnel in case of emergency. The dimensions of this emergency passage are such as to preclude the provision of accommodation for Post Office cables. It was therefore necessary to find an alternative route to lead the cables away from the shaft, to the public highway, a distance of approximately 175 yards.

The terms of the Standing Agreement between the Post Office and the Mersey Docks and Harbour Board are such that, if required, the Post Office shall remove their plant at comparatively short notice. An endeavour was made to have the terms varied in respect of the proposed plant, but without success. The land in question is capable of development for building or other purposes, and although the Mersey Docks and Harbour Board had no immediate proposals in this respect, the land may be required for development ultimately. Security of tenure of the Post Office plant is essential at this point, and having regard to all the circumstances involved, it was decided eventually to place the Post Office conduits at a level that would ensure immunity from disturbance.

Octagonal Ducts.

At P, Fig. **8**, is a line of 30 octagonal ducts connecting the vertical shaft at Morpeth Dock, Birkenhead, and the manhole at Hamilton Street, Birkenhead. Consideration was also given to the alternative method of constructing a subway having the necessary cable bearing arrangements, but the octagonal duct method was the more economical and was, therefore, adopted. The formation of conduits at this point differs from that employed at B, Fig. **8**, where the Post Office pipes enter the tunnel precincts at Liverpool. The change in formation is due to a considerable economy resulting from reduction in the width of rock tunnelling.

Manhole, Birkenhead.

At Q, Fig. **8**, is a manhole constructed in Hamilton Street, Birkenhead, and in which the 30 octagonal ducts leading from the vertical emergency shaft at Morpeth Dock terminate. The ducts enter the manhole at a level of approximately 35 feet below ground level. Fig. **18** is a section of this manhole.

Construction.

The circular cast-iron lining of the shaft consists of a series of rings, each ring being formed of segments united by bolts passing through the flanges in such a manner as to form a continuous cylinder in conjunction with the similar rings on either side. Each complete ring consists of a number of ordinary segments with radiated flanges, a single key piece with flanges inclined as shown on the drawing, and two special segments of which one flange is radiated and the other formed to fit the inclination of the key piece. The ends of all the segments are machined true to the correct profile. Every segment is provided with two $1\frac{1}{4}$-inch diameter grout holes. All the cast-iron work was dipped while hot in approved composition. All bolts in every third circumferential joint are of such a length that each nut provides two clear inches of threaded bolt protruding beyond the nut for the accommodation of subsequent attachment for the Post Office cable racks.

The longitudinal joints of the shafts are served with a mixture of red and white lead, ground in boiled linseed oil, with the addition of two pieces of yarn dipped in the same mixture and not less than $\frac{1}{4}$-inch in diameter, placed in the joint one piece between the bolt and the outer side of the joint, and the other piece between the bolt and the inner side of the joint. The segments are bolted together.

The circumferential joints have placed within them, between the bolt and the outer side of the joint, rope yarn soaked in a mixture of red and white lead ground together in boiled linseed oil, and where the shaft is sunk through dry material the remainder of the joint is completely filled with neat portland cement.

Watertightness.

Where the shaft is in a water-bearing strata, the vertical joints were formed in a similar manner, but in addition the inner edge of the joint is caulked with blue lead, and yarn grummets, previously soaked in a mixture of red and white lead ground together in boiled linseed oil, placed under each of the head and nut washers and between them and the flanges of the castings.

Grummets are also provided for the circumferential joints in water-bearing strata, and the joints are caulked with blue lead for a sufficient depth between the bolt and the outer side of the joints to make them completely water tight.

The space between the cast-iron lining of the shaft and the surrounding material is completely grouted up with neat portland cement mixed with water. The mixture so formed was sufficiently liquid to admit of its being forced through the grout holes in the castings by the grouting apparatus, by means of compressed air under a pressure of not less than 60 lb. per square inch. The grouting was done immediately every two rings were completed. The holes in the castings through which the grout was forced were carefully plugged with neat portland cement where in dry ground, but where wet ground or water-bearing strata occurred, the holes were tapped and fitted with screw plugs or plugged with blue lead.

The upper manhole is of reinforced concrete. Two entrances are provided, one situated immediately over the vertical shaft for cabling purposes. From this position a direct cable feed can be obtained to the conduits radiating from the manhole, and to the 30 octagonal ducts below. A vertical mild steel ladder is provided down the shaft, and is permanently bolted to the cast-iron linings. Another advantage accruing from the position of the cover over the shaft is that ladders of any length can be lowered into the shaft and used in cabling

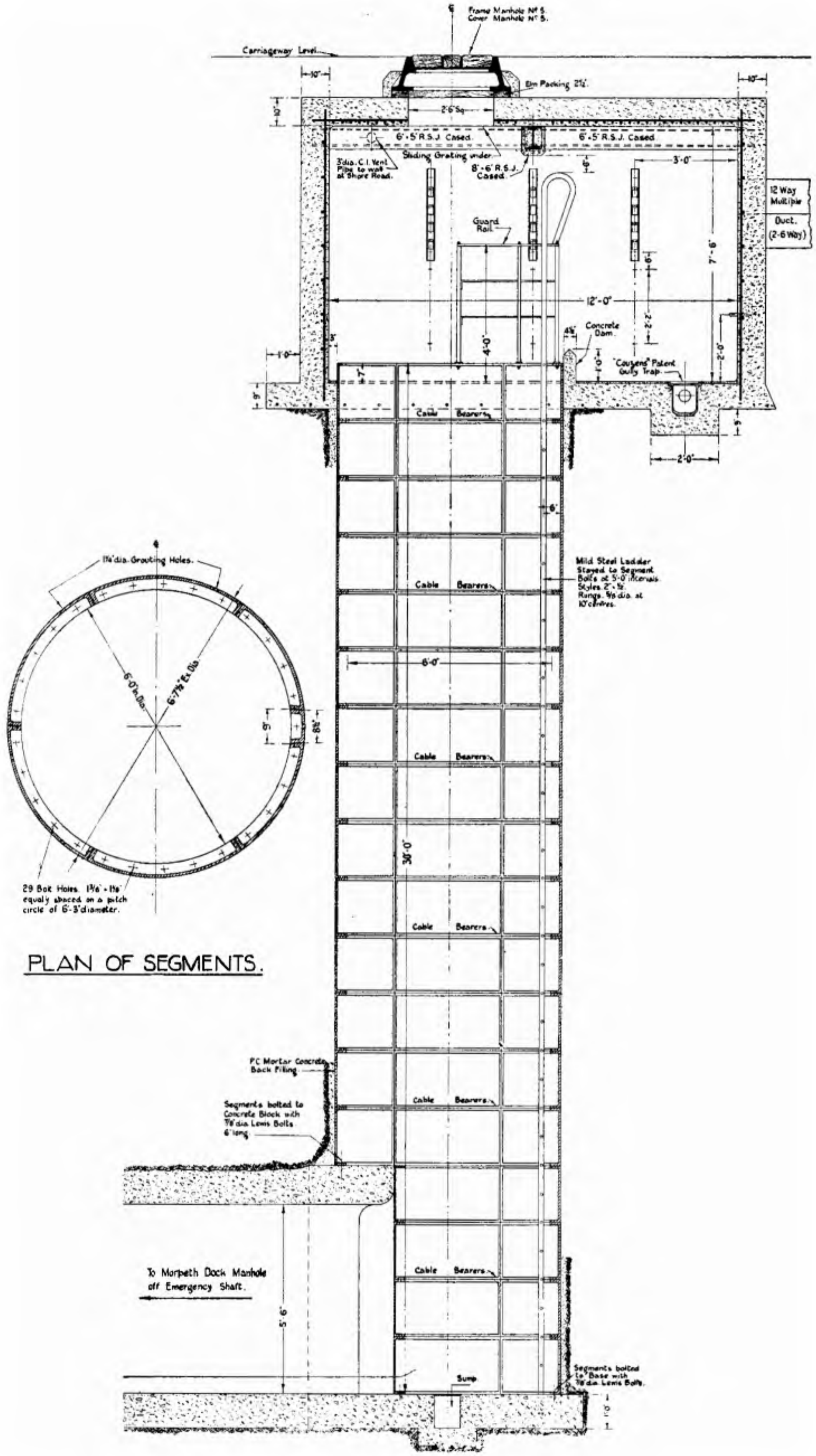


FIG. 18.—SECTION OF MANHOLE, POINT Q.

operations or in the subsequent maintenance of the shaft.

Safety Precautions.

As a preventive to accidents arising when the manhole cover is removed, a sliding wrought-iron grating is fitted in the webs of the girders immediately under the opening, and if necessary the grating can remain *in situ* during cabling operations, the cable passing between the bars of the grating. A guard rail 3′ 6″ in height attached to the bolt holes in the upper circumferential ring of the vertical shaft encloses the shaft.

Draining.

The manhole is drained to an adjacent sewer through a ball valve set in the manhole floor, and as a further precaution against the entry of water to the vertical shaft a concrete sill 12 inches high is erected on the manhole floor and encloses the circumference of the shaft. The top of the concrete sill is shaped to an acute angle to prevent the placing thereon of hammers or other tools which might fall down the shaft and cause injury to workmen.

Ventilation.

Ventilation is provided by a 3-inch pipe fitted under the soffit, and connected to a stanchion pipe and cowl attached to a wall on the adjacent footway.

Cabling Arrangements.

Cabling and jointing in the tunnel and associated shafts will require careful preliminary consideration, and to secure maximum economies in this direction during the actual operations regard must be given to efficient organization. The difficulties to be encountered are by no means inconsiderable. The changes in direction and the frequent alteration in the formation of the cables together with the restriction in the space available for workmen at certain points suggest that future cabling proposals will be of unusual interest.

The approximate cable length between the manhole situated in Goree, Liverpool, and the upper manhole at Hamilton Street, Birkenhead, is 2074 yards of which 1729 yards are contained in the north air duct.

It is not possible entirely to cut off the air stream in the air duct, but the velocity will be reduced at night when the amount of vehicular traffic in the tunnel is at a minimum and it is only during these periods that it will be convenient to proceed with cabling and jointing operations in the air duct.

The cable length from the manhole in Goree, Liverpool, to Point I, Fig. 8, is approximately 133 yards, and it is anticipated that the first joint in the tunnel at the Liverpool end will occupy a position on the stainless steel bearers attached to the vertical wall at Point I, Fig. 8.

At the Birkenhead end it will be necessary to cable from the manhole in Hamilton Street, and provide a portable or ratchet winch in manhole 0 for the purpose of drawing in. This method will be necessary owing to the inaccessibility of manhole 0, and the emergency passage for a cable drum. The length of cable required from manhole 0 to the first wall bearer in the north air duct at K is approximately 25 yards, and it is hoped to dispense with a joint in manhole 0 and continue the cable to Point K, where the first joint at the Birkenhead end will be made.

Cable Key.

Having regard to the unusual features in this case, it is imperative that the ultimate disposition of cables shall obtain as designed. To ensure that the installation and disposition of future cables shall be according to plan, complete sets of drawings and instructions have been prepared and are filed in the office of the Sectional Engineer for reference purposes.

Technical Advisers.

The Engineer responsible to the Mersey Tunnel Joint Committee is Sir Basil Mott, Bart., C.B., F.R.S., Past President of the Institution of Civil Engineers, of the firm of Mott, Hay and Anderson, Iddesleigh House, Caxton Street, Westminster, with whom is associated as Joint Engineer, Mr. John A. Brodie, M.Eng., Past President of the Institution of Civil Engineers, and who was for many years the City Engineer of Liverpool.

The Architect to the Mersey Tunnel Joint Committee is Mr. Herbert J. Rowse, F.R.I.B.A., of Martins Bank Building, Liverpool.

The Engineer-in-Charge of the work was Mr. B. H. M. Hewett, A.C.G.I., F.R.G.S., M.Inst.C.E., until his death in November, 1933. The Resident Engineer is Mr. B. H. Colquhoun, B.Sc., A.M.Inst. C.E., who is now in charge. We are indebted to Mr. Colquhoun for the information relevant to the tunnel work contained in this article, and for the loan of photographic blocks.

The British Post Office International Exchange

S. BIRCH and
C. H. HARTWELL

INTERNATIONAL communication has developed with surprising rapidity during the past few years. This is particularly so in regard to traffic from England to the Continent, and also over Radio channels from England or the Continent, to all parts of the world *via* London.

The extent of the International communication network is shown in Figs. 1 and 2.

"Demand" trunk lines, so that the overseas services can derive full benefit from the Demand System.

In view of the importance of the International Exchange, the internal decoration and construction of the switchroom has been given special consideration.

Lighting, ventilation and noise reduction have

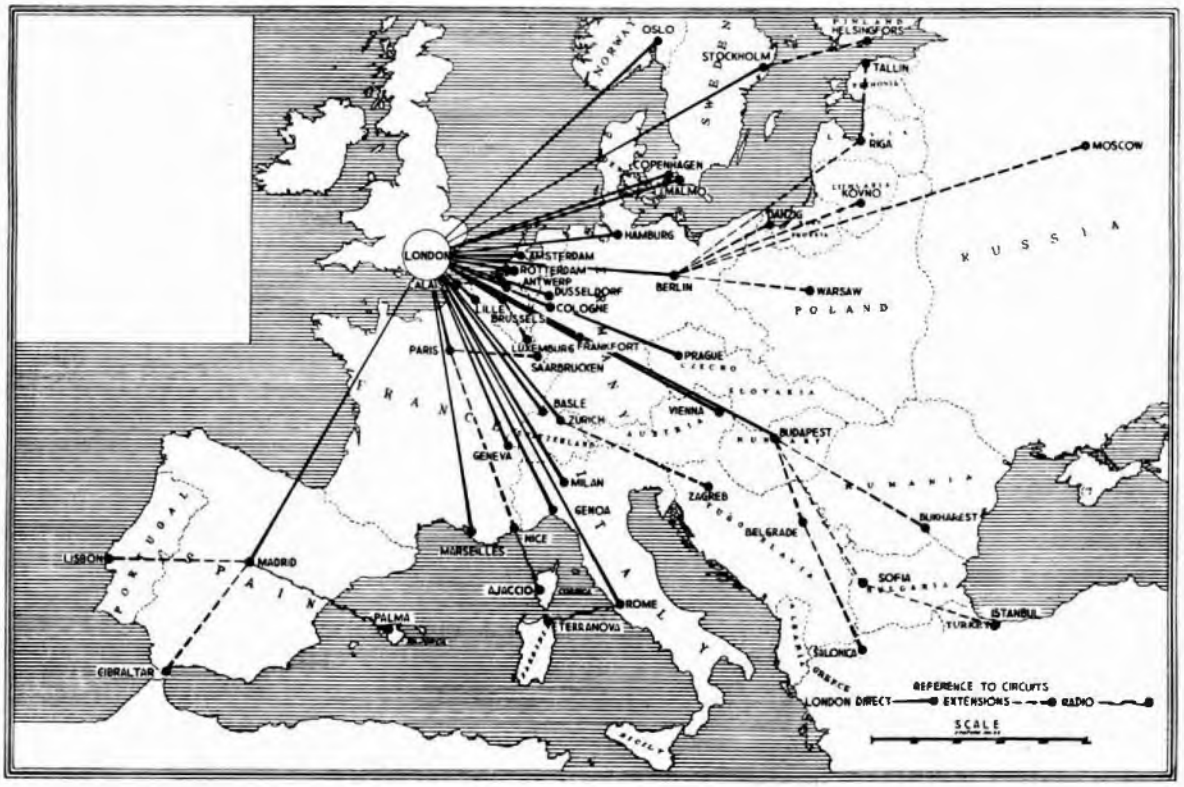


Fig. 1.—Map of Continental Network.

The specialized type of working involved has resulted in the special design of a new exchange to deal exclusively with overseas traffic. This exchange has been installed at the Faraday Building (North Block) in London, and was formally opened by The Right Honourable The Lord Mayor of the City of London on the 4th May, 1933. H.R.H. the Prince of Wales also visited the exchange later, on the same day.

The installation of the International Exchange in the same building as the Inland Trunk Exchanges facilitates the extension of the overseas circuits to the inland network and allows ready access to the

received a great deal of attention and as a result the switchroom may be considered as embodying the latest principles in these respects.

The wall surfaces of the switchroom are comparatively small and broken up by large windows so that no special form of decoration beyond distempering was considered practicable. A stone colour has been used with a dado of green. The woodwork has been carried out in mahogany, french polished.

For lighting, artificial illumination simulating daylight conditions as nearly as possible, by means of a combination of direct and indirect fittings, has been employed.

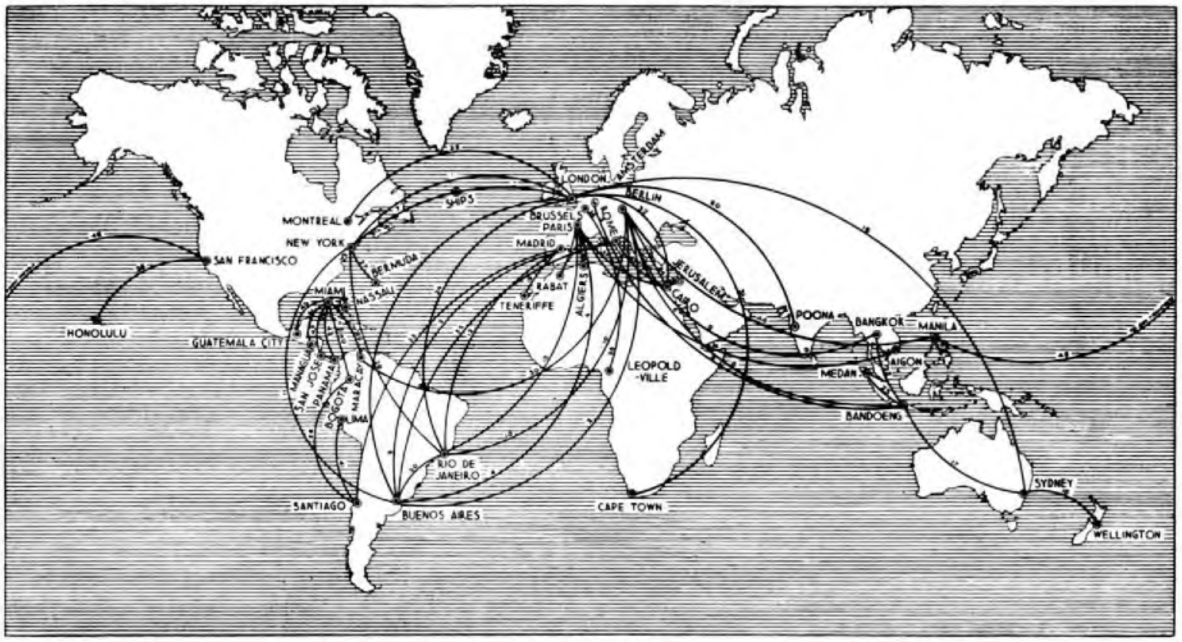


Fig. 2.—Map of Radio Network.

Heating is by means of a newly installed hot water system, which supplies the whole building. Radiators are fitted against the walls at the rear of the sections and, as usual, air inlets for ventilation are provided at each radiator. Air is taken out of the switchroom by three large fans operating into a central light well of the building. The fans are specially constructed with a view to noiseless operation, a most desirable feature.

In all large switchrooms, noise is an important factor, tending to worsen operating conditions and the International Exchange switchroom has been treated to reduce the reverberation to a small amount. The wall surfaces are small and broken up by the windows besides being partially hidden by the switchboard, so that little side echo results. The main surfaces concerned are the ceiling and the floor and it is to these that the treatment has been applied.

The floor has been covered with cork squares specially prepared for hard wear. The cork is approximately ¾″ in thickness and very little echo is produced. The ceiling is most productive of echo and a sound proofing system using " Sanacoustic " tiles has been installed. Metal containers in the form of a shallow lid constitute the actual tile. They contain a pad of " Banroc " wool 1″ in thickness, and this is the sound absorbing material. The tiles are 16″ square of 20 gauge perforated metal, the surface of which is enamelled. The tiles clip into T shaped spring bars fixed along the ceiling and a very close fitting joint is obtained. In the installation at the International Exchange an additional 3″ of loose " Banroc " wool was placed on the top of the 1″ pad in order to increase the absorption, particularly at the lower frequencies. The tiles are enamelled a cream tint so that the light reflecting property is good. The absence of the usual amount of switchroom noise is most marked and the operating conditions greatly improved.

The lay-out of the switchroom and apparatus room is shown in Fig. **3**. The principal equipment in the apparatus room consists of the intermediate distribution frame, relay set racks, chargeable time indicator racks and a fuse panel. All the relay sets for the trunks and junctions are mounted on the standard channel type shelves.

The I.D.F. has a total of 106 verticals and serves the Inland trunk exchanges on other floors in addition to the International Exchange. This also applies to the M.D.F. on the ground floor on which are terminated all cables entering the building.

The switchroom has been divided into two parts as indicated by the dotted line in Fig. **3**. The left hand portion deals entirely with the Continental services and the right hand with Radio. The line controlling positions are in two suites along the sides of the switchroom. Between the two side suites are various subsidiary desks consisting of, in the Continental portion, a record and enquiry suite of low type double-sided desks, a route and rate quoting position, ticket filing position, ticket distribution position, supervisors and superintendents desks, and in the Radio portion, an enquiry and observation desk and supervisors and superintendents desks.

Adjoining one of the side suites are installed racks to supply current for the multipled lamps.

The type of section installed for the line controlling positions is the same as that standardized for large trunk " Demand " boards. The sections are 7′ 6″ high, 6′ 8½″ wide and consist of three operating positions. Seven panels are accommodated per section and " B " gauge jacks are used throughout. Only the operator's position and cord circuit relays are fitted in the sections, the major part of the

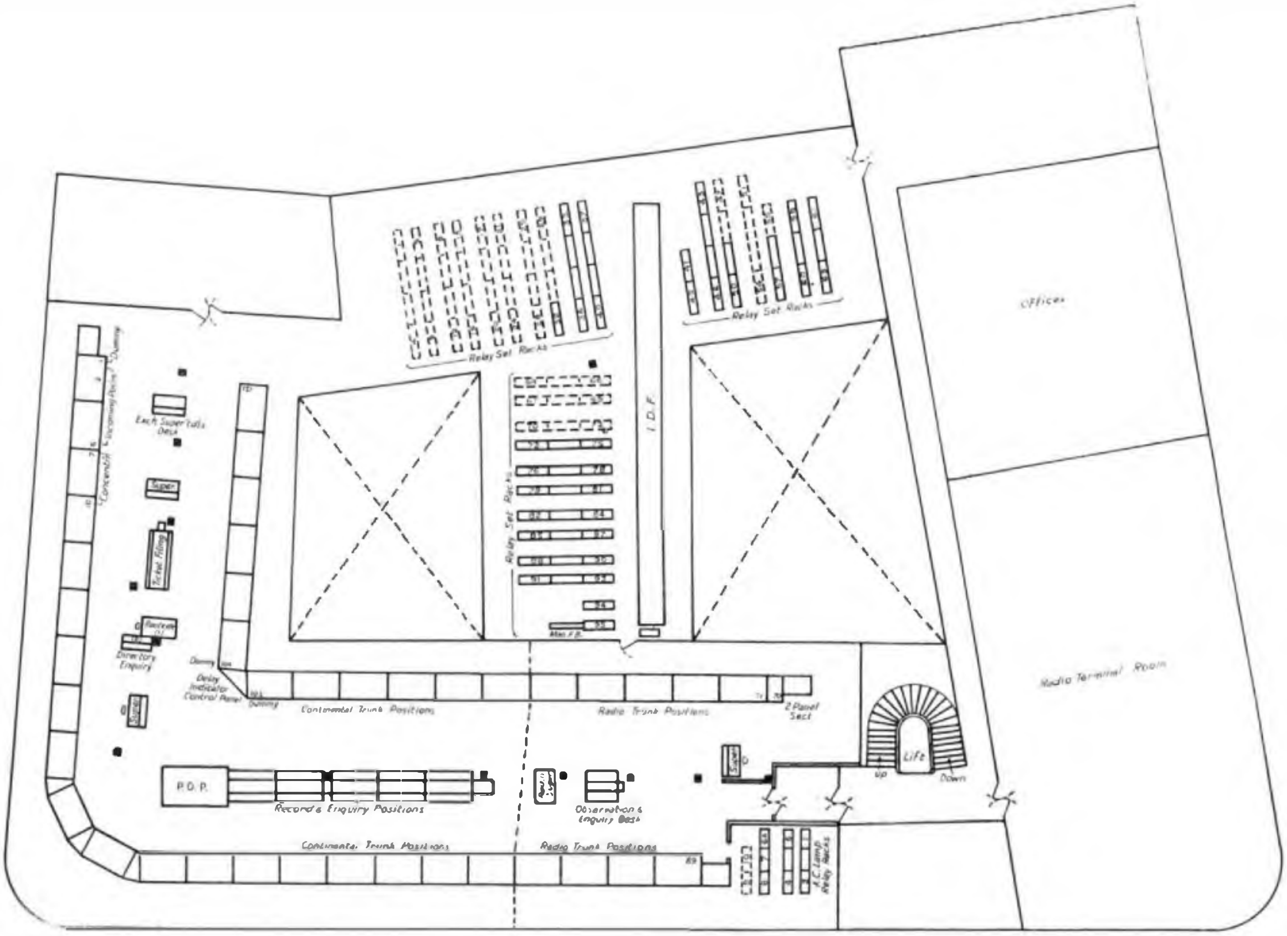


FIG. 3.—LAY-OUT OF SWITCHROOM AND APPARATUS ROOM.

equipment being mounted in the apparatus room.

A general view of the switchroom is given in Fig. 4.

FIG. 4.—GENERAL VIEW OF SWITCHROOM.

The switchroom contains in all 121 positions, of which 93 are equipped for Continental and 28 for Radio working. There is no difference between the positions so far as the construction is concerned, and the multiple equipment is the same throughout the exchange. In other respects the two services have been treated separately and keyboards and answering equipment provided accordingly.

The multiples are wired on a 6-panel basis and are common to both Continental and Radio suites. From the top of the panel they include outgoing lines to trunk and toll centres, local junctions to London exchanges, trunk subscribers, Continental trunk lines, and finally the interposition and service circuits. The total multiple capacity is 3480 lines and the space is allocated as follows :—

Inland Trunk and Toll lines...	1320
Local London Junctions ...	1080
Trunk Subscribers	240
Continental Trunks	480
Interposition and service lines	360

A group engaged tone equipment is provided on the multiple of local junctions to London exchanges. The standard arrangement is employed, *i.e.*, tone is applied to the bush of the first jack when all lines in a group of five are engaged. The junction multiples on the two side suites have been cabled separately in order that the circuits may, if necessary, be divided ultimately into two groups and thus double the capacity.

The trunk and toll and also the Continental trunk multiples are equipped with the new Visual Idle Indicating feature, standardized for trunk multiples under the Demand Scheme. The Visual Idle Indicating lamps are fitted in a strip immediately above the circuit jacks and in front of the lamp jacks is fitted a thin designation strip punched with small holes through which the lamp glow may be seen. The designation and lamp strips are thus combined to economize in multiple space. In a particular group of outgoing lines, the lamp associated with the first idle circuit is normally glowing, indicating that this line may be picked up. As soon as this happens the lamp is extinguished and the lamp of the next idle circuit glows and so on. Only one lamp in a group is glowing at any one time and the current consumption and heating effect are thus minimized.

The lamp and jack immediately preceding the first circuit in the group is used as a delay indicator. The lamp glows through a red aperture in the designation strip when there is abnormal delay on a particular route. The lamps are supplied from alternating current transformed to a low voltage from the public mains.

Fig. 5 shows the V.I.I. and delay lamp circuit. With no lines engaged the A.C. supply is connected *via* KA1 and KA2 to the lamps associated with the first circuit in the group. One lamp is provided at each appearance of the line in the multiple. When the 1st circuit becomes engaged relay KA is operated and the A.C. supply is extended to the next circuit *via* KB1 and 2. When the second circuit becomes engaged KB operates and the A.C. supply is further extended to the next circuit and so on. As circuits become clear the associated relay releases and it will be seen that the first idle circuit in a group is always indicated.

The delay lamps are controlled separately by a set of keys fitted in a panel on an angle section and are switched on or off by the supervisor in charge. Reference to Fig. 5 will show that the lamps light *via* VC relay contacts when the control key is thrown.

The jack under the delay lamp is utilized to give an indication, when required, of the actual delay period on the particular route. The circuit arrangement is shown in Fig. 6. The control keys are connected to the multiple jacks and a cord circuit on each line controlling position has connected with it three coloured lamps. The conditions set up by throwing a key or combination of keys, govern the lighting of the lamps when the cord circuit plug is inserted in the delay jack of the route concerned :—

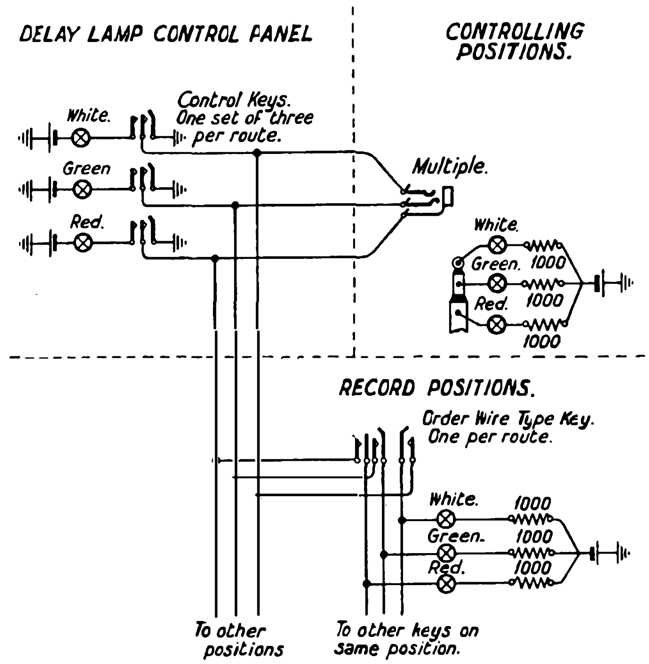


Fig. 6.—Delay Lamp Circuit.

The delay indications are as follows :—

White lamp glows—
30 minutes delay.

Green lamp glows—
45 minutes delay.

Red lamp glows—
60 minutes delay.

White and green lamps glow—
90 minutes delay.

All three lamps glow—
Indefinite delay.

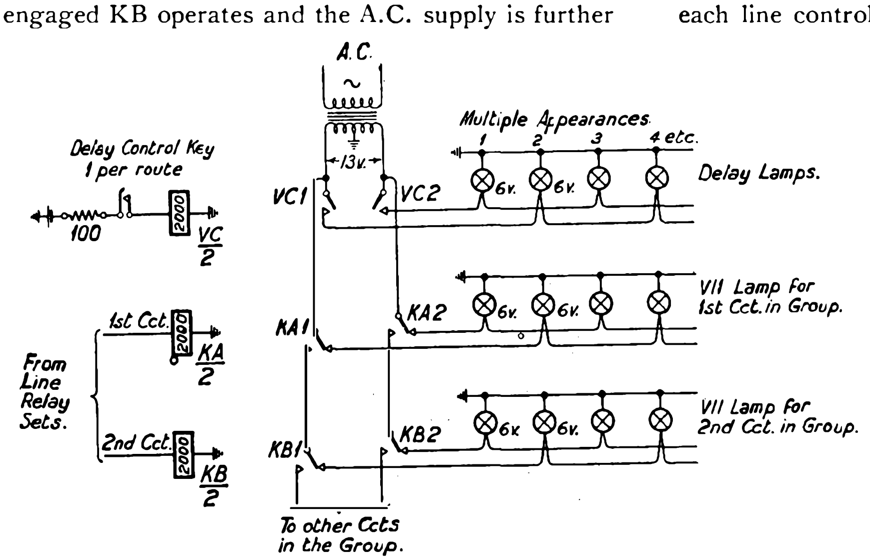


Fig. 5.—Visual Idle Indicator Circuit.

Apart from the multiples, the Continental and Radio equipments differ considerably and the two types of positions will be treated separately.

Continental positions have a face equipment as shown in Fig. 7. The answering equipment is comparatively simple and consists of a strip of ten jacks with calling lamps and also concentration keys by means of which the lamp signals may be switched to concentration positions.

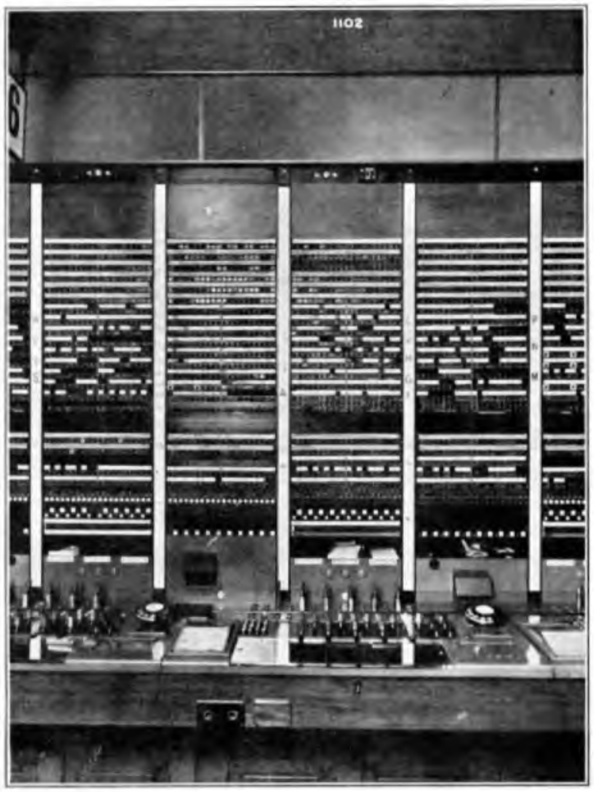


Fig. 7.—Continental Position.

Below the answering field is fitted the chargeable time indicator display lamp strips and routine test jacks. Three separate displays are fitted on each position.

Pigeon holes containing spare tickets, vertical holders for delayed call tickets, and an incoming pneumatic ticket tube terminal complete the panel equipment except for such details as battery jack, cord repair tube, etc.

The keyboard is equipped with five cord circuits, each of which has associated a speaking and monitoring key, ringing key, and a timing key. The association of the cord circuits with the chargeable time indicator displays is indicated by two white lines. Either of the first two cord circuits will light the top display, the second or third cord circuits will light the middle display and the fifth cord circuit the lowest display. There are thus three effective cord circuits on which calls may be connected simultaneously, the other two cord circuits may be regarded as reserve circuits. The standard colour scheme for the cords is used, namely, black, yellow, green and neutral with, of course, black again for the fifth pair. There are also keys common to the position circuit and these are fitted on the right of the keyboard. The facilities provided are the same as those on trunk demand positions, *i.e.*, coupling, call supervisor, transfer and dialling.

Tickets relating to calls in hand are held under spring clips screwed to the cord circuit speaking key mountings. To the left of the connecting cords there is the single plug and three lamps used in connexion with the delay indicating facility previously mentioned.

The order wire keys are in strips of five and two such strips fit into a space equivalent to two speaking keys. With the completion of the transfer of local exchanges to automatic working the order wire keys will be recovered and the instruction circuit has therefore been connected to a separate plunger key fitted to the right of the fifth cord circuit supervisory lamps. A green calling lamp is associated.

The automatic dial may readily be replaced by a V.F. keyset when required.

In front of the dial is an inlet valve to the pneumatic ticket tube. Details of the tube system are given later. The remainder of the keyboard is taken up by a bulletin sheet under a glass panel and on the left a compact card index file. The files on alternate positions give information relating to inland routes and Continental routes respectively.

The Enquiry and Record suite in the centre of the switchroom presented a problem in design. The space between the side suites is limited, but the number of positions could not be accommodated in one single line. It was necessary, therefore, to use double-sided positions and a saving in the depth of the positions was obtained by fitting the jack equipment on one side in the top half of the panel, and on the other side in the lower half of the panel, so that the distance between the two sides, measured between the faces of the panels, is only the depth of a jack and associated cable form. In the bottom of the panels are fitted ticket pigeon holes. The answering field has record and enquiry lines, incoming from the Inland trunk exchanges. These lines are multipled on a 7-panel basis and are divided into four groups. There are three languages used on Continental routes, namely, English, French and German, and, dependent on the destination of the call, a line in the appropriate language group is used for booking the call. The fourth group is used for booking calls from Provincial exchanges. The keyboards are the standard size and the equipment consists of three cord circuits with speaking keys, card index file, and glass bulletin panel.

There is also a delay indication which is given by lamps operating in a similar manner to those on the line controlling positions. The absence of the multiple of outgoing circuits on the enquiry and record positions makes it necessary to adopt a different arrangement from the plug and jack scheme and instead, order wire type keys are used as shown in the lower part of Fig. 6. Each position has a total of 60 keys, one for each route. The keys are multipled on all the record and enquiry positions.

Concentration of the incoming circuits on both the record and enquiry suite and controlling suites is effected during slack periods. On the record and enquiry positions the incoming signals are switched to the line controlling positions where the circuits are multipled and may be answered by the controlling operators who thus combine the functions of booking and connecting during slack periods.

On the controlling positions the concentration of Continental trunks is carried out in two stages. For the first stage one side suite is closed down and the lines are switched to the other side suite which then controls all lines. For the final stage of concentration the lines are switched to the first twelve controlling positions over which they are multipled with three lamp appearances.

Calls to the Continent are dealt with as follows: Taking first the case of a London subscriber, he will call or dial " Trunks " and be connected over a junction circuit to a demand position at the trunk exchange. The demand operator will extend the subscriber over a circuit in the appropriate language group to the Continental record and enquiry suite in the International Exchange. Here a Continental recording operator will take particulars of the call and enter them on a ticket. The subscriber will be advised of abnormal delay on the call, if any, and will be released. The time of booking is shown on the ticket in 24-hour timing as this is used on the Continent. The ticket will be sent to the pneumatic distribution position and from there will be despatched to the position controlling circuits to the country for which the call is required. Tickets are here arranged in order of booking time. The operator at the controlling position will ring the London subscriber as soon as a Continental circuit is available for the call, and the connexion will be established. The call will be controlled throughout its duration solely by the London Continental exchange operator, who will initiate the clearing of the connexion when the conversation is terminated.

In the case of calls from other zones *via* the London trunk exchange, the originating zone centre demand operator takes particulars of the call and releases the subscriber. The call particulars are passed forward by telephone to the Continental record operator *via* an incoming position and a zone record transfer circuit. The call is recorded on a ticket which is sent to the Continental controlling position by pneumatic tubes as before. When a Continental circuit is available, the London Continental exchange operator will call the originating trunk exchange over an outgoing trunk circuit and establish the connexion. Control will still be exercised by the London Continental exchange to ensure that a linguist operator is available on the circuit both for setting up and also supervising the connexion.

The circuit arrangements used in the Continental equipment conform in general to the new Sleeve Control system adopted in connexion with the Trunk Demand installations throughout the country. This system will be described in more detail in an article on the London Inland Trunk Centre in the next issue of this Journal.

Complete interchangeability of the equipment is one of the advantages of the sleeve control system and this is amply demonstrated by the fact that, to meet the development of the International services in the future, space for a new and large switchroom devoted entirely to Radio traffic has been earmarked on the second floor of the building. The Radio suite in the present switchroom will then be used for Continental working and the only work entailed will be that of increasing the number of cord circuits, adding C.T.I. equipment, monitoring keys, and rearranging the answering field.

The Radio link as a part of a telephone network is only of very recent introduction. The first commercial Radio Telephone channel to be opened was between this country and the United States of America in January, 1927. Traffic over the circuit was considerable and other channels were opened in 1928 and 1929. In later years services to other countries have been provided and at the present time there are in service twelve channels, four of which are to the United States and the remaining eight to various other countries.

For economic reasons radio equipment is not provided for every route. There is a certain amount of common equipment as all the channels are not required to work simultaneously.

The equipment of the Radio positions differs from the Continental positions principally in regard to answering and keyboard equipment. The multiples are identical as has already been mentioned. The answering equipments cater for the two-wire terminations of the Radio channels, incoming record circuits from the outgoing multiple over the Inland and Continental exchanges, and the terminations of interposition circuits.

It was the practice in the old exchange to terminate the Radio channels on a four-wire basis using double plugs and twin jacks. Extensions to local junctions and some two-wire trunks were effected on a two-wire basis with a simple 600 ohm network as a compromise balance. On two-wire trunks balanced for cord circuit repeater working the connexions were set up using the correct line balance. The extension of the Radio circuits to four-wire trunks or other Radio channels was on a four-wire basis using the well known " tail-eating " or " whiting " arrangement, and for this the double plugs and jacks were essential. The Radio channels appeared only on the home positions and no multiple was provided.

In the design of the new exchange it was considered desirable to multiple the channels over all Radio positions to give better facilities for through switching of the Radio channels and also flexibility between channels and positions. With the old four-wire system this would have entailed elaborate and cumbersome arrangements and might have proved impracticable.

The advantage of the four-wire system was that the correct balance for the circuit was always used with the line. This has become less important of recent years. The general improvement in transmission over trunk lines has made it necessary to balance lines more accurately in order to prevent instability, and most lines have now a 600 ohm impedance. The increased use of terminal repeaters ensures a 600 ohm termination in these cases, also lines are always closed with a 600 ohm network when the circuits are not in use. The Radio terminal hybrid coils have been replaced by others of a type having a far better balance than the previous type and this holds good over a much greater frequency range. Improvements in the actual Radio circuits have resulted in a better signal to noise ratio than was obtained some years ago and this gives incidentally a better balance when calls are set up.

The sum result of all these improvements is that the extension of Radio channels on a two-wire basis has been entirely successful, and a multiple of Radio channels has become a practical proposition.

The Radio channels are connected on a strip of ten jacks on alternate positions over the entire suite. Below the line jacks are three strips of lamps by means of which individual lamps or combinations of lamps may indicate what restrictions, if any, must be observed in extending a particular channel over land lines.

It will be appreciated that the conditions on the Radio circuits are variable and at times the circuit conditions may be bad and unsuitable for long extensions or may even be uncommercial, so that a convenient method of advising the operators of the conditions prevailing is essential.

Above the Radio circuit jacks is a strip of visual idle indicating lamps, with one lamp for each channel. The lamps are alight when the channels are open for service and are switched off by the controlling operators when a call is established. Controlling keys are fitted immediately above the lamps. Next is a strip of monitoring jacks, one for each channel, and a designation strip denoting the individual channels.

Order-wire calling signals from the technical operators are provided on each channel so that if the distant end calls verbally on a channel and no London operator is in circuit, the technical operator, who is of course always in circuit, may call in a telephonist. The lamps are fitted at the bottom of the panel and the speaking circuits are provided by two strips of order-wire keys to the various technical operators.

The pigeon holes at the bottom of the panel are larger than those on the Continental positions. The size of the tickets is not restricted as is the case with Continental working where pneumatic tubes are used. The larger tickets allow greater space for the necessary particulars.

The keyboard equipment is comparatively small. Fig. 8 shows a keyboard in detail. Only three cord circuits are provided, for not more than one channel can be dealt with on one position as the operator must be monitoring throughout the call. Speaking and ringing keys are provided for each cord circuit and the standard common keys for the position, call supervisor, coupling, dialling circuit, etc., are fitted.

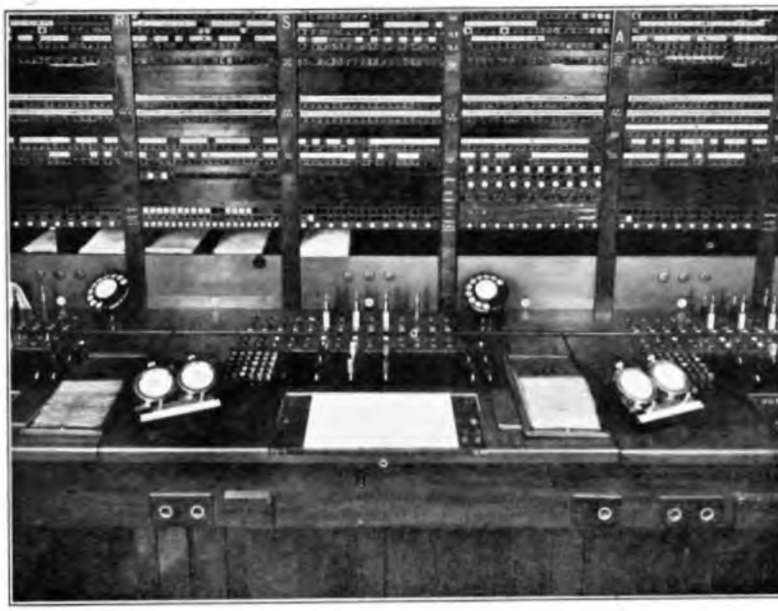


Fig. 8.—Radio Position Keyboard.

Monitoring is obtained by a separate cord which may be inserted into the monitoring jack of any channel, thus giving direct monitoring on Radio calls. The delay indicating cord is not provided as Radio calls have priority over other calls and the delay period does not apply.

A glass panel for bulletins, a card index file, outgoing order-wires in strips of five, dial, and stop-watches for timing complete the keyboard equipment. Fig. 9 shows a general view along the Radio suite. No ticket tube has been provided as the expense is not warranted. Tickets are circulated by the supervisor when necessary.

The progress of a Radio call is similar to that for a Continental call. Delay working is in force at all times on the Radio services. The subscriber dials "TRU" or asks his local operator for "trunks" and is connected to a trunk demand position. The demand operator extends the subscriber over a local circuit to the Radio line controlling positions. The answering equipment of these local circuits is multipled over all Radio positions and any operators not engaged in dealing with a call may take particulars from the subscriber and enter them on a ticket. The subscriber is released and the ticket handed to the enquiry desk where the particulars given by the subscriber are verified and a serial number allotted. A rough duplicate is held on the Radio controlling position and the particulars are passed to the distant Radio operator who reports on whether the wanted subscriber is available. The call is always referred to by the serial number hereafter for convenience. If the wanted party is available the call is set up. Two operators are concerned at each end. An advance operator obtains the

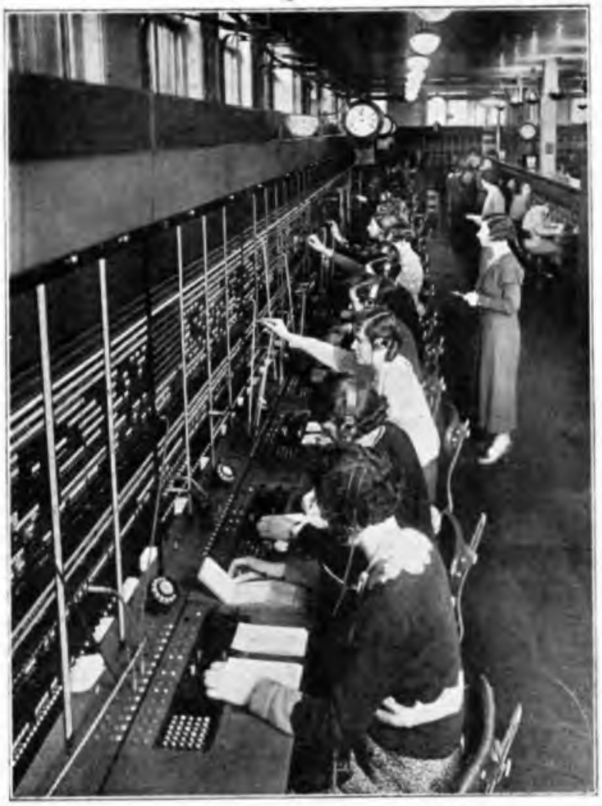


Fig. 9.—View along Radio Suite

originating London, Provincial, or Continental subscriber over a multipled circuit. The channel operator takes over the subscriber from the advance operator as soon as the subscribers on both sides are ready and the call is established. Advance operators have language qualifications in order that Continental circuits may be connected without difficulty. Where a delay route is concerned with a Radio connexion, priority is given over other calls and a line is allotted as soon as possible.

The circuit arrangements on the Radio positions embody the sleeve control system. The cord and position circuits, Fig. **10**, are standard except for monitoring and timing. The junction and trunk line relay sets are, as previously mentioned, used in common with the Continental positions and are standard sleeve control units. The relay sets used on the Radio channels are of special design and will be described in detail.

The complete circuit arrangement for one channel is shown in Fig. **11**. Monitoring is obtained from the terminal equipment and is connected direct to the monitoring jack. These jacks are multipled so that operators may listen on the channel they are controlling by simply inserting the position monitoring plug into the jack of the appropriate channel.

When a channel is open for service the technical operator throws a key to indicate the state of the channel. This operates one or more of relays L, Z and D, and the V.I.I. lamp is lit at contacts L1, Z1, or D1. As soon as a channel is in use for a call, the controlling telephonist operates the V.I.I. control key and the lamp is disconnected at K1. When the channel is released by the telephonist the V.I.I. key is restored and the V.I.I. lamp glows. This feature is of importance on the American service where there are several channels.

The circuit for the order-wire between the technical and exchange operators is shown in the lower part of the diagram. Bothway working is provided. The technical operator calls by inserting a plug into the jack and operating OL. Contact OL1 lights the calling lamps and OL2 connects the night alarm circuit. Relay OS disconnects the calling signal when a telephonist presses the order-wire button, and locks *via* OL2 and OS3 until the technical operator clears. The exchange telephonist calls by depressing the order-wire button and relay OS operates and at OS2 lights the calling lamp on the technical operator's position. The lamp is disconnected when the technical operator answers and relay OS is locked *via* OS3 and OL2 as before.

On the Radio channels no calling signals are provided; the relay set equipment is necessary to ensure the correct operation of the voice-operated device and also the gain control.[1]

On all calls other than Radio to Radio, the voice-operated device must be in circuit. On Radio to Radio calls, only the voice-operated devices at the terminal ends of the through connexion, *i.e.*, the two distant Radio terminals, are required and the London voice-operated devices are cut out; but if the through connexion is broken down, the London voice-operated devices must come into circuit to prevent singing.

The operation of the relay set is as follows :—

When a connexion is to be established, the cord circuit plug is inserted into the channel jack, Fig. **11**, and relays S and SS operate. The telephonist must now throw the ringing key, Fig. **10**, and battery is applied to the tip wire, through relay RR and rectifier to earth, (note that the conductive direction of the rectifier from positive to negative is indicated by the arrow-head portion of the symbol). Relay RR restores when the ringing key is released. Contact RR1 prevents premature operation of relay VC. Relay RA operates *via* RR2. Relay TR operates on one winding from earth *via* 650-ohm resistance and to battery *via* RA2 and 100-ohm resistance. Contact TR1 locks RA relay which cannot now release until TR relay restores or plug is removed from jack. Contact RA3 operates relay RB which, being slow to release, will hold *via* RB2 when relays TR and RA restore.

Contact RB1 connects 50-volt positive battery in place of the rectifier. Relay CI is operated by RA5 and at contacts CI1 and 2 disconnects the terminating impedance and extends the Radio circuit to the exchange jack and cord circuit. Relay CI remains operated until SS releases, *i.e.*, until the plug is withdrawn. Contact CI4 prepares a circuit for VC relay. Relay DR operates whilst cord circuit speaking key is thrown and the earth connexion, *via* DR1,

[1] "Radio Telephony Terminal." W. H. Scarborough. P.O.E.E.J., April, 1931.

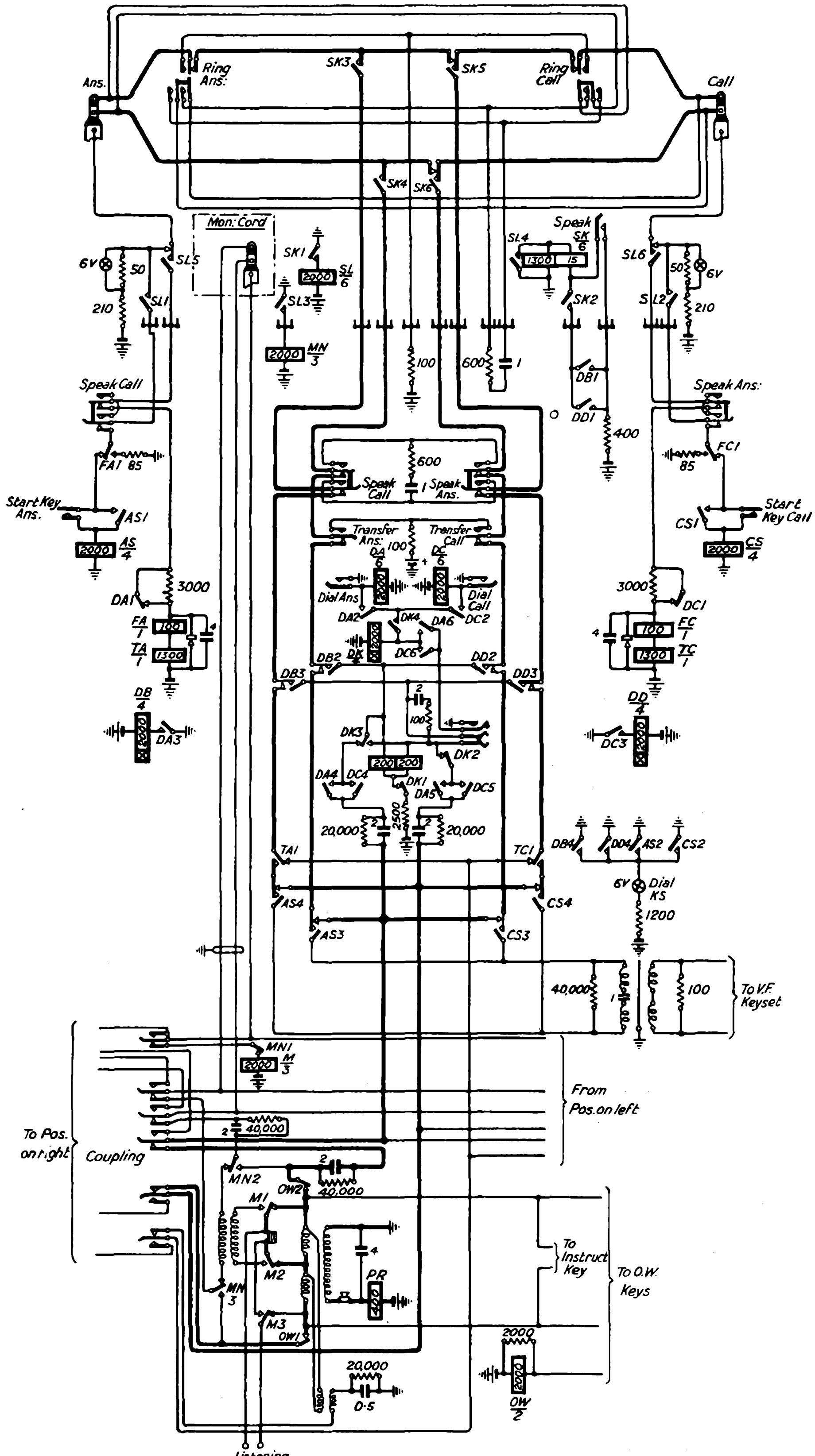


FIG. 10.—CORD AND POSITION CIRCUIT, RADIO SUITE.

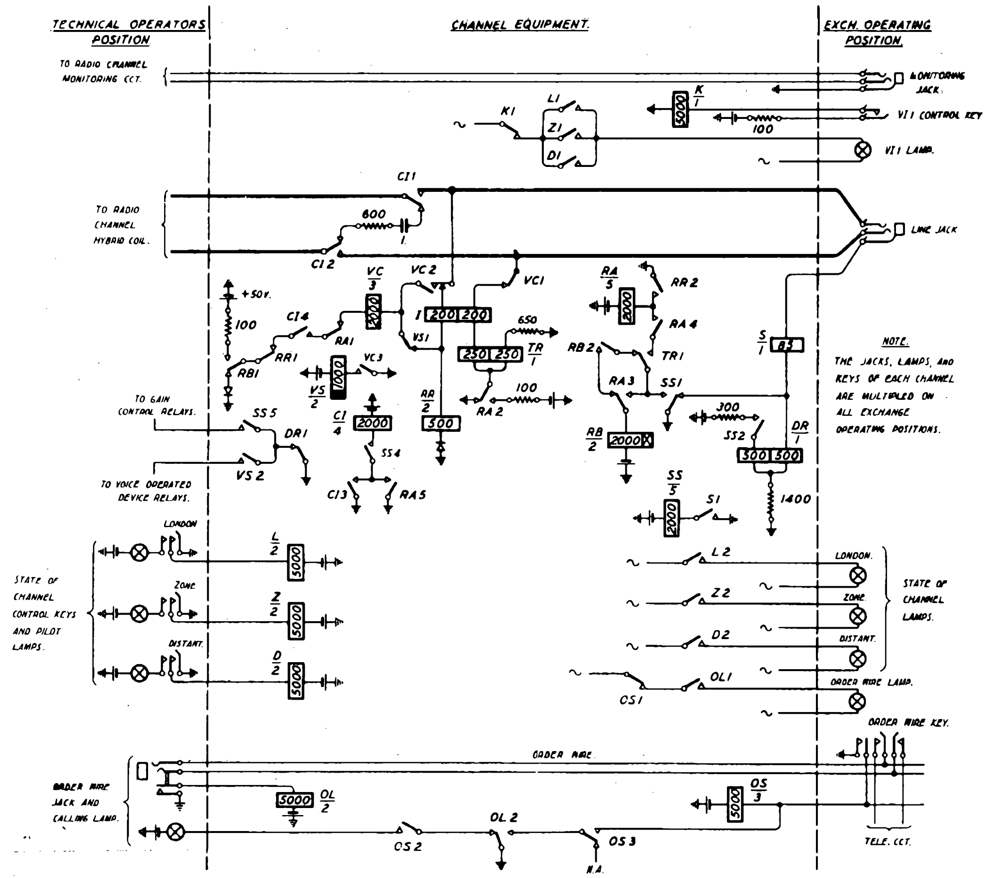


FIG. 11.—RADIO CHANNEL CIRCUIT.

which cuts out the voice-operated device, is removed until the speaking key is restored.

If the Radio channel is extended to a trunk or junction circuit, the conditions set up above remain unchanged throughout the call. The conditions are maintained by relay TR which holds in relay RA, etc. To release relay TR, an earth *via* 450 ohms resistance on the tip wire would be necessary. This would send a current through the second winding of relay TR to oppose the effect of the current in the first winding. No junction or trunk relay set will give this condition.

If the Radio channel is extended to another Radio channel (say channel 2) a 450-ohm earth is applied to the ring wire immediately the plug is inserted into the second channel jack and before the telephonist rings. This 450-ohm earth releases relay TR of channel 1. Contact TR1 disconnects relay RA which releases. Relay RB is slow to release and holds *via* RA3, RB2, TR1, and SS1. Contact RA1 restores, connecting positive battery to tip wire and out to channel 2. Contact RA2 connects earth to TR relay coils. (To differentiate between relays in channel 1 and those in channel 2 the former will be printed in ordinary type and the latter in italics.) Relays *S* and *SS* of channel 2 operate. Relay *RR* operates when telephonist rings as in the case of channel 1. Relay *TR* (2nd channel) will not operate as equal currents flow through the two windings of *TR*. Relay *RA* does not lock but operates *via* *RR*2 whilst ringing key is thrown. *RA*2 extends battery to TR relay (channel 1) which operates and disconnects the lock up of relay RB. Relay TR releases when ringing key is restored and *RA* thereby released.

During the operation of relay *RA*, *RB* operates and prepares a locking circuit at *RB*2. Contact *RB*1 replaces the rectifier by a 50v positive battery, and contact *RA*5 operates relay *CI*. Relays *CI* and *DR* operate as in channel 1. Relay *RA* restores when ringing key on channel 2 is released and at *RA*1 connects the 50v positive battery from channel 2 *via* *VC* relay, tip wire, VC relay to rectifier channel 1. The VC relays of both channels operate and disconnect the two I retards from the line. Relays VS (slow to operate) on each channel disconnect the RR relays from the tip wire and also extend earth from DR1 contacts to cut out the voice-operated devices of the Radio channels.

The relay conditions when a Radio to Radio call is established are as follows :—

Channel 1. Relays operated :—VC, VS, CI, S and SS.

Channel 2. Relays operated :—*VC*, *VS*, *CI*, *S*, *SS*, and *RB*.

It will be appreciated that relay TR of channel 1 disconnects the lock up of relay RB channel 1, but in the case of channel 2 relay *TR* does not operate during the setting up of the connexion; therefore relay *RB* remains locked up and provides the 50v positive battery to meet the rectifier of channel 1.

Any interference with the connexion drops out relays VC and VS of both channels and the voice-operated devices are brought into circuit by the VS2 contacts which release and disconnect the earth connexion which holds out the voice-operated devices.

The reason for arranging that the telephonist must ring on the circuit to set up the connexion is to prevent false operation of the relay train when the plug is being inserted into the jack.

The gain control feature is also dependent on the conditions given from the relay set and this operates on all connexions. When the call is set up the technical operator controls the gain of the transmitted speech and on difficult land lines the gain may be considerable. If the telephonist at London were to enter the circuit and speak under these conditions the volume would be excessive and as a safeguard against this trouble, the operation of the cord circuit speaking key cuts out the controlling switch of the transmit amplifier and connects to a moderate gain which suits the average speech volume of telephonists. The operation is as follows :—The speaking key in Fig. **10**, when thrown, operates relays SK and SL. Contact SL5 changes the condition on the sleeve of the plug from a battery connexion *via* approximately 240 ohms to a battery connexion *via* 1400 ohms. The current through one coil of relay DR, Fig. **11**, is thereby reduced and relay DR operates on the out-of-balance current. Relays S and SS are operated when the plug is inserted in the jack so that normally the currents through the two windings of relay DR are equal and opposite in effect. Contact SS5 is operated when a cord circuit is connected and with DR1 in the normal position the technical operator's gain control switch is in circuit.

Ticket distribution on the Continental suite is by means of the Department's standard pneumatic tube system for trunk exchanges.[2] A sketch of the installation is shown in Fig. **12**.[3]

The tickets originate at the Record and Enquiry positions from which they are carried by a band conveyor to the Pneumatic Distribution Position, Fig. **13**. From here, the tickets are sent *via* individual tubes worked on a pressure basis to the various controlling positions. There are altogether 44 pressure tubes from the P.D.P. to the Continental positions, each tube serving two positions. The tube outlet can be seen at the bottom of the second panel in Fig. **7**. Completed call tickets are despatched to the Ticket Filing Position by means of tubes worked on a vacuum basis. These tubes are not individual to a position, but are common to 9 positions. The tubes are run under the keyboards and inlet valves are provided on each keyshelf. A total of 11 tubes serves the Continental suite. At the Ticket Filing Position, Fig. **14**, the tickets are ejected on to a horizontal shelf and sorted by the operators into compartments in horizontal trays. Full trays are taken to the clerical section for final accounting and filing.

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[2] "Recent Developments in Pneumatic Tube Design." J. E. M. McGregor, A.C.G.I. P.O.E.E.J., July, 1932.

[3] "Pneumatic Tube System at G.P.O. South." J. E. M. McGregor, A.C.G.I. P.O.E.E.J., Jan., 1934.

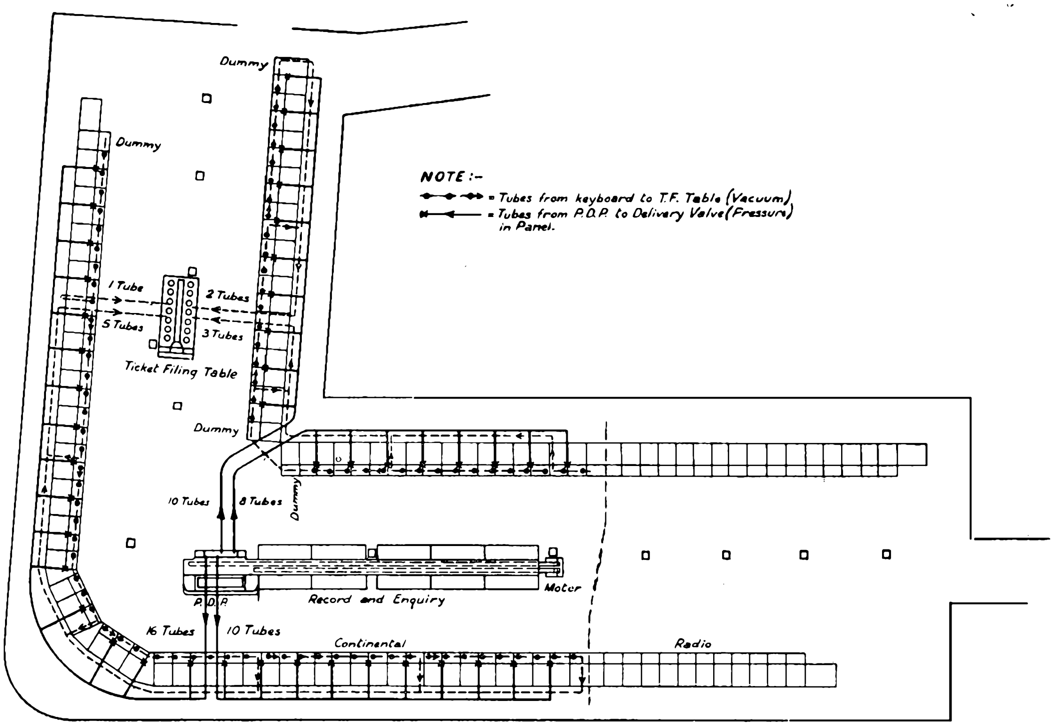

FIG. 12.—PNEUMATIC TUBE SYSTEM.

FIG. 13.—PNEUMATIC DISTRIBUTION POSITION.

Fig. 14 also shows the Route and Rate Quoting position from which controlling operators may obtain, *via* a circuit in the multiple, all information relating to direct and auxiliary routing on the Continent, day and night rates, and information regarding hotels, etc. Telephone directories of all European countries are held at the position.

The timing facilities at the International Exchange have received special consideration in view of the high revenue-earning capacity of Continental and Radio circuits and also because the telephone administrations of other countries are involved.

On the Continental positions a chargeable time indicator is fitted. The type used for " Demand " working has the disadvantage that a continuous display is not given. This difficulty is overcome by providing three separate displays on each position, associated with the cord circuits as previously described. It is thus possible to control simultaneously a maximum of three calls if required. The chargeable time indicator equipment is started by throwing the controlling key forward. The associated display is illuminated immediately, indicating one minute and changing after each minute period to 2, 3, 4, etc. Before changing, the lamp flickers for 12 seconds, indicating to the operator the necessity for monitoring. A twelve second steady glow is given by the red keyboard lamp immediately before the end of each three-minute period. The limit of the device is 18 minutes and this is indicated by a continuous flicker on the red keyboard lamp until the control key is operated to the reset position and then restarted if necessary.

In the case of Radio calls, the whole of the time that a subscriber is connected may not be satisfactory for conversation. Radio channels are subject to fading and interference so that controlling operators must assess the satisfactory speaking time as distinct from the total time of connexion. Two stop-watches are provided mounted side by side and linked mechanically by a starting lever, which starts them simultaneously. The right-hand watch is in operation for the whole duration of the connexion and records the overall time. The left-hand watch may be stopped and restarted independently from the linking lever and this is done during interruptions so that this watch only indicates satisfactory time.

On both the Continental and Radio suites the actual time of day is obtained from electric clocks fitted at the top of the sections. These clocks are marked with 24-hour figures as this system is used internationally.

The installation of the International Exchange was carried out by Standard Telephones and Cables, Ltd., to the design of the Post Office. The new features introduced in this specialized equipment have presented many problems in design; and considerable credit is due to those responsible for the various phases of the work involved in the completion of the first International Exchange in the world.

FIG. 14.—TICKET FILING POSITION.

Transmission of Pictures by means of Mobile Transmission Sets

J. STRATTON, A.C.G.F.C., A.M.I.E.E.

THE purpose of this article is mainly to show the results achieved by mobile picture transmission sets. The art of transmitting pictures has been previously described in this Journal[1] and in a paper read before the I.P.O.E.E.[2]

The first transmission from a mobile picture set was made by the "Scotsman" on the 7th September, 1933, from Ballater to Edinburgh, using the Ballater-Aberdeen and Aberdeen-Edinburgh trunks. The transmission was made under private wire conditions, *i.e.*, the circuit was set up by means of soldered connexions on the main frame and all exchange apparatus cut out.

On the occasion of the visit of the Duke and Duchess of York to the Isle of Skye, the "Scotsman" transmitted pictures from Portree to their office in Edinburgh. The call was routed over the Portree-Kyle, Kyle-Inverness, Inverness-Aberdeen, Aberdeen-Edinburgh trunks with cord circuit repeater assistance at Inverness. In this case, the pictures were transmitted over ordinary trunk connexions with the cord circuits inserted, and not, as in the Ballater case, with soldered connexions on the main frames. The results were highly satisfactory and a typical picture is shown in Fig. 1 which is published by courtesy of the "Scotsman."

FIG. 1.—THE DUKE AND DUCHESS OF YORK AT KYLEAKIN.

FIG. 2.—TRANSMISSION APPARATUS.

In the summer of 1933, the "Evening Standard" purchased a mobile transmission set operated on the Belin principle, the whole apparatus being contained in two cases about the size of an ordinary suit case, as illustrated by the accompanying photographs. The first case, Fig. 2, contains the transmission apparatus, and the second, Fig. 3, the necessary battery power required to operate the apparatus. Other newspapers are now purchasing sets, and transmissions have been made by the "Evening Standard," "Daily Mirror," "Daily Mail," and "Daily Sketch."

The general practice is to send the apparatus by train, car or aeroplane to any site of interest of which a picture is required for publication. Speed is of the utmost importance, since any delay would probably mean missing an edition of the afternoon or evening paper.

The transmitting apparatus is connected direct to Post Office lines, the connexion being made by a Post Office Engineering Officer. A list of exchanges where linemen are readily available has been prepared and is furnished to the newspapers concerned. As far as possible, pictures are transmitted from an exchange, the apparatus being joined straight to the trunk line at the main frame. In some cases, however, pictures have been transmitted from sub-

[1] Oct., 1928. "Picture Telegraphy," by E. S. R.
April, 1930. "Phototelegraphy," by E. S. Ritter.
July, 1930. "Picture Telegraphy." Siemens-Karolus-Telefunken-System, by G. E. Carr.
April, 1931. "Facsimile Transmission in the United Kingdom," by A. T. J. Beard.

[2] I.P.O.E.E. paper No. 129, by E. S. Ritter.

FIG. 3.—BATTERY CASE.

scriber's premises, the subscriber's instruments being disconnected and the mobile picture transmission set substituted.

FIG. 4.—S.S. " MAJESTIC " ENTERING SOUTHAMPTON GRAVING DOCK.

The receiving apparatus is, of course, permanently situated at the offices of the newspapers concerned, and when a mobile set is being sent out, a call is booked and Sectional Engineers are advised by telephone, in order that a lineman may be available to make the necessary connexion. Sports and similar events are known well in advance and a written notice will suffice.

If practicable, the use of aerial circuits is avoided when selecting trunks as overhead circuits are liable to interference from noise. Operators are warned that there must be no monitoring or time announcements on the call, otherwise the picture will be spoilt. At the terminal exchange, the switchboard is usually cut out, the trunk being joined straight through at the test desk to local ends, rented by the newspaper, between " Trunk Test " and the receiving apparatus.

Apart from the calls mentioned above, picture calls have been made to London from, among other places, Cardiff, Leicester, Portsmouth, Gosport, Southampton, Epsom, Wembley, Hastings, Salisbury, Brussels, Plymouth, Lincoln, Liverpool, Worcester and from St. Andrews to Manchester. From the experience already gained, it would appear that, generally, a satisfactory service is to be expected. It should perhaps be remembered that in the Portree example already quoted the majority of the circuits were aerial and the number of switching points was on the high side for the type of call expected.

The " Evening Standard " have kindly loaned photographs and so enabled a few typical examples to be illustrated. On the 19th January, 1934, one of their first transmissions was made from Southampton from a subscriber's installation, the Royal Pier Hotel Southampton. The picture was transmitted over an ordinary 4-wire repeatered trunk between Southampton and London, and it was found necessary to join the subscriber's line straight through to the trunk at Southampton. Following the practice which has since become standard, the London end of the trunk was joined straight through to the local

FIG. 5.—THE FUNERAL OF THE LATE KING OF THE BELGIANS.

Fig. 6.—Bournemouth Motor Car Rally.

ends at " Trunk Test." This was done in each of the following examples. Fig. 4 shows the results of this transmission and shows the " Majestic " entering the new graving dock at Southampton.

Probably the most spectacular use of the mobile picture set was when the " Evening Standard " sent their transmitting set to Belgium in connexion with the funeral of the late King of the Belgians. The earlier pictures were published in the newspapers and sold in London before the funeral ceremony was actually completed in Belgium. Transmission was over a 4-wire circuit between Brussels and London and by the courtesy of the Belgian Administration, the transmitting apparatus was located in the Brussels Repeater Station. Fig. 5 is a reproduction of one of the pictures transmitted.

For the Motor Car Rally at Bournemouth on the 13th March, 1934, pictures were transmitted from Bournemouth; Fig. 6 is a reproduction of one of the received pictures on that occasion. The line used was an underground 4-wire repeatered circuit between Bournemouth and London Trunks.

In connexion with the launching of the " Endeavour," Mr. T. O. M. Sopwith's challenger for the America's Cup, the " Evening Standard " transmitted pictures from Gosport, and Fig. 7 is an example. In this case, spare wires in the local cable were used to extend a London-Southampton 4-wire repeatered trunk on a 4-wire basis to Gosport.

Figs. 8 and 9 are examples of the recent transmission from Worcester on the occasion of the first match by the visiting Australian Cricket Eleven. The first illustration is a reproduction of the original picture and the second a reproduction of the picture received in London. The circuits used were an underground 2-wire circuit between Birmingham and Gloucester and a London-Birmingham 2-wire repeatered circuit, 25 lb. I. 120/1.136 with repeaters at Birmingham and Fenny Stratford.

It is interesting to compare the foregoing examples with the test picture which is used by the " Evening Standard "; this picture is only transmitted from the sending to the receiving apparatus at London, *i.e.*, no lines are included. Figs. 10 and 11 show results of the test, Fig. 10 being the transmitted, and Fig. 11 the received, picture. Comparing these with Figs. 8 and 9, it will be seen that the loss of definition is approximately the same in each case. In other words, the effect of transmitting over ordinary telephone lines is about the same as transmitting straight from sending to receiving apparatus.

The system will probably develop as far as the evening papers are concerned, and, judging from the results already obtained, a satisfactory service should be given.

All the illustrations are reproductions from prints loaned by the " Scotsman " or the " Evening Standard " and the author wishes to express his appreciation of their very helpful co-operation.

Fig. 7.—Launch of Mr. T. O. M. Sopwith's " Endeavour."

Fig. 8.—The Australians at Worcester.

Fig. 9.—The Picture (Fig. 8) as Received in London.

Fig. 10.—Test Picture used by the "Evening Standard."

Fig 11.—Test Picture as Received.

Manchester Automatic Area

Engineering Fault Complaint and Repair Service

H. MORTIMER

THE object of this service is to enable automatic exchange subscribers in certain automatic areas to report complaints in connexion with their telephone installations direct to the Engineering Staff. Complaints other than those relating to plant defects will be reported by the subscribers to the Traffic Department in the usual manner.

In Director Areas, the subscribers will dial the code " ENG " and in Non-Director Areas " 97 " will be dialled; the call will then be routed to the " ENG " Test Desk and dealt with by a Test Clerk, who is known as a Fault Complaint Officer.

It will be appreciated that the subscriber, being able to get in direct communication with an engineering officer, is able to state his complaint fully, a condition which is not obtainable under the docket system of fault reporting, however efficient this may be.

The " ENG " system of complaint reporting also eliminates the unavoidable delay in the passing of the docket from the traffic staff to the engineering staff. Valuable time is thus gained which enables the engineering staff to locate and clear faults more quickly and thus prevent further complaints.

It is of vital importance that faults on common equipment such as Directors, A-digit Selectors, Coders, Senders, etc., should be located and cleared at the earliest possible moment.

It would perhaps be of interest if the difficulties expected to be reported by subscribers over the " ENG " circuits were enumerated here :—

(*a*) No dialling tone. These faults will probably be reported from another telephone.
(*b*) Bell not ringing, ringing faulty, or persistently tinkling.
(*c*) Transmission difficulties.
(*d*) Extension faults.
(*e*) Faults on P.B.X. Switchboards.
(*f*) Apparatus broken.
(*g*) Complaints of wrong numbers or cut off troubles of a general character.

It is possible that a subscriber may dial 0 for reporting the foregoing difficulties, in which case the operator will connect the subscriber to the " ENG " Test Desk over one of the Auto-Manual Switchboard " ENG " circuits.

The Engineering Fault Complaint and Repair Service, now known as the " ENG " Service, was introduced at automatic exchanges in the whole of the London Automatic Area in July, 1931, and the continued success of the service induced the British Post Office to carry out an experimental trial of this service in the following automatic areas :—Manchester, Birmingham, Newcastle, Edinburgh and Leeds. The first two are Director areas and the others Non-Director areas.

The service was introduced in the Edinburgh and Newcastle areas in January, 1934, and it is expected that it will be in operation in the Manchester and Birmingham areas at the end of July, 1934.

The Manchester Automatic Area has been chosen as the subject for this article, as the scheme to cover this area is considered to be of more interest to the reader than those in the other areas.

In the Manchester " ENG " scheme, the service is to work to eight controlling centres, each centre controlling one or more exchanges, details of which are given in Table I.

TABLE I.

Controlling Exchanges.	Controlled Exchanges.
Blackfriars	Deansgate, Pendleton, Swinton, Walkden
Sale	Urmston, Longford
Ashton	Denton
Collyhurst	—
Moss Side	—
Ardwick	—
Main	Middleton, Failsworth
Stockport	Gatley, Heaton Moor, Woodley

With the introduction of the " ENG " service, centralized testing and centralized fault control will be brought into operation at the same controlling centres. Under this scheme, the fault cards for both the controlling exchange and the controlled exchanges will be located at the controlling exchange.

Sale Group: Routing of " ENG " Traffic.

It is not proposed to explain in detail the routing of the " ENG " traffic at each of the controlling and controlled exchanges, but only that for the Blackfriars group and also for the Sale group. The latter group is typical of the Ashton, Main, and Stockport groups of exchanges.

When all the controlling (except Blackfriars) and controlled exchanges are left unattended, the " ENG " traffic is routed to Blackfriars " ENG " test positions. At the outset, however, an exception will be made in the case of the Stockport Group of exchanges which will work to the controlling exchange (Stockport) both for day and night service. On reference to the Sale Group routing diagram (Fig. 1) it will be seen that the " ENG " traffic for Sale, Longford, and Urmston is routed to the Sale " ENG " test desk from a selector level at each exchange.

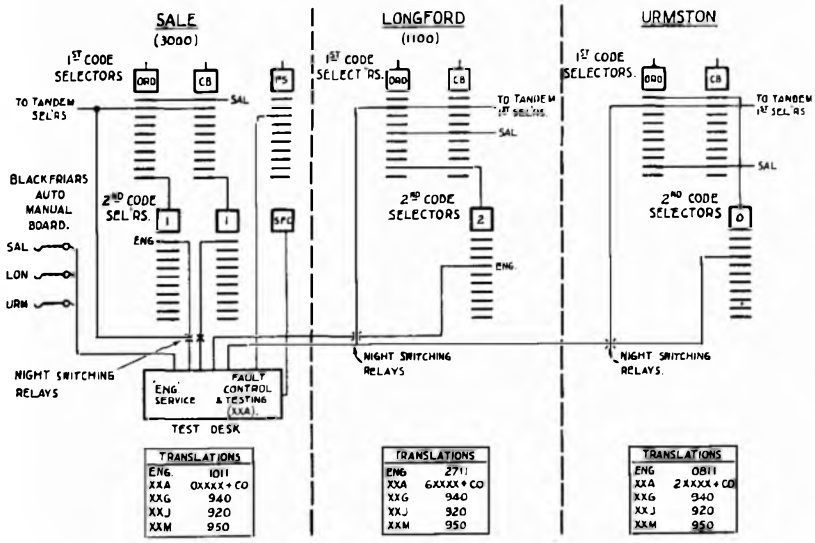

FIG. 1.—SALE GROUP.

When a subscriber at Longford dials " ENG," the code is translated to 2711, although 27 would route the call to Sale. The 11 digits have been added to the code translations for " ENG " at all exchanges except those in the Blackfriars group so as to avoid the need for complicated switching arrangements at each exchange for the purpose of changing the code translation for " ENG " from day to night service.

Referring again to the routing diagram, it will be seen that in the case of Longford, when the Director has sent out 27, the calling lamp of the Longford " ENG " circuit on the Sale " ENG " test desk will glow. Immediately after, the calling lamp will flick twice in response to the 11 sent out by the Director. The two digits " 11 " have been chosen so as to keep the flicking of the calling lamp to a minimum. When the Sale " ENG " test desk is left unattended, the night switching relays are operated at each exchange and the last line of the " ENG " circuits is switched over to the last outgoing junction to Tandem, the switching facility also making busy the remainder of the " ENG " circuits at each exchange.

When the last " ENG " circuit is extended, the code translation 2711 will route the call *via* 27 level in the case of Longford, over the Tandem junction to the Longford incoming Tandem Selector at Tandem thence *via* level 11 of Tandem Selectors to the Blackfriars " ENG " test desk over the Backfriars group of " ENG " circuits.

Blackfriars Group.

Referring to the Routing diagram for this group of exchanges (Fig. 2), it will be seen that Incoming Tandem Selectors, Blackfriars, and Deansgate subscribers, and Keysender positions have access to the " ENG " circuit; it should perhaps be explained that the Blackfriars, Deansgate, and Tandem exchanges are situated in the same building. The code " ENG " for Blackfriars and Deansgate exchanges and the Keysender positions is translated to 10 and for the Tandem Selectors to 11. These two levels are teed together and the outlets taken to the Blackfriars " ENG " test desk. Level 11 in the Blackfriars group is used for other purposes and was not available for the " ENG " service. Swinton, Walkden, and Pendleton, which are in the Blackfriars group, obtain access to the Blackfriars " ENG " circuit *via* the incoming junction from that exchange to Tandem.

Availability to the " ENG " circuits has been given to the Keysender positions to enable an " ENG " call received at the Ashton Auto-Manual Board to be routed *via* the Keysender position to Blackfriars " ENG " test desk, when the Ashton " ENG " test desk is unattended.

It will be seen from the diagram that separate " ENG " circuits are shown from coin box groups of subscribers. This has only been arranged where the circuits are internal, such as at the controlling exchanges. At the controlled exchanges, the " ENG " traffic from the coin box telephones is com-

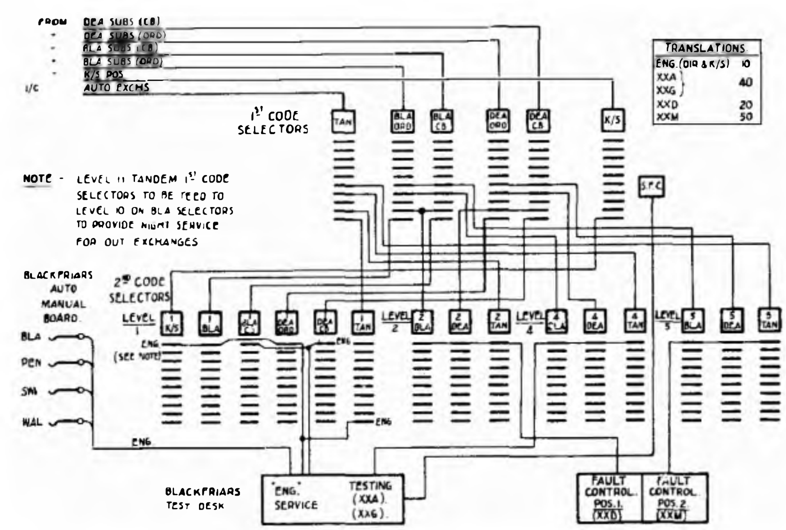

FIG. 2.—BLACKFRIARS GROUP (TANDEM, BLACKFRIARS, AND DEANSGATE EXCHANGE).

bined with that of the ordinary group of subscribers and routed over the same circuits. If the traffic were segregated for such an exchange as Longford, separate junctions would be required to the Sale " ENG " test desk. As the amount of traffic from coin box telephones is very small, direct circuits are not warranted between controlled and controlling exchanges. The scheme for routing the coin box traffic at the controlling exchanges is that the first outlet in the grading of the coin box group of 2nd code selectors is connected to a separate " ENG " circuit to the " ENG " test desk, the remaining outlets being commoned to the " ENG " circuits of the ordinary group.

The individual circuit provided for the coin box group at the controlling exchanges is to enable the Fault Complaint Officer to know that when the calling lamp lights the call was originated from a coin box telephone and that it would be necessary to ask the caller to press button " B " before the caller and the Fault Complaint Officer could speak to each other. Should this circuit be engaged and another " ENG " call originate from a coin box telephone, the call will be received on the ordinary group of circuits. On answering the call and receiving no reply, the Fault Complaint Officer will have to assume the call is from a coin box telephone and will ask the caller to press button " B."

Auto-Manual Switchboard " ENG " Circuits.

Special circuits are provided between the auto-manual switchboards and the " ENG " test desks at controlling exchanges in the auto-manual switchboard group. There are three auto-manual switchboards in the area, one at Blackfriars, one at Ashton, and one at Main.

The controlling exchanges in the respective auto-manual switchboard groups are :—

Auto-Manual Switchboard.	*Exchanges.*
Blackfriars.	Blackfriars, Sale, Ardwick, Collyhurst, Moss Side, Stockport.
Main.	Main.
Ashton.	Ashton.

Direct circuits have therefore been provided from the respective auto-manual switchboard to the exchanges named.

Standard supervision is given on these circuits; this condition is not obtainable on the subscribers' " ENG " circuits if the " ENG " calls received on the auto-manual switchboard are passed over them by the operators dialling " ENG," as non-registration circuits are used by subscribers. The direct circuits are provided to enable the operator to transfer a subscriber's call which has been received on the 0-level circuits and for which complaint the subscriber should have dialled " ENG "; also, faults on the auto-manual switchboard equipment brought to the notice of the operators are reported over these circuits.

When the controlling exchange " ENG " test desk is left unattended, calls from subscribers as stated above will be passed over the Special Fault circuits to the exchanges which are night controlling exchanges, *i.e.*, Blackfriars, Main, and Stockport.

Night Switching Scheme for " ENG " Subscribers' Circuit.

When the controlling and controlled exchanges are left unattended, it has been arranged to route the " ENG " traffic to Blackfriars " ENG " test desk from all exchanges except those in the Main group. To enable this to be accomplished, it is necessary to provide some form of switching at each exchange so that an " ENG " circuit can be teed into an outgoing Tandem junction. This switching facility can be provided either by means of a key or relays. As two of the exchanges are not normally attended, it would have been necessary, if the key-switching scheme had been adopted, to send someone to each exchange every day to operate the switching key. Also should an officer, when leaving an exchange unattended, fail to operate the key, it would have been necessary to get the key operated before the controlling exchange for the particular group was left unattended.

To avoid the foregoing difficulties, it was decided to introduce the relay-switching scheme at each exchange in the area except in the Blackfriars group.

The switching scheme arrangement is shown in Fig. **3**.

The switching and restoring is carried out by dialling spare bank contacts on the test distributor at each exchange. Each controlling exchange has access to a test distributor at each exchange in its group and, in addition, the Blackfriars " ENG " test desk has access to a test distributor at each exchange in the area. It will be seen, therefore, that the switching and restoring can be performed from two sources. Should the switching fail to have been performed by any controlling exchange for its own and those in its group, then Blackfriars " ENG " test desk carries out the operation.

Contacts 80 and 90 were spare on the test distributor banks at each exchange and were allotted to the relay-switching scheme; 80 is used for switching and 90 for restoring the circuit. It is not proposed to go into the circuit details as the diagram and notes are self-explanatory.

Although Stockport exchange is to be continuously staffed, and the switching of an " ENG " circuit to Blackfriars is not required, the switching facility is provided so that if in the case of emergency it is necessary to leave this exchange unattended it is possible for an " ENG " circuit to be switched to Blackfriars.

When the Blackfriars " ENG " test positions are left unstaffed, the last two lines for the Blackfriars group of subscribers' " ENG " circuits are extended to telephones in the Blackfriars automatic apparatus room. The calling lamps of these two " ENG " circuits are also extended to the Blackfriars exchange alarm system. When a call is received on either circuit, the exchange alarm bell will ring intermittently. Should a normal alarm be in operation, *i.e.*, continuously ringing the alarm bell, when a call

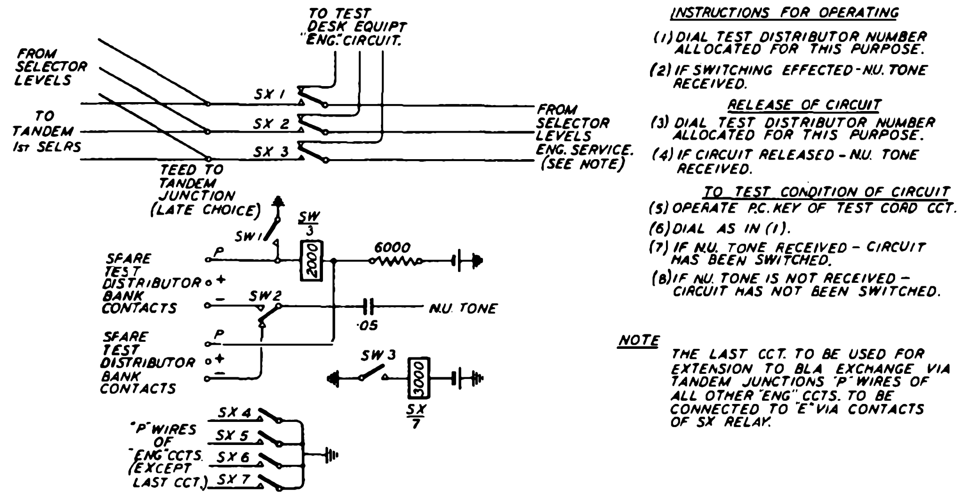

Fig. 3.—Switching Scheme for " ENG " Circuits.

is received on an " ENG " circuit the continuous ring will change over to an intermittent one, thus indicating to the exchange staff that immediate attention is required on one of the " ENG " circuit telephones. It is desirable not to cause any delay in answering subscribers' calls on the " ENG " circuits and for this reason the foregoing scheme was introduced. If some arrangement of this nature had not been provided, it would be necessary for the exchange Maintenance Officer to travel down two or three floors to the " ENG " test positions before the call could be answered. When the call has been answered on one of the telephones, and it is necessary for a test of the subscriber's circuit to be made, the subscriber can be asked to hold the line while the exchange Maintenance Officer proceeds to the " ENG " test desk, speaks again from there to the subscriber, and makes any tests necessary.

The auto-manual switchboard circuits to the " ENG " test desks are not extended to the automatic apparatus rooms. In the event of a call being received at the auto-manual switchboard for which the subscriber should have dialled " ENG," this call will be passed over the special fault circuit when it will receive immediate attention.

Test Distributor Scheme.

It is necessary for the Fault Complaint Officer at a controlling exchange to have access to a test distributor at each controlled exchange in its own group. Access to a test distributor at each exchange in the area is also provided on Blackfriars " ENG " test desk. This facility enables the Fault Complaint Officer to test any subscriber's line at any exchange in the group and also permits any subscriber's line at any exchange in the whole of the automatic area to be tested from Blackfriars " ENG " test desk.

Where there are two test distributors at an exchange, one is set apart for the exclusive use of the controlling exchange " ENG " test desk and the other is for combined use of Blackfriars " ENG " test desk and local testing if necessary. The circuit arrangement of the latter is such that when either end is using the test distributor, the other end receives a " busy signal."

The test distributor access scheme for the area is shown in Fig. 4.

Centralized Testing.

As previously stated, centralized testing will be introduced at the same time as the " ENG " service as it is, of course, essential that if the " ENG " service is to be centralized then centralized testing facilities must be provided. The Fault Complaint Officer who deals with the complaint received on the " ENG " circuit will, in addition to testing the subscriber's line, carry out any testing required by the faultsmen (line, subscriber's apparatus, and exchange) over the appropriate test distributor circuit. To enable the faultsman to obtain a Fault Complaint Officer for a test, the following codes have been allotted, viz., XXA, XXG.

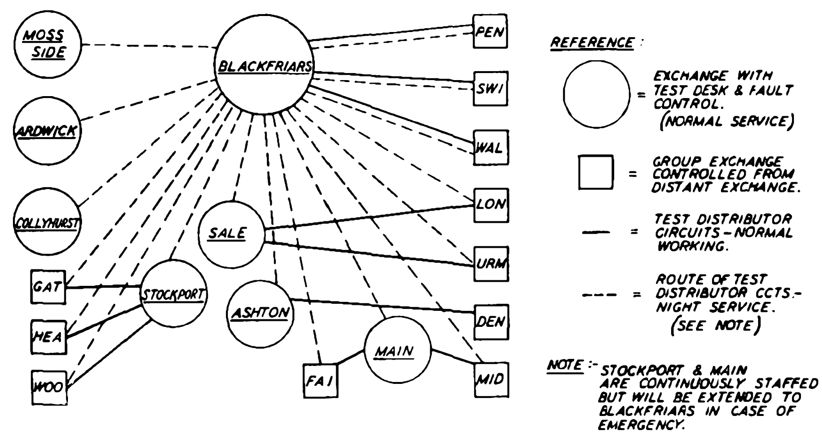

Fig. 4.—Test Distributor Access Scheme.

The XXA code is used when the respective " ENG " test desks are attended and XXG when the desks are left unattended. In the latter case this also includes the Fault Control.

Code XXG has been allocated so that the faultsman can obtain access to the Blackfriars " ENG " test desk from any exchange in the area except those in the Main and Stockport groups; for these two groups, the code XXG will be translated so that the call will be routed to the respective desks. The general adoption of code XXG for testing and fault control after normal hours ensures that when emergency faultsmen from any one area are attending faults in any other area the call will be routed to an exchange that is continuously staffed and not to an unattended test desk as would be the case if XXA were dialled.

When the Blackfriars desk is unattended, the XXA and XXG circuits will not be extended to the automatic apparatus room. If a test is required by a faultsman, the code " ENG " will be dialled, the call being promptly dealt with by the exchange maintenance staff in a similar manner to that for an " ENG " call from a subscriber.

At the majority of the exchanges, XXA will be translated to a P.B.X. final selector number at the controlling exchange. To avoid the use of final selector numbers, it would have been necessary to provide direct XXA circuits from a selector level at the controlled exchanges. The amount of traffic passing over the XXA circuits in these cases will be very small and does not warrant direct circuits. The traffic will therefore be routed over the normal junction route to the controlling exchange, as will be seen from the diagram for the Sale group of exchanges (Fig. 1).

At certain other exchanges, the XXA circuits are routed from a selector code level, but as the circuits are internal it is more convenient to adopt this method of routing them than *via* final selector numbers.

Fault Control.

The eight controlling exchanges will also be the engineering fault control centre for the exchanges in the group, and in some cases fault control centres also for certain manual exchanges. Special fault control panels fitted with the necessary equipment and card distributors are provided for certain exchanges; at the other exchanges this work will be dealt with on the " ENG " test desk.

The code XXD will be dialled by a faultsman to obtain the local fault control; in addition, the code XXM will also be dialled in the Blackfriars group, as two fault control positions are provided at this exchange. To enable Fault Control officers at fault control centres (other than Blackfriars) to obtain the Blackfriars Fault control, it will be seen from the Sale diagram that the codes XXJ and XXM are given a translation so that XXJ and XXM calls will be routed *via* a Tandem junction to the Blackfriars Fault Control.

It will be necessary for the Blackfriars Fault Control to know the appropriate final selector numbers set apart for fault control purposes at all other exchanges in order to get in touch with the respective Fault Controls.

Facilities on " ENG " Test Positions.

In addition to the usual standard testing facilities, two pairs of connecting cords instead of the usual one pair have been provided. These cords are used for the purpose of extending calls over the outgoing lines to the automatic equipment for subscribers who may have dialled " ENG " when " 0 " should have been dialled. Also it is possible that when a subscriber makes a complaint over the " ENG " circuits the subscriber may request the Fault Complaint Officer to obtain a number, in which case the required number will, if possible, be obtained and completed *via* the connecting cords. In the case of a request from a subscriber over an " ENG " circuit for a call to be extended, the call must be debited to the subscriber's account on the form provided for the purpose, if completion of the call is successful.

Jacks are provided on the " ENG " test positions to enable the Fault Complaint Officer to demonstrate to the subscriber the Ringing, Dialling, Busy and Number Unobtainable tones *via* the connecting cords.

In the case of Blackfriars " ENG " test desk, a special speaker circuit is provided between the desk and the main distribution frame. This circuit has been provided to enable prompt attention to be given to the requests from the desk for disconnexion, etc., at the M.D.F. At the remaining exchanges, a final selector number will be used for this purpose and will be dialled, if required, by the Fault Complaint Officer at Blackfriars and controlling exchanges. The Fault Complaint Officers at all controlling exchanges except Blackfriars will carry out the disconnexion, etc., on the M.D.F. terminations in their own exchange.

With regard to access to the Special Fault Circuit, each controlling exchange can obtain direct access in its own exchange, but access to the controlled exchanges Special Fault Circuit is obtained *via* a final selector number.

It is most important that on the receipt of a complaint over an " ENG " circuit, the Fault Complaint Officer should obtain the complaining subscriber's fault card immediately. Arrangements have therefore been made to locate the subscribers' fault cards for the controlling and controlled exchanges as near as possible to the Fault Complaint Officers at each controlling exchange.

To enable the quality of service given by the Fault Complaint Officers on the " ENG " circuit to be ascertained, listening-in circuits are provided. These circuits are connected across each Fault Complaint Officer's telephone circuit and terminate on keys and a receiver in the Inspector's office.

It is essential that prompt attention should be given to the answering of calls on the " ENG " circuits. A subscriber who has a complaint to make will no doubt already be irate and the subscriber should not be given further grounds for complaint due to delay in answering of the " ENG " circuits by the Fault Complaint Officers. To avoid this, an average " speed of answer " of 10 seconds, as a maximum, is aimed at. To draw the attention of the "ENG" test desk staff to the fact that the calling signal of an "ENG" circuit has been glowing for a period of 20 seconds, the continuous glow of the calling lamp changes to an intermittent glow. This condition calls for immediate attention to be given to this call.

Alarms.

The usual practice is for the Prompt and Deferred Alarms at exchanges which are left unattended to be transferred to a controlling exchange. In the Manchester Automatic Area, these alarms are transferred to the Blackfriars "ENG" test desk, except in the case of Main and Stockport which are continuously staffed. When the Blackfriars desk is left unattended, only the "Prompt" alarm will be transferred to the exchange alarm system. An alarm received from an exchange over one of the "Prompt" alarm circuits will be dealt with by the exchange staff on duty, the emergency duty arrangements being brought into operation, so that the responsible officer for the exchange concerned can be advised to attend to the fault.

The introduction of the "ENG" service eliminates the issue of dockets by the Traffic staff to the Engineering staff as far as the reports of complaints from subscribers are concerned. In addition, all faults on the auto-manual switchboard equipment brought to the notice of the operators will be reported over the direct "ENG" circuits. Thus no dockets will be issued to the Engineers by the Traffic staff for fault reports referring to any automatic exchange in the area. Dockets will, however, continue to be issued for faults on manual and unit automatic exchanges in the Fault Control Area.

A very brief summary of the progress of a complaint from the time it is received by the Fault Complaint Officer to the clearance of the fault is as follows :—

On receipt of a complaint, the preliminary details are entered on a form (T.E.659) and the subscriber's fault card is immediately obtained, so that the past history of any trouble on the circuit can be seen while the subscriber is on the circuit. The circuit is tested and the necessary particulars are entered on the fault card. The fault card is then passed to the Fault Distribution Officer and, if the fault is outside the exchange, particulars of the fault are passed to the faultsman concerned for attention. Should the faultsman desire a test, XXA will be dialled, and the faultsman will then be able to obtain a test by a Fault Complaint Officer. When the fault has been cleared, the faultsman dials XXD and gives the clear to the Fault Distribution Officer. The clear is entered on the fault card and the card is passed to the Fault Record Officer for the details to be entered on the standard fault returns.

Should the circuit when tested prove to be faulty inside the exchange, however, the Fault Complaint Officer will call the exchange Maintenance Officer *via* the Special Fault circuit and pass particulars of the fault to this officer, who will enter details of the fault on a docket (T.E.641). After the fault is cleared, the clear is entered on the docket and the docket is returned to the Fault Distribution Officer, who then deals with this matter as stated above.

Telegraph and Telephone Plant in the United Kingdom

TELEPHONES AND WIRE MILEAGES. THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31st MAR., 1934.

Number of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange*	Spare.		Telegraph.	Trunk.	Exchange*	Spare.
822,870	570	8,574	44,868	3,274	London	38,235	200,720	3,699,643	166,269
99,598	2,166	18,772	45,754	5,215	S. Eastern	4,650	54,036	369,531	50,444
114,986	3,798	37,257	71,509	4,921	S. Western	26,102	45,531	292,892	72,290
79,202	4,637	41,437	68,470	8,587	Eastern	16,183	61,331	167,611	54,292
126,042	7,087	49,786	55,950	8,624	N. Midland	12,910	158,496	334,737	129,041
100,848	3,872	31,449	64,194	4,288	S. Midland	17,153	65,190	316,012	67,821
69,095	3,003	29,560	56,144	6,623	S. Wales	6,786	53,818	166,382	44,017
137,782	5,612	31,011	58,481	6,020	N. Wales	9,855	76,458	449,401	116,420
181,393	938	10,222	26,420	6,432	S. Lancs.	11,027	121,810	664,017	80,611
115,978	5,252	27,374	38,681	7,926	N. Eastern	11,133	92,587	342,822	56,531
76,297	2,744	22,045	27,027	7,065	N. Western	4,601	45,570	252,104	57,869
59,012	1,839	14,906	22,022	6,145	Northern	4,020	51,072	190,298	34,638
29,084	3,262	11,140	12,092	1,001	Ireland N.	262	5,427	71,028	5,458
84,445	4,849	32,067	40,658	3,662	Scotland E.	2,709	52,880	179,053	45,011
106,091	4,833	22,556	32,770	4,426	Scotland W.	8,564	50,658	275,787	44,121
2,202,723	54,462	388,156	665,040	84,209	Totals.	174,190	1,135,584	7,771,318	1,024,833
2,176,523	55,397	390,117	658,959	83,223	Figures as at 31 Dec., 1933	181,260	1,088,549	7,650,794	1,028,952

* Includes low gauge spares (*i.e.*, wires of 20 lb. or less in cables and 40 lb. bronze on overhead routes).

A New Type of Quick Search Radio Receiver

A. H. MUMFORD, and
H. STANESBY

1. Summary.

A DESCRIPTION is given of the principles and design of a short wave receiver of a novel type which has been developed in the Radio Laboratories at Dollis Hill and installed at Burnham Radio Station.

2. Introduction.

High frequency telegraph traffic from ships is received on several bands of frequencies of the order of 0.25 megacycle wide and located between 8 and 18 megacycles. Ships are liable to call on any frequency within a specific band and to change frequency within a band on request in order to avoid interference. Coupled with the fact that many of the transmitters installed on ship board are liable to wander in frequency, this necessitates the use of a receiver which can be tuned to any frequency within any one of the bands upon which it may at the moment be working with the least effort and loss of time on the part of the operator. In the ideal case it should therefore be necessary to use only one control for tuning the receiver within the limits of any one frequency band.

In spite of the necessity for easy searching facilities it is essential that the receiver shall be selective so that if a superheterodyne receiver is used it must be entirely free from image channel interference. Another most important requirement is that the overall gain of the receiver shall be sufficiently high and distributed among the various stages in such a way that the thermal noise generated in the circuits preceding the first valves shall be the major factor limiting the response to signals and external noise.

3. Review of Existing Types of Receiver.

The problem of designing a receiver to conform with the foregoing general specification is one of exceptional difficulty if it be approached on conventional lines, which will be reviewed briefly.

The normal single demodulation receiver is unsuitable for several reasons, the most important being the fact that it is impossible to obtain sufficient selectivity by introducing it directly on the signal frequency.

The only alternative is the superheterodyne receiver. In the efficient superheterodyne receiver protection must be provided against image channel interference which is liable to be produced by signals spaced on one side or other of the desired intermediate frequency, or twice the beating oscillator frequency, which ever is the less.[1] But on the normal superheterodyne receiver used on high frequencies, the intermediate frequency is made much lower than that of the signal, so that the requisite selectivity may be introduced with comparative ease, and the source of image channel interference is therefore closely adjacent in frequency to the signal it is desired to receive. This necessitates the use of several stages of signal frequency selectivity. For point-to-point working, in which a receiver may operate on the same frequency for hours at a time, these stages of selectivity which have to be tuned to the signal frequency cause no trouble. When searching over a band of frequencies, however, it becomes necessary to vary the tune of all the signal frequency circuits and of the oscillator, either separately or from a common control. The former method is obviously unsuitable in the present case, and the latter involves the accurate alignment and control of perhaps three signal frequency circuits and the beating oscillator by some system of mechanical coupling; an arrangement which from a purely technical point of view is very difficult, particularly when low resistance circuits are used; and it becomes even more awkward when introduced in a receiver which must be accessible, easy to maintain, and of the highest efficiency.

4. Principle of Quick Search Receiver.

With a view to avoiding the necessity for all but the simplest protection against image channel interference, a novel form of superheterodyne receiver, introducing other desirable features at the same time, has been developed in the Radio Laboratories at Dollis Hill. This will be referred to in future as a " Quick Search " receiver.

The essential principle of the receiver is the employment of an intermediate frequency higher than the highest signal frequency, the beating oscillator operating on a higher frequency still, so that the " difference " beat is still selected. This increases the spacing between wanted signals and image channel interference to such a high value that a single tuned circuit provides more than sufficient discrimination.

If the beating oscillator were made to function at less than the intermediate frequency and the " sum " beat frequency employed, the whole advantage of employing a high first intermediate frequency would be lost, for image channel interference would only be separated from the desired signal by twice the oscillator frequency, which would grow less and less as the signal frequency increased. Apart from this, the arrangement adopted enables the receiver to operate on all frequencies appreciably less than the first intermediate frequency, for changes in oscillator

[1] See Appendix I.

frequency of less than 100 per cent. on its lowest value; this spreads the signal frequency spectrum more or less uniformly over the tuning ranges of the beating oscillator and makes coil changes in the oscillator unnecessary.

But on high frequency receivers especially, the use of an intermediate frequency higher than the signal makes it impossible to obtain a satisfactory degree of selectivity without resorting to extreme measures such as crystal filters, reaction, etc., and it reduces the gain per stage of the intermediate amplifier to a low value. This is overcome by using a second frequency changer followed by a second intermediate frequency amplifier operating on a much lower frequency. The main selectivity and amplification of the receiver are introduced in the second intermediate frequency stages, the first facilitating the removal of image channel interference.

By these means the essential tuning controls of the receiver are reduced to two, the main control which adjusts the frequency of the first beating oscillator, and one other which adjusts the tune of the input circuit and need only be used occasionally, when searching over a wide band.

It may here be mentioned that, since in this type of receiver the signal frequencies are always lower than the first intermediate frequency, and image channel interference is always higher, it is possible to eliminate image channel interference by employing an electric wave filter cutting off at a little above the highest frequency on which it is desired to receive, so as to dispense with a tuned input circuit; this has not been done in the present receiver for the following reason.

In all receivers there is a well defined limit below which noise voltages spontaneously generated in the first valves, and in subsequent parts of the circuit, cannot be reduced, and it is therefore necessary to apply as large a signal voltage to the first grid filament circuit as possible in order to obtain the best signal noise ratio. If therefore the considerable voltage magnification of a low resistance tuned input circuit is abandoned, a large reduction in the signal to set noise ratio amounting to 20 or 30 decibels must result.

For this reason it is unwise to dispense with a tuned input circuit on a receiver designed to operate when necessary on as low an input signal voltage as possible.

5. The Choice of First and Second Intermediate Frequencies.

Although the quick search receiver is intended primarily for use on frequencies between 8 and 18 megacycles, it has been designed to operate on frequencies as high as 25 megacycles and experimentally down to frequencies of the order of 0.1 megacycle. It should be mentioned, however, that in this particular receiver considerations of selectivity limit the lowest frequency on which it may usefully be employed. The selectivity has been adjusted to the optimum value for the class of traffic for which it is primarily intended; when, however, this selectivity is translated to the lower radio frequencies, where telegraph stations operate with frequency separations perhaps as low as a fraction of a kilocycle, it becomes quite inadequate.

The highest frequency to be received having been fixed at 25 megacycles, 30 megacycles was chosen as suitable for the first intermediate frequency.

In order to provide for reception on all frequencies from 25 megacycles downwards, the minimum range to be covered by the first beating oscillator was fixed at 30-55 megacycles, a frequency ratio of less than 1 : 2.

In these circumstances the signal frequency selectivity has to provide sufficient discrimination to eliminate image channel interference from signals spaced 60 megacycles from the desired signal; not a very exacting requirement. In a similar way the first intermediate frequency selectivity has to protect subsequent stages of the receiver from what may be termed second order image channel interference which is liable to be produced by signals spaced from the desired signals by twice the second intermediate frequency. If the first intermediate frequency circuits be regarded as the signal frequency circuits of a normal superheterodyne receiver operating on 30 megacycles, the necessity of protecting against second order image channel interference becomes more apparent. The choice of the second intermediate frequency was therefore based on estimates of the selectivity to be obtained in the first intermediate frequency amplifier, a small allowance being made for the signal frequency selectivity provided by the first tuned circuit. A frequency of 600 kilocycles was adopted, for which the discrimination of the preceding circuits against second order image channel interference was always greater than 60 decibels.

6. Outline of Receiver Design.

The essentials of the receiver are indicated in the outline diagram shown in Fig. **1**, the more important features being discussed in some detail in the following sections :

1. *Input Circuit.*

It will be seen from the diagram that an inductively coupled input circuit is used. As this functions at the signal frequency several coils are needed to cover the wide range of frequencies efficiently. These coils are mounted on plugs and may be readily changed from the front of the receiver. It may be pointed out that this is the only place where it is necessary to change coils in order to cover the whole frequency range of the receiver.

The primary winding is connected to the antenna system through a balanced transmission line, the secondary winding is tuned to the signal frequency, and the coupling between the windings is adjusted so that in the middle of the frequency band covered by any specific coil, the impedance presented to the transmission line approximates to the characteristic impedance for the tune condition.

2. *First and Second Beating Oscillators.*

It will be thought, particularly by those who have

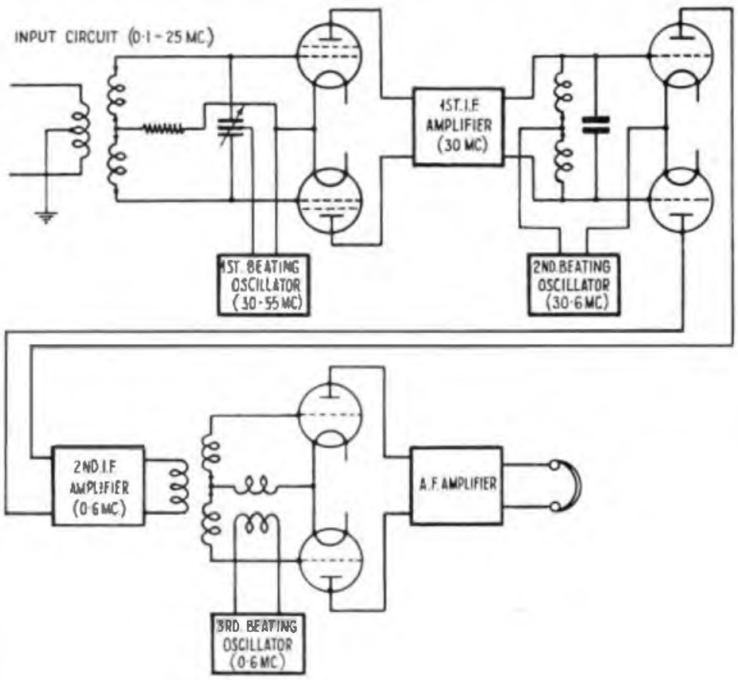

FIG. 1.—OUTLINE DIAGRAM OF QUICK SEARCH SHORT WAVE RECEIVER.

had some experience in the design and operation of short wave receivers, that the necessity for the use of oscillators on frequencies as high as 55 megacycles is a serious disadvantage, particularly when heterodyne reception is employed. That this can be a serious obstacle preventing the construction of a successful receiver must be admitted, for when receiving on a wave-length of 15 metres the frequency of the first beating oscillator alone has only to change by 10 parts in a million for the audio frequency beat note to change by 500 cycles.

The Radio Section of the Post Office is, however, fortunate in having already developed the technique of building constant frequency oscillators to a high degree and as a consequence no trouble has been experienced due to variation in frequency. The receiver may be used the moment it has been switched on, as the initial frequency drift is so small as to be inappreciable. Moreover it has been found unnecessary to employ Barretter tubes, or any other means of maintaining the power supplies any more constant than those of the normal common batteries fitted in a radio station. In fact when operating on any signal frequency within the range of the receiver, the low tension supply voltage may be varied by 10 per cent. or more without the heterodyne beat note passing out of the range of audibility; the performance is somewhat more sensitive to changes in anode voltage, but variations of the order of several volts may be made with the same result.

In view of the importance of the oscillators as a factor contributing to the successful design of a receiver of this type, a relatively detailed description of the design will be given. This may be supplemented by an examination of a photograph reproduced in Fig. 2, of a similar type of oscillator, which operates on a somewhat lower frequency.

A push-pull oscillating circuit is used of the type indicated in Fig. 3. Grid bias is provided by the voltage drop developed across the grid leaks due to grid current. It may be mentioned in passing that unless grid current can be completely eliminated—and this involves the use of very high anode voltages—grid leak biassing provides a very valuable method of reducing frequency variations due to grid current, a most potent source of frequency instability.

The oscillatory circuit controlling the frequency of oscillations is designed to have as low a resistance as possible, and all the elements of the circuit are extremely rigid, so that the frequency of the oscillator shall not be susceptible to vibration. The whole oscillatory circuit is enclosed in a lagged box so as to protect it from rapid changes in temperature due to heat generated in the valves or to changes in the ambient.

The tuning condenser is a very important part of the oscillator design, for the frequency control of the first beating oscillator is the main tuning adjustment

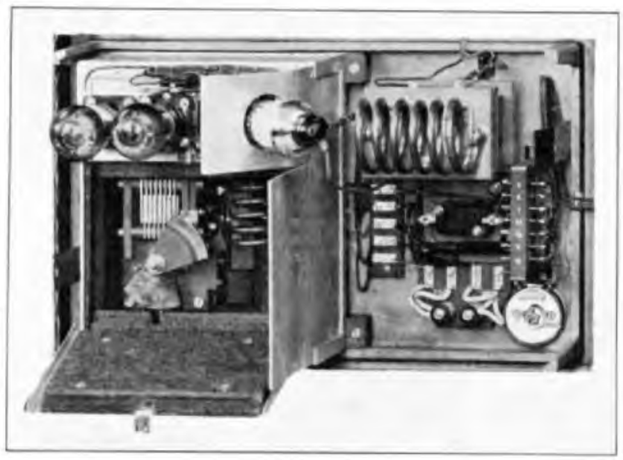

FIG. 2.—SHORT WAVE BEATING OSCILLATOR.

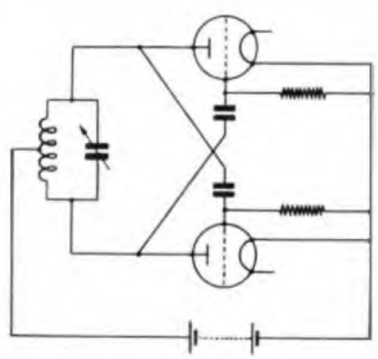

FIG. 3.—PUSH-PULL OSCILLATING CIRCUIT.

of the whole receiver, and is in use almost continually. The capacitance can be varied continuously by a rotating plate, series gap condenser, and in steps by a switch which connects in parallel the individually insulated plates of a fixed air condenser, the change in capacitance for one step of the latter being somewhat smaller than the range of continuous variation of the former. By using these two condensers in combination the capacity variation is spread over sixteen ranges, each of which corresponds to 180° movement on the continuously variable condenser dial.

The frequency of the oscillator is rendered independent of adjustments made to the external circuits by a buffer stage of screen grid amplification. The anode circuit of the buffer stage is tuned, the output power for the demodulator being obtained by inductive coupling. In the neighbourhood of optimum heterodyne input the variation of detector efficiency with beating oscillator voltage is very flat and if the latter is correctly adjusted it becomes unnecessary to retune the anode circuit of the first beating oscillator buffer stage, except when changing the oscillator frequency by a large amount.

Details of the physical construction may be seen in Fig. **2**. The thermally insulated box containing the tuned circuit of the oscillator lies on the left-hand side of the picture; through the open door of the box the coil and part of the variable condenser can be seen. The oscillator valves are located immediately above this box and the buffer stage screen grid valve projects through a screening partition which separates the oscillator stage from the rest of the unit.

3. *The First Demodulator.*

The voltages due to the signal and first beating oscillator are combined in the first tuned circuit of the receiver and applied to the first demodulator.

A balanced demodulator is employed here as in later stages of the receiver. Since the mode of operation and advantages of such a demodulator do not appear to be well known, the theory underlying its action is outlined in Appendix II.

It is clear that in the case of the normal unbalanced demodulator, the output contains the sum and difference of the input frequencies and the second harmonics of the latter (Appendix I). Moreover if the input signal had consisted of two or more frequencies, the output would have contained the sum and difference of all these and the beating oscillator frequency, taken two at a time, and the second harmonics of all the input frequencies. A superheterodyne receiver employing an unbalanced demodulator would under these conditions respond to a greater or less degree when any one of these products of demodulation corresponded to the intermediate frequency. If, however, a balanced demodulator is used, the sum and difference frequencies produced by signals beating among themselves tend to balance out and a corresponding freedom from spurious responses is obtained. A little consideration will show that these properties are not merely of value when developed in the first demodulator of a receiver; they are of considerable advantage elsewhere.

The unusual method of injecting the voltage due to the first beating oscillator is of some interest. In contradistinction to the normal conditions obtaining with a superheterodyne receiver, in this case the frequency at which the first beating oscillator operates is always very much greater than that of the signal. Owing to this, the normal method of connecting the beating oscillator to a balanced demodulator, as exemplified by the outlines of the second and third demodulator circuit in Fig. **1**, cannot be applied here; the high reactance of the coil, due to incomplete coupling between the two halves, and the relatively low input impedance of the demodulator valves make it impossible to develop sufficient potential from the first beating oscillator. But for the high frequencies on which the first beating oscillator operates, the reactance of the three electrode variable condenser in the first tuned circuit is very small; moreover, the reactance from the centre electrode to one side is only half the total, so that in this case the artifice of injecting the beating oscillator voltage *via* the centre electrode of the variable condenser has been adopted. Fixed condensers of 20 micro-microfarads capacitance have been connected from each side of the variable condenser to the centre electrode, so that the reactance between the centre electrode and the grid of one of the demodulator valves is always less than the input impedance of the valve and the potential drop across the condenser is always small compared with that developed between the grid and filament.

The anode circuit of the first demodulator is tuned to 30 megacycles, the first intermediate frequency, and there is therefore an inductive impedance of considerable magnitude in the anode circuit at the higher signal frequencies. If triode valves were used in the demodulator the relatively high grid-anode capacitance and the inductive load would cause the input impedance of the valves to have a negative resistance component which would be liable to cause instability. Screen grid valves are therefore used in the first demodulator in order to reduce the grid-anode capacitance and prevent such undesirable reaction effects.

4. *Remaining Units.*

The rest of the receiver is designed on the lines normally followed by the Radio Section of the Post Office Engineering Department in the construction of high-performance short wave superheterodyne receivers.

The first intermediate frequency amplifier consists of three push-pull stages of screen grid amplification, the selectivity being provided by low resistance tuned anode circuits.

The second demodulator and second beating oscillator have been briefly referred to already.

The second intermediate frequency amplifier consists of three stages of screen grid amplification coupled by sections of band pass filter which provide the necessary selectivity. Working adjustments of the overall gain of the receiver are made by means of a resistance network between the first and second stages of this amplifier. Sufficient amplification is introduced prior to this point, to prevent the loss introduced by the gain control from degrading the signal set noise ratio.

The third demodulator is also of the balanced type and, as heterodyne reception is normally used, a third beating oscillator is provided. At times however, signals have to be received from transmitters which suffer from severe frequency variation, and heterodyne reception is uncomfortable under these conditions as the frequency of the beat note changes and may even wander beyond audibility. An alternative method of reception is provided for use in such cases, the second beating oscillator being modulated at an audio frequency, so that the beat note resulting from the interaction of the signal and output from the second beating oscillator is correspondingly modulated. Signals then become audible at the output of the third demodulator without the use of a third beating oscillator and the note is of course independent of the frequency of the station. The latter arrangement is not, however, preferable to heterodyne reception when jamming is present, for when employing it all signals are modulated by the same frequency so that it is impossible for an operator to exercise aural discrimination.

The receiver proper is terminated by an audio frequency amplifier to the output terminals of which the operator's headphones are connected.

The operation and maintenance of the receiver is facilitated by the provision of a comprehensive system of adjusting and monitoring the power supplies, and by connecting the input and output circuits of the second intermediate frequency and audio frequency equipment to jacks.

7. Mechanical Construction.

The general appearance of the receiver and some details of its construction may be seen in Figs. 4 and 5, and the various units may be identified with the aid of the key to the front view of the receiver given in Fig. 6.

In order to give the reader unfamiliar with commercial practice some idea of the size of the receiver, it may be mentioned that it is 7 feet long, 6 feet 6 inches high, and approximately 1 foot deep, from the front of the panels to the back of the covers, which were of course removed when the photograph was taken.

One of the most important requirements of the design, and one unfortunately to which all considerations of technical expediency had to be subordinated, was that of placing the main controls, which may be used almost continually, at the most convenient operating level. These may be seen in Fig. 4 at the bottom of the first demodulator and first beating oscillator panels and arranged immediately above the shelf.

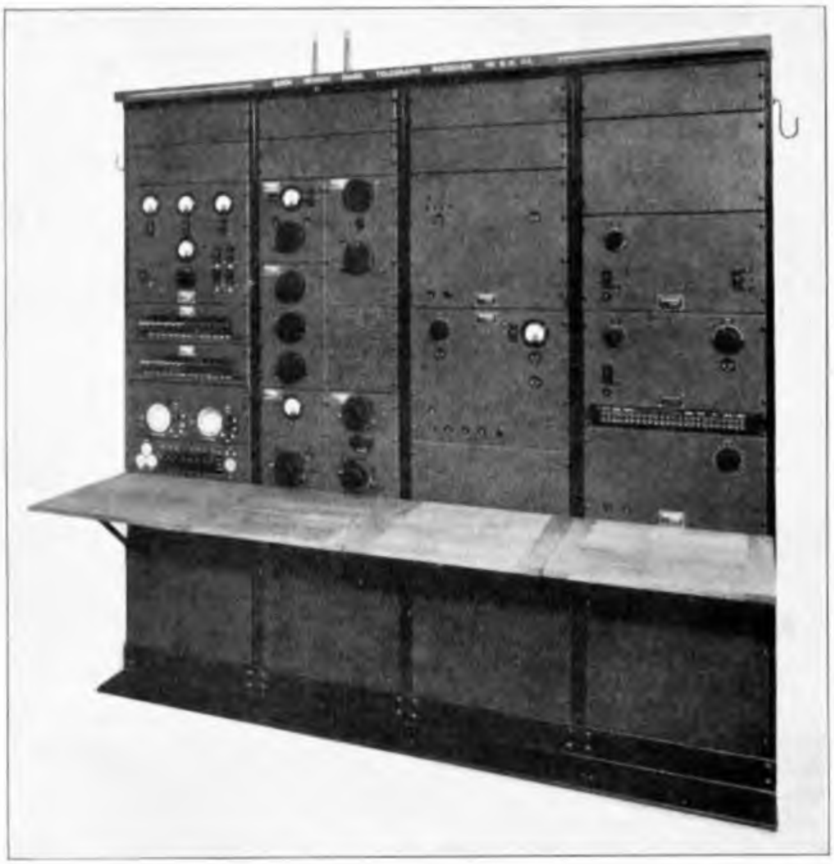

Fig. 4.—Quick Search Short Wave Receiver, Front View.

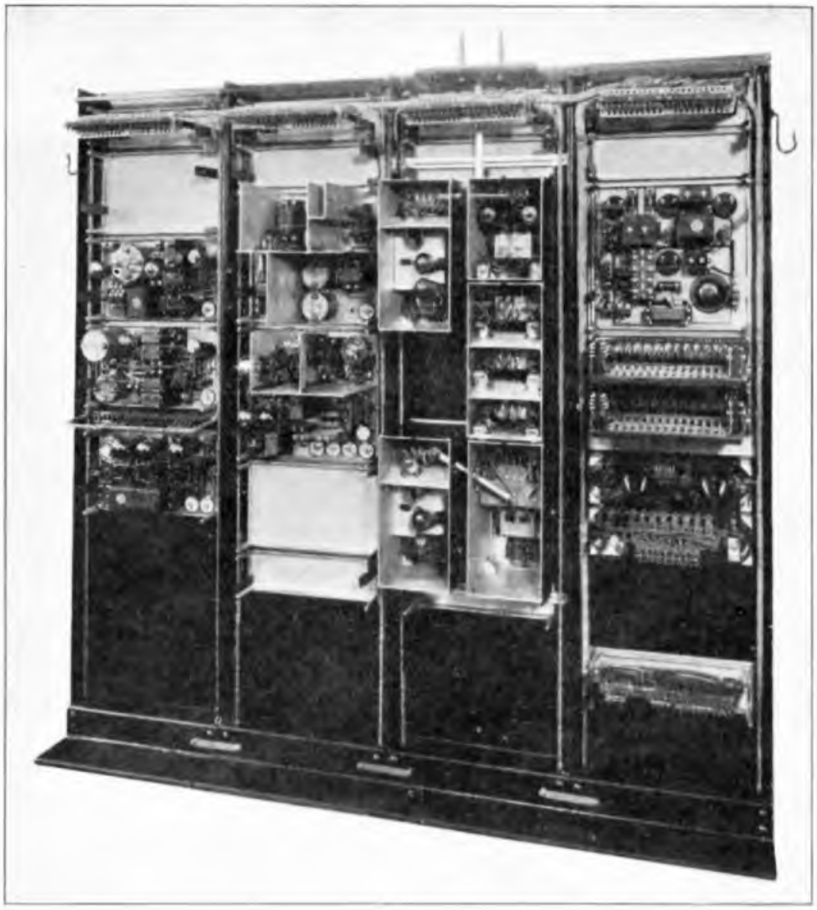

FIG. 5.—QUICK SEARCH SHORT WAVE RECEIVER, BACK VIEW.

The antenna system is connected to the receiver through a two-wire transmission line which is joined to the terminals projecting above the top of the receiver. A subsidiary transmission line enclosed in metal tube connects these terminals to the first demodulator unit.

Other points in connexion with the construction of the receiver are not of sufficient novelty to warrant description in this article, the main object of which has been to describe the underlying principles of an unusual type of receiver.

APPENDIX I.

SPACING OF IMAGE CHANNEL INTERFERENCE FROM SIGNAL IN SUPERHETERODYNE RECEIVERS.

Neglecting steady values, let the characteristic of a demodulator be represented by :—

$$i = Bv + Cv^2$$

where i is the output current and v is the input voltage.

Let $v = P \sin \omega_1 t + Q \sin \omega_2 t$, the two components in order being the beating oscillator and signal voltages. Substituting for v we get :

$$i = B\,(P \sin \omega_1 t + Q \sin \omega_2 t_1) + C\,(P^2 \sin^2 \omega_1 t + 2PQ \sin \omega_1 t \sin \omega_2 t + Q^2 \sin^2 \omega_2 t)$$

$$= B\,(P \sin \omega_1 t + Q \sin \omega_2 t_1) + C\left(\frac{P^2}{2} - \frac{P^2}{2} \cos 2\omega_1 t + PQ \cos (\omega_1 - \omega_2)t - PQ \cos (\omega_1 + \omega_2)t + \frac{Q^2}{2} - \frac{Q^2}{2} \cos 2\omega_2 t\right)$$

From this it will be seen that frequencies corresponding to the sum and difference of ω_1 and ω_2 appear in the output from the demodulator. If ω_i is the intermediate frequency, in the absence of signal frequency selectivity the receiver will therefore respond to signals corresponding to the values of ω_2 given by the following relationship :

$$\omega_i = |(\omega_1 \pm \omega_2)|$$

Case 1. $\omega_i < \omega_1$.

Since in this case ω_i is less than ω_1, there can be no solution for the positive sign, but for the negative sign,

$$\omega_i = |(\omega_1 - \omega_2)|$$

and $\omega_2 = \omega_1 \pm \omega_i$

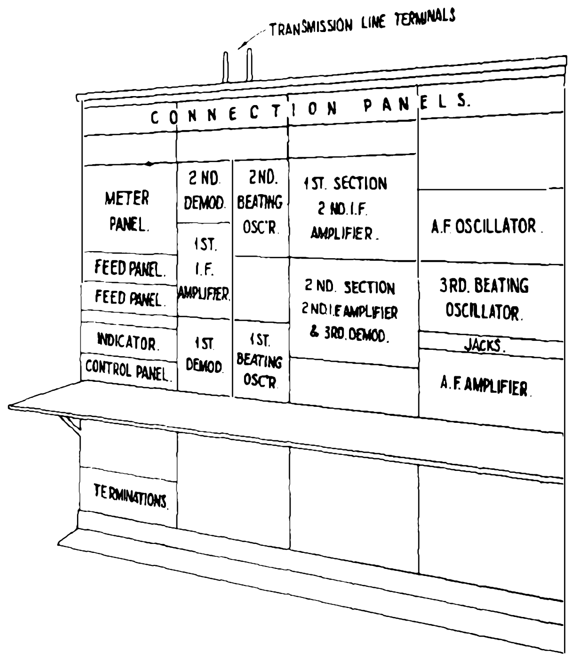

FIG. 6.—KEY TO FRONT VIEW OF RECEIVER.

Case 2. $\omega_i > \omega_1$. For the positive sign

$$\omega_i = \omega_1 + \omega_2$$

that is $\omega_2 = \omega_i - \omega_1$

and for the negative sign $\omega_i = |(\omega_1 - \omega_2)|$

but since $\omega_i > \omega_1$, the expression within the brackets must be negative and we have

$$\omega_i = \omega_2 - \omega_1$$

that is $\omega_2 = \omega_i + \omega_1$

or combining the last two solutions

$$\omega_2 = \omega_i \pm \omega_1$$

From these results it is clear that the two frequencies to which the receiver will respond are separated by an interval equal to twice the intermediate frequency or twice the beating oscillator frequency, which ever is the less.

APPENDIX II.

APPROXIMATE THEORY OF BALANCED DEMODULATOR.

A typical form of balanced demodulator employing triodes is shown in Fig. A, but it should be clear that the following treatment may be applied equally well to similar forms of demodulator employing diode rectifiers, metal rectifiers, etc.

Let the input signal develop an instantaneous voltage $2\,v_S$ across the secondary of the input transformer, the two halves of which are in series aiding, and let the instantaneous value of the beating oscillator voltage be v_0. The signal will excite the two rectifiers 180° out of phase and the beating oscillator will excite them in phase, so that, assuming the voltages are additive for valve 1, the total input voltages will be given by

$$v_1 = v_0 + v_S$$
$$v_2 = v_0 - v_S$$

Let the characteristic of each rectifier be represented by

$$i = Bv + C\,v^2$$

As the anode currents i_1 and i_2 flow in opposite directions through the two halves of the primary winding of the output transformer which are also connected in series aiding, the current i_L in the secondary will be proportional to the difference, that is,

$$i_L = K\,(i_1 - i_2)$$

but $i_1 = B\,(v_0 + v_S) + C\,(v_0 + v_S)^2$

and $i_2 = B\,(v_0 - v_S) + C\,(v_0 - v_S)^2$

whence $i_L = K\,(B \cdot 2\,v_S + C \cdot 4\,v_0\,v_S)$

If $v_0 = P \sin \omega_1 t$

and if the signal input contains two components having different frequencies represented by

$$v_S = Q \sin \omega_2 t + R \sin \omega_3 t$$

then substituting for v_0 and v_S and expanding

$$i_L = K\,[2B\{Q \sin \omega_2 t + R \sin \omega_3 t\} + 2C\,\{PQ \cos(\omega_1 - \omega_2)t - PQ \cos(\omega_1 + \omega_2)t + PR \cos(\omega_1 - \omega_3)t - PR \cos(\omega_1 + \omega_3)t]$$

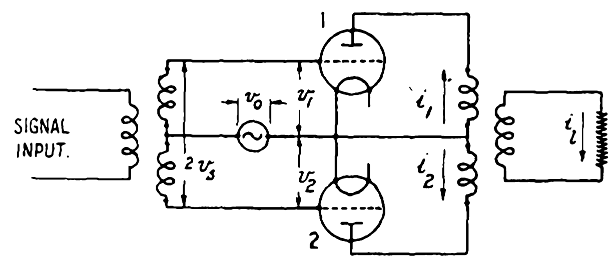

FIG. A.—TYPICAL FORM OF BALANCED DEMODULATOR EMPLOYING TRIODES.

The output from the demodulator only contains the original signal frequencies and the sum and difference beats of each signal component with the beating oscillator input, the second harmonics of the signal components, the beats between them, and the beating oscillator frequency being absent. In practice the latter components will not of course be entirely balanced out owing to dissimilarity in the valve characteristics, but their strengths will be much reduced below those of the corresponding products from an unbalanced demodulator.

The Engineer-in-Chief's Training School

A. AKESTER, A.M.I.E.E.

IT is now 10 years since the Training School was established and its work has become so important that a short account of its progress and present position will doubtless be of interest to readers of the Journal.

The experience gained by observations on the working of the official switch, and of the several trial exchanges in different parts of the country, and the decision to introduce automatic working generally, made it necessary to introduce an organized system of training so that staff would be available for the supervision and maintenance of the exchanges and equipment.

During the period from 1924 to 1930 the School was housed in King Edward Building adjacent to the circuit laboratory, and the co-operation between the two was mutually advantageous. In 1930, when the School was transferred to Dollis Hill, the partnership was dissolved.

The number of students trained has steadily increased from 29 in the opening year to 2,657 in the current year, and in the same period the number of different courses has increased from 3 to 31.

The introduction of new systems and the increase in the quantity of automatic apparatus brought into use are factors bearing on the increase in the number of students. Progress not having been confined to the automatic telephony side of communications engineering, it became necessary to open out the School and extend its activities to training in many other items; hence, a substantial increase has occurred in the number of courses of instruction.

The decisions to introduce training courses for Probationary Engineers and Inspectors and Youths-in-training also resulted in an increase in the numbers who attend the School.

The subjects included in the current training programme, together with relative information, are given in Table I. Column 1 shows the effect of developments in the technique on training requirements, for it will be seen that the first thirteen courses are all variations of the main subject of automatic telephony, and the next five are allied to repeater station practice.

In almost any educational establishment, engaged in adult training, an average attendance for the whole year of 270 would be considered good and the completion of 14,000 student weeks training in one year deemed a satisfactory performance; but whereas such an establishment would normally have a general change of students only once a year, the Training School will complete 120 courses this year. This constant change of students involves a highly efficient organization: whilst at the School, students are in a similar position to itinerants, and arrangements have to be made for travelling; payment of wages and subsistence; week-end visits home; medical attendance, etc.

Courses of instruction must be arranged so that the maximum advantage may be taken of the services of the available staff and accommodation, and the availability of tools and apparatus required for practical work. The number of students in each class is governed by lecture room accommodation, available equipment, and the demand for trained staff.

Fig. 1 illustrates one of the indicator boards used to enable the controlling staff to keep in touch with the current position, and to enable changes of class rooms to be promptly conveyed to students. The picture seen above the indicator board in Fig. 1 is a group of School staff and students.

Fig. 1.—Indicator Board.

In addition to offices required for staff, the School accommodation consists of lecture rooms and practical work rooms. The former are equipped with optiscope lanterns, and slides chosen from a library of 2,500 are used for the illustration of lectures. Working models are available in the practical training rooms, and tables provided which are equipped for apparatus adjustment work.

To keep abreast of developments, and to ensure that adequate training facilities are always available, the equipment in the School is constantly overhauled and brought up to date. Some recent additions are Units Amplifying; repeater station tariff equipment; group service; units auto No. 6, and an operator's position equipped with demand circuits, chargeable time indicators, and visual idle indicators.

For the purpose of providing suitable practical training in external work, a construction park is available, where various operations are demonstrated. Here Probationers and Youths carry out overhead and underground work. A group of Youths receiving instruction in overhead work is shown in Fig. 2.

FIG. 2.—VIEW OF CONSTRUCTION PARK.

A building of the bungalow type has been erected on the park, the exterior of which is used to demonstrate house attachments and leads. The interior walls are constructed and finished in different materials to which telephone apparatus is fitted; this apparatus is joined up in accordance with various plan numbers and serves to indicate methods of fixing and wiring when different walls are encountered. It is thus possible to demonstrate and explain freely the facilities given by the apparatus and the operating procedure.

Although there is a wide difference in the subject matter of many of the courses, they are conducted on the same general lines and, with one or two exceptions, each includes lectures, study, note-writing, apparatus and adjustment demonstrations, practical work and written tests. These are in varying proportions depending upon the subject. The subject matter and duration of the courses needs continual revision so that additions and developments may be included. The courses for Probationers are designed to give an insight into almost the whole of the Department's activities, and in addition to lectures and practical instruction by the school staff, a number of lectures are given by specialists from Headquarters.

In the case of the training of Youths, the five weeks' course provides for an introduction to the fundamental principles underlying the Department's practice. Talks are given on numerous subjects and practical experience is gained in such operations as use of detectors, soldering, cable waxing and lacing, erection and recovery of poles, line wire and stays, jointing and soldering of small lead-covered cables, and the drawing in and out of underground cables. The syllabus for the eight week's course is confined to internal work and aims to supplement the knowledge gained during the first-year course, together with more advanced operations, including testing and adjusting relays, M.F. and I.D.F. work, cord circuits, apparatus fitting and joining up to plan numbers, small switchboards, testing for and clearing apparatus faults and Bridge megger tests.

The marking of answers to the questions set in the written tests keeps lecturers in touch with the progress of the students and enables special instruction to be given to those whose answers indicate the necessity for it.

Before adjustment work is undertaken by students, a demonstration of each piece of apparatus is given to a small group, at which the dismantling, reassembling, and adjustment are carefully explained; the use of the correct tools being specially emphasized.

When training in such items as dials, relays, selectors, teleprinters and typewriters, a complete piece of apparatus, not necessarily in correct adjustment, is given to the student who dismantles, reassembles, and re-adjusts it. An instructor carefully watches the operations as they proceed, giving advice and assistance as required, finally checking all assemblies and adjustments and awarding marks accordingly. Constant checks are made of the instructors marking to ensure that the student is being given full credit for his work. In the case of small items such as dials and relays, from 6 to 10 of these are handled in order that a good average result is obtained, and to ensure that the student has sufficient experience in handling the tools required. In the case of teleprinters and typewriters the time available allows for only one item to be completed.

Figs. 3 and 4 show groups of students engaged in practical work. Marks are awarded for both theoretical and practical work, and individual students are finally placed as highly qualified, qualified, or unqualified in each division according to the number of marks obtained.

The standard achieved is high and only a small percentage fail to qualify, a fact which is considered very creditable, for in practical work a dial is dismantled into 52 parts, a two-motion selector into 101 parts, a typewriter into 105 parts, and a teleprinter 7A into 1,340 parts. It may also be interesting to readers to realize that tracing a simple call on a non-director system involves 2 uniselectors, 3 two-motion selectors, 25 relays, 97 moving springs, and the making and breaking of 134 electrical contacts. A simple director call involves 8 uniselectors, 6 two-motion selectors, 55 relays, 247 moving springs, and 388 electrical contacts. Further complications are introduced when the call also involves coders, decoders, senders, displays, or V.F. keysending. Consequently, considerable care and attention to circuit work is necessary.

It will be appreciated that in an establishment such as the Training School, a large amount of information must be available to students in a form suitable for study, and to meet this requirement the school staff prepare bulletins giving essential details. These are known as school mimeos and in addition to their use by students, frequent demands for them are made by the district staffs.

TABLE I.

Course.	Duration in weeks.	Number of Courses in Present Session.	Average number of Students.	Estimated total in Present Session.	Student Weeks.
Director System	12	6	23	138	1,656
Non-Director System	10	4	25	100	1,000
Siemens No. 16 System	8	1	15	15	120
Siemens No. 17 System	—	—	—	—	—
Common Control System	—	—	—	—	—
Coded Call Indicator	12	1	15	15	180
Bypath System " S "	7	2	18	36	252
Unit Exchanges No. 5 and 6	7	8	22	176	1,232
,, ,, No. 7	10	1	14	14	140
,, ,, Bypath QC and R ...	8	2	11	22	176
Group Service Scheme	3	1	15	15	45
P.A.B.X. Siemens No. 2	6	2	15	30	180
P.A.B.X. Unit No. 4	6	2	10	20	120
Repeater Station Practice	12	3	17	51	612
Units Amplifying	3	5	20	100	300
Multi-Channel V.F. Telegraphy ...	3	2	20	40	120
Carrier Current Telephony	4	1	12	12	48
Wireless Interference	4	12	27	324	1,296
Teleprinters 3A	2	8	16	128	256
Teleprinters 7A	3	4	32	128	384
Telegraph Typewriters	1	12	18	216	216
Headquarters and London Supervising Officers	*	1	75	—	—
Provincial Supervising Officers ...	2	2	24	48	96
Traffic Officers	2	2	15	30	60
Probationary Asst. Engrs.	16	—	—		
Probationary Inspectors	16	1	24	24	384
Youths-in-Training, 5 weeks	5	9	36	324	1,620
,, ,, ,, 8 weeks	8	6	45	270	2,160
Trunking and Grading	2	2	20	40	80
Misc. Automatic Adjustments	2	4	6	24	48
Clerk of Works—Automatic	4	2	14	28	112
Chargeable time Indicator	3	12	20	240	720
Cable Balancing	8	1	30	30	240
U/G Works Supervisors	2	1	25	25	50
Total	—	120	—	2,657	13,903

* One lecture per week for 20 weeks.

There is also a series of publications known as M.A.I's (Maintenance Adjustment Instructions) which are drawn up by the school staff in conjunction with the interested Headquarters' Sections. This information is presented in a form convenient for use of students at benches. It is interesting to observe that these M.A.I's are used throughout the country and by the Department's contractors.

FIG. 3.—TELEPRINTER CLASS.

A very important activity of the school is the conducting of correspondence courses in Calculations, Mathematics, Electricity and Magnetism, Telephony, Telegraphy, and Radio Communication. Each phase of the courses is divided into 15 lessons. These are despatched to students, at their private addresses, at fortnightly intervals.

The number of students enrolled in these courses indicates that a real need is being met and that in the past a large section of the staff was apparently denied the opportunities of self-advancement which were available to others more fortunately placed.

During the session which has just closed, 1,177 students completed the courses for which they enrolled. This number involved the preparation of 150 lessons and the despatch, correcting and recording of 38,000 lesson papers. The courses are conducted on the most modern lines and students appreciate the personal element resulting from direct contact between the tutors and themselves.

The Training School enjoys a world-wide reputation for, in addition to rendering assistance to the

Fighting Services, Colonial and Foreign Administrations regularly seek permission for members of their organizations to attend the school for instruction. Recently representatives were simultaneously in attendance from New Zealand, Australia, India, South Africa, Iraq, and Ceylon and, at the time of writing these notes, engineers from South Africa, Kenya Colony, and Portugal are undergoing training, whilst engineers from the Federated Malay States and Jamaica will be reporting in the course of the next few weeks.

During the ten years that have passed, the training school has developed to a remarkable extent and in the coming years it is to be expected that still further demands will be made upon it.

FIG. 4.—PRACTICAL WORK ON AUTOMATIC EXCHANGE APPARATUS.

Teleprinter Voice Frequency Broadcasting Scheme

The Teleprinter Voice Frequency Broadcast Scheme now in course of investigation at the Post Office Research Station is being designed to make use of existing P.B.X. networks over which it is desired primarily to transmit simultaneously emergency messages to some or all of the subscribers connected to the P.B.X. Routine Broadcast Transmissions may also be carried out.

The Central Office and the Out Stations will be provided with the standard Post Office " Telex " equipment together with an auxiliary cordless switchboard and Voice Frequency Amplifier at the former office and a compact switching and lamp unit at the latter. D.C. signalling will be used.

To make a Broadcast Transmission, the Central Office operates the keys associated with the stations required. This operation seizes the P.B.X. line (irrespective of what may be taking place on the circuit), warns the P.B.X. operator that the line has been taken, switches the Out Station to Teleprinter reception (starting up the Teleprinter Motor and Telex Converter), disconnects the Out Station transmission (Telephonic or Teleprinter; this is necessary to prevent an Out Station from interfering should he attempt to transmit during a broadcast transmission), gives a visual and/or audible warning to the Out Station.

Simultaneous Teleprinter transmission can then be proceeded with to all stations concerned.

A mains-operated single-valve amplifier provides an adequate output from the central office " Telex " Converter, and is suitable for 10, 20 or 30 line installations where the transmission equivalent will not exceed 20 db. on any Out Station link.

The Out Stations will acknowledge the message by key operation. Upon the receipt of this signal, the officer controlling the " Broadcast " will release the line and thus restore it to normal P.B.X. service.

A " Query " signal is also provided whereby the Out Station may indicate that he requires further information before being restored to the P.B.X. In these circumstances the Central Office may make individual connexion to this station; this connexion will restore the Out Station transmission and they are then free to make a normal Telex communication.

The " Query " signal may also be used to inform the Central Office that the Out Station wishes to communicate during the progress of a broadcast.

An experimental scheme for adaptation to C.B. P.B.X's has been tried out and appears to be entirely satisfactory. A second scheme for adaptation to magneto systems is now being prepared.

An article dealing with the details of the scheme will follow in due course.

Reconditioning Telegraph Circuits for Audio and Carrier Working

E. J. WOODS, A.M.I.E.E.

AN article describing the reconditioning of the Preston-Glasgow (Northern underground) telegraph cable for trunk purposes appeared in the *P.O.E.E. Journal,* Vol. 25, Part 2, pp. 108-115.

Similar action was undertaken recently on the telegraph circuits in the London-Derby-Leeds-Newcastle-Edinburgh trunk cables, but the methods employed differ to some extent from those adopted for the Preston-Glasgow cable, and are described in the following paragraphs :—

General.

The cables affected by the scheme are given below in schedule form, together with details of the circuits made available for trunk purposes.

Section.	Type of Cable.	Number of pairs released for trunk purposes.
London—Derby	160 pair 40 lb. P.C.M.T.	56
Derby—Leeds	60 pair 20 lb. + 34 pair 40 lb. + 62 pair 20 lb. + 56 pair 40 lb. P.C.M.T.	56
Leeds—Newcastle	do. do. do. do.	46
Newcastle—Edinburgh	38 pair 20 lb. + 28 pair 40 lb. + 54 pair 20 lb. + 50 pair 40 lb. P.C.M.T.	30

The total route mileage is 395 miles, repeater or amplifier provision being made at London, Fenny Stratford, Leicester, Derby, Sheffield, Leeds, Catterick, Kenton, Jedburgh, and Edinburgh.

The telegraph circuits were transferred from unloaded to loaded conductors, voice frequency multi-channel telegraph working being introduced. The released pairs were balanced and loaded to provide efficient channels for audio and single channel carrier trunk circuits.

A considerable amount of preparatory work was necessary in order that the contractors could complete the job within the specified time limits of ten weeks. A preliminary examination showed that the lengthening of subsidiary cables would be necessary to give reasonable access to joints, and in a number of manholes rearrangement of cables and loading coil pots was found to be desirable to avoid congestion, and to keep the length of the subsidiary cables to a minimum.

As the pairs used for telegraph purposes were unloaded, the subsidiary cables were usually short, so that the position of the pot was of some importance.

At Northampton and Darlington, the circuits that had been led in for telegraph purposes were cut out and jointed through in the main cable to give the maximum number of long distance channels. At the London end, the circuits were led into Wood Street Repeater Station, being extended on 2-wire terminal ends to G.P.O. South.

Loading.

In order to secure a sufficiently high cut off for carrier working without incurring high costs in building new manholes, light loading was provided at existing spacing; 19 millihenry coils were used between London and Derby, spacing being 1.6 miles, and 27 millihenry coils between Derby and Edinburgh at 1.136 mile intervals. At Fenny Stratford, Leicester, and Derby Repeater Stations, where the end loading sections were approximately a full loading space, 9.5 millihenry coils were used. This loading gives a cut off of 6900 throughout, and an impedance of 495 ohms between London and Derby, and 645 ohms between Derby and Edinburgh.

Considerable saving in space as well as in cost, as compared with earlier types, was secured by installing the welded steel type of loading coil case. Between London and Derby the cases contained 56 19-millihenry coils, Derby to Leeds 56 27-millihenry coils, Leeds to Newcastle 46 27-millihenry coils, and Newcastle to Edinburgh 30 27-millihenry coils. The maximum widths of the cases installed between London and Leeds, and Leeds and Edinburgh are $12\frac{1}{8}''$ and $13\frac{1}{8}''$ respectively.

Testing and Balancing.

All pairs were tested for " side to side " cross-talk, and any abnormal unbalances were corrected, but no attempt was made to improve the general " side to side " values, as only 4-wire working within quad was required. Special attention was given, however, to " pair to pair " cross-talk.

By suitable selection of pairs, and provision of capacity balancing tails in each loading coil section, it was found possible to obtain near end cross-talk values of 90 decibels (mean) and 80 decibels (maximum) between London and Derby, and 87 decibels (mean) and 80 decibels (maximum) between Derby and Edinburgh.

The balancing and loading were carried out by contract, Messrs. Standard Telephones and Cables, Ltd., being responsible for the London-Leeds section, and Messrs. Pirelli General Cable Works, Ltd., undertaking the Leeds-Edinburgh length.

The work on the London-Leeds portion was commenced on July 24th, 1933, two groups of men starting one on each side of Leicester, proceeding towards London and Leeds concurrently. The work was completed by the contractors, and the final acceptance tests completed on October 18th, 1933, on all sections.

On the Leeds-Edinburgh portion, work was commenced on July 31st, 1933, by three groups of men, one group commencing at Edinburgh working towards Jedburgh, and two groups commencing one on each side of Catterick working towards Newcastle and Leeds. The acceptance tests on all sections were completed on October 19th, 1933.

New Design of Capacity Balancing Tails.

The capacity balancing tails on the " Northern underground cable " consisted of 5-foot lengths of 300 pair 20 lb. twin cable. They are of such bulk that they cannot be placed in the same pipe as the main cable, and special couplings are required for their accommodation.

Two new designs, which simplify installation work, were proposed by the contractors and were adopted.

Fig. 1 shows the " Cotopa " condenser tail used between London and Leeds by Messrs. Standard Telephones & Cables, Ltd., and Fig. 2 the condenser unit tail installed by Messrs. Pirelli General Cables, Ltd., between Leeds and Edinburgh. A brief description of these will be of interest.

The " Cotopa " unit consists of a woven cotton core, approximately 3/32 inch in diameter, around which are closely spiralled two 20 lb. enamelled conductors with a double lapping of white cotton, giving an overall diameter of $\frac{3}{8}$ inch. The capacity is 10 $\mu\mu$F per inch, making the selection of any required value a simple matter. When prepared for insertion in the joint, the core at one end is bound with half a dozen turns of fine red twine, the two conductors being unwound to a sufficient length to allow of their being jointed across the cable conductors whose out-of-balances it is desired to correct. At the other end the two conductors are insulated, a 10 lb. paper sleeve being placed over the end of one conductor, and the other laid up alongside the 10 lb. sleeve, and a 20 lb. paper sleeve placed over both. To protect the whole tail, 40 lb. paper sleeves are placed over the whole length, allowing sufficient spacing to permit of folding the tail on itself, and of its being conveniently placed in position in the joint. The tail is then laid up in the joint in parallel with the conductors. All tails are placed in the joint at the " down end " of the loading section, that is, in the loading manhole. The number of tails in any joint is very small, so that their presence does not unduly increase the size of the lead sleeve at the joint. Between London and Leeds the number of tails fitted was 28, distributed over 13 points. The average value of the tails used was 114 $\mu\mu$F, the maximum being 150 $\mu\mu$F and the minimum 90 $\mu\mu$F. A schedule was prepared for maintenance purposes showing the location of all points at which tails were fitted, together with a list of the conductors affected.

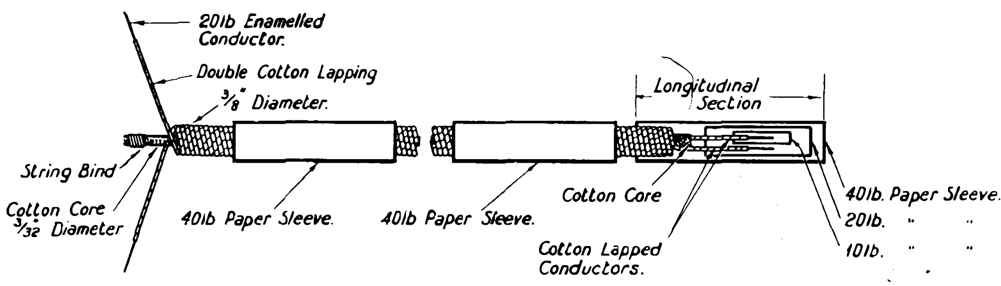

FIG. 1.—COTOPA BALANCING TAILS.

The condenser type consists of a centre core of metal surrounded by a few turns of tinfoil insulated by means of oiled paper. A thin metal plate of semicircular form is placed outside this, and the

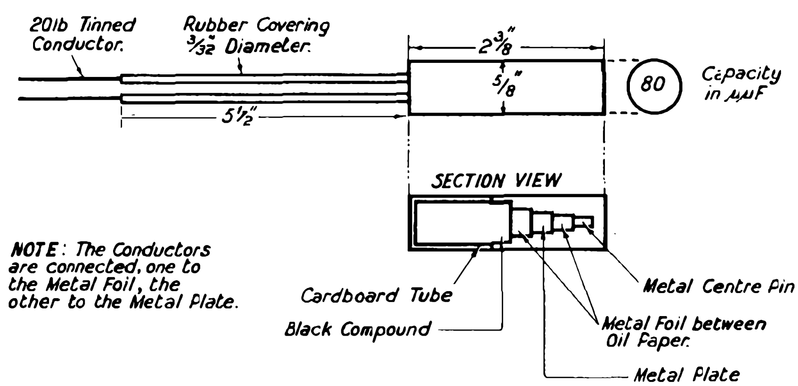

FIG. 2.—BALANCING CONDENSERS.

layers of tinfoil and oiled paper are continued for a few turns. The whole is sealed in a cylinder of cardboard with compound, the lower end being closed by a card disc bearing the value of the unit in $\mu\mu F$. The top end is finished with a yellow compound through which protrude two rubber covered conductors of 20 lb. weight. The unit is not variable as in the " Cotopa " type, and requirements are met by providing units nominally of 40, 80, 120, and 160 $\mu\mu F$ with a 5 $\mu\mu F$ tolerance.

The method of using these condensers is as follows:—The pairs to be loaded in each loading coil section are disconnected at each end. At the down end, a quad of rubber covered conductors, coloured red, green, blue, white, and approximately 6 inches long, is inserted on all conductors in the joint between the cable and the loading pot stub, forming a 3-wire twist joint, the end of the tail being insulated. The joint is then taped up with the tails hanging outside. The end of the tail bears a paper sleeve numbered to agree with the conductor number. The unbalances are measured from the up end of the cable in the distant manhole, and if the out-of-balance is beyond the permissible limit, say 120 $\mu\mu F$, a condenser of like value is connected to the tails concerned. A repetition of the test is made to confirm the accuracy of the work, before disconnecting the quad from the testing instrument, and making the condenser joint permanent. Where more than one condenser is attached to a conductor, the connexion is made to the end of the tail, so that the main joint is not disturbed.

On completion of the testing on all pairs, the condensers are laid up along the taped joint, a final taping preventing them from moving while the lead sleeve is being drawn over. In the event of a fault, the removal of the outer taping frees all the tails and condensers for testing without disturbing the main joint. The arrangement necessitates the use of a lead sleeve of sufficient size to accommodate the maximum number of condensers. The maximum fitted in one joint was 34.

The final results fully met expectations, the final lining up indicating that approximately 50 per cent. of the circuits which have been reconditioned will be suitable for carrier working. The audio circuits provided are as under :—

London to Edinburgh	...	15—4-wire circuits
London to Newcastle	...	8—4 ,, ,,
London to Leeds ...	...	5—4 ,, ,,

Insulation Test Set giving an Audible Alarm

The testing of the insulation of large numbers of similar articles, *e.g.*, switchboard plugs, jacks, etc., has heretofore been carried out by means of motor-driven meggers. The response of these is not rapid, and, together with the necessity for watching a pointer, severely limits the rapidity of testing a succession of articles. In addition, there is need for carrying out insulation measurements at various voltages between 100 and 500 which, normally, necessitates the use of a different instrument for each test voltage.

There is clearly a considerable field of application for an insulation test set which avoids these disadvantages. Such a set should be capable of applying any desired test voltage within a wide range and be instantaneous in operation. It should give, preferably, an audible indication when the insulation resistance of the article under test falls below a predetermined value in order to leave the eyes of the operator free to assist him in the manipulation of the test articles. The set should operate over a wide range of insulation resistances, and should be easily adjusted and stable in operation.

A set which promises closely to meet these requirements is being developed in the Research Section. The test specimen is connected in series with a resistance across the testing potential. In conjunction with a fixed biassing voltage, the potential difference across this series resistance due to the passage of the leakage current controls the effective grid bias of a thermionic valve. The anode current of the latter flows through a high resistance, the potential difference across which is therefore controlled by the leakage current of the test specimen. The anode of the valve is coupled to the grid of a gas-filled relay by means of a neon tube, the initial grid bias for the gas-filled relay being applied through a grid leak in the normal manner. The circuit constants are so chosen in relation to the characteristics of the neon tube that the potential difference across the latter remains substantially constant although the current flowing through it varies over an appreciable range. Due to this property of the neon tube, variations in P.D. across the anode resistance of the valve appear as changes in effective grid bias on the gas-filled relay. The small P.D. across the resistance in series with the test specimen is thus amplified to a degree sufficient to effect reliable control of the operation of the gas-filled relay. When the leakage current of the specimen attains or exceeds the value implied by its specified insulation resistance, a discharge occurs in the anode circuit of the gas-filled relay which operates an ordinary telephone relay and thence an electric bell or buzzer or other audible device.

The complete device is being designed for " all mains " operation and is expected to cover a range of insulation resistances up to 500 megohms at a test voltage of 100, up to 2500 megohms at 500 volts and *pro rata* at intermediate voltages with an error not exceeding 5%. The actual insulation resistance at which the device operates is determined by the setting of the (adjustable) resistance in series with the test specimen.

Note on the Graphical Solution of Problems in Transmission

T. B. VINYCOMB, M.C. M.A.,
Woolwich Polytechnic

THE use of the hyperbolic functions of complex quantities in the study of transmission problems presents difficulties in practice which annul to a large extent their usefulness in simplifying the analysis. This note is an attempt to remove these difficulties by using a graphical method of solution. The accuracy attainable depends largely on draughtsmanship and can be made equal to the accuracy of the experimental results of ordinary methods of testing.

Theorem.

Consider a triangle APA′

Let O be the mid point of the base AA′ = $2a$.

Join OP.

Take as axes OX along A′A, OY perpendicular to OX.

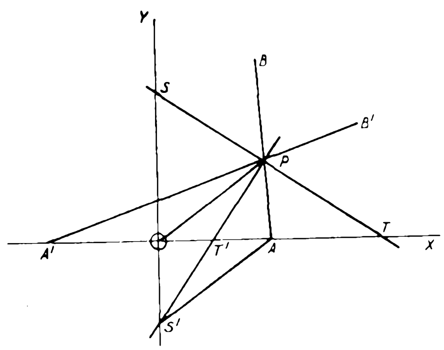

FIG. 1.

The vector A′P = A′O + OP = a + OP

AP = OP − OA = OP − a.

$$\text{The ratio } \frac{A'P}{AP} = \frac{a + OP}{OP - a} \text{ as a vector equation}$$

$$= \frac{OP/a + 1}{OP/a - 1}$$

Let OP = $a \tanh (u + jv)$

$$\text{Then } \frac{A'P}{AP} = \frac{\tanh (u + jv) + 1}{\tanh (u + jv) - 1}$$

$$= - \frac{e^{(u + jv)}}{e^{-(u + jv)}} = - e^{2(u + jv)}$$

$$\text{or } \frac{PA'}{AP} = e^{2u} \cdot e^{2jv}$$

That is, the ratio of the scalar lengths A′P/AP = e^{2u} and the angle A′PA = $\pi - 2v$.

Problem I.

Hence, if we are given a vector OP = $a \tanh (u + jv)$, by marking off the lengths OA and OA′ along OX, each equal to a, and drawing the figure, we can find the values of u and v from measurements of AP, A′P and the angle APA′.

Or we may proceed as follows :—

Bisect the angle APA′ internally by the line PT′S′ cutting OX in T′ and OY in S′; bisect it also externally by SPT cutting OX in T and OY in S. These two bisectors are at right angles.

The circle circumscribing the triangle APA′ is cut by OY at the mid points of the two arcs into which AA′ divides the circle. The bisectors PT′S′ and SPT cut this circle in the same points. S and S′ are therefore on this circle. The angle A′AS′

$$= \text{angle } A'PS' = \frac{\pi}{2} - v$$

∴ Angle AS′O = v and OS′ = $a \operatorname{Cot} v$

Similarly, OS = $a \tan v$

So v can be found by measuring OS or OS′. v is to be taken negative if S is below, or S′ above, O. Further, the other bisector of the angle APA′ meets OX in points T′ and T which divide A′A internally, and externally in the ratio A′P/AP.

$$\text{So } \frac{A'P}{AP} = e^{2u} = \frac{a + OT'}{a - OT'}$$

$$\text{so } \frac{e^{2u} + 1}{e^{2u} - 1} = \frac{a}{OT'}$$

$$\text{or } OT' = a \times \frac{e^{u} - e^{-u}}{e^{u} + e^{-u}} = a \tanh u$$

Similarly it follows that OT = $a \coth u$

Hence u can be found by measuring OT or OT′. u is to be taken negative if T and T′ are to the left of O. If the base of the triangle is taken two units long, then $a = 1$.

Whether OS or OS′, or OT or OT′ is to be used for the determination of u and v will depend on the circumstances of the case. A good intersection of lines at not too acute an angle is needed as well as a length which is not too short to be measured with accuracy. Both may be used and the mean value taken.

Problem II.

When measurements have been made of the impedances of a line or network with the distant end open and short circuited the characteristic impedance and the propagation constant can be found by an application of this method. Thus :—

Let $OQ = Z_f$ the impedance at input with output open

$OP = Z_c$ the impedance at input with output shorted

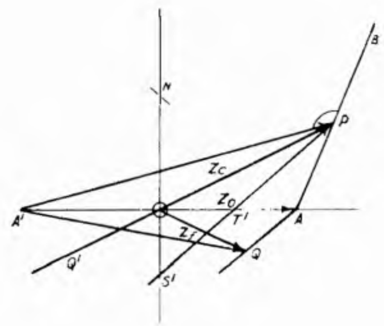

Fig. 2.

Then $Z_c = Z_0 \tanh Pl$ | Z_0 = characteristic impedance

$Z_f = Z_0 \coth Pl$ | P = propagation constant $= \beta + j\alpha$

l = length of line.

Draw Z_c and Z_f as measured. OP and OQ.

Produce OP back to Q′ so that the length OQ′ = length OQ.

Draw the bisectors of the angles POQ and QOQ′. Through the mid point of PQ′ draw a line perpendicular to POQ′ meeting the bisector of QOQ′ in N.

By construction N is equidistant from P, Q and Q′.

Draw the circle centre N and radius NP meeting the bisector of POQ in A and A′ and the bisector of QOQ′ in S′. Join AP, A′P, and PS′ meeting OA in T′.

PS′ is the bisector of the angle PAP′.

Hence $Z_c = OA \tanh (u + jv)$ where

$OS' = OA \cot v$

and $OT' = OA \tanh u$

By construction the scalar relation holds.

$$OP \cdot OQ = OP \cdot OQ' = OA^2$$

and OA bisects the angle POQ,

so the vector relation $OP \cdot OQ = OA^2$ is true.

That is $OA^2 = Z_0 \tanh Pl \times Z_0 \operatorname{Coth} Pl = Z_0{}^2$

Consequently $Z_0 = OA$, and $u + jv = Pl = \beta l + j\alpha l$

So we get from measurements of the lengths

$OA = Z_0$

$OS' = Z_0 \cot v = OA \cot v = OA \cot \alpha l$

$OT' = Z_0 \tanh u = OA \tanh u = OA \tanh (\beta l)$

which give the quantities sought.

If the line PT′S′ does not give good measurement conditions for u and v, the line through P perpendicular to it will cut the lines ON and OA in S and T, being the external bisector of A′PA, and in that case

$$OS = OA \tan v \quad OT = OA \coth u$$

This line is got by joining P to the other point S where the circle, centre N, cuts ON.

Problem III.

Let the diagram (Fig. **3**) represent a T section equivalent to a piece of line or a four terminal network which is symmetrical.

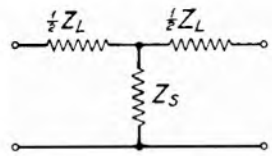

Fig. **3**.

Let Z_f be the input impedance from either end when the other end is open circuited.

Z_c be the input impedance when the output is short circuited.

Then $Z_f = \frac{1}{2} Z_L + Z_S$

$$Z_c = \frac{1}{2} Z_L + \frac{\frac{1}{2} Z_L Z_S}{Z_S + \frac{1}{2} Z_L}$$

$$\text{So } Z_f - Z_c = Z_S \left(1 - \frac{\frac{1}{2} Z_L}{Z_S + \frac{1}{2} Z_L}\right)$$

$$= \frac{Z_S{}^2}{Z_S + \frac{1}{2} Z_L}$$

$$= \frac{Z_S{}^2}{Z_f}$$

Hence $Z_f{}^2 - Z_f Z_c = Z_S{}^2$

Or $Z_f{}^2 - Z_0{}^2 = Z_S{}^2$ where Z_0 = characteristic impedance.

Therefore Z_S is the geometric mean between

$Z_f - Z_0$ and $Z_f + Z_0$

and $\frac{1}{2} Z_L = Z_f - Z_S$. Hence, if we know Z_0 and Pl, or Z_f and Z_c we can find the components of the equivalent symmetrical T section.

This is most simply carried out graphically.

In Fig. **4** the letters correspond to the same points as in Figs. **1** and **2**, *i.e.*, $A'O = OA = Z_0$

$OQ = Z_f$

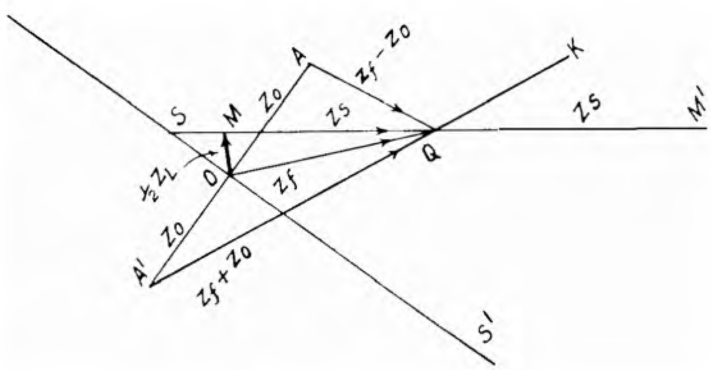

Fig. **4**.

Circle circumscribing AQA′ cuts the perpendicular to AOA′ through O in S and S′.

Then QS and QS′ are the bisectors of AQA′

$A'Q = Z_f + Z_0$

$AQ = Z_f - Z_0$

Hence Z_S bisects the angle AQA′ and has a length which is the geometric mean of AQ · A′Q.

S′Q is perpendicular to SQ which is the direction of Z_S

With centre S′ and radius SA draw a circle.

This circle passes through A′ and cuts SQ in M and M′ and A′Q produced in K.

By construction, $A'Q \cdot QK = QM \cdot QM' = QM^2 = A'Q \cdot AQ.$

Hence $MQ = Z_S$

Since $\frac{1}{2} Z_L + Z_S = Z_f = OQ$

$\frac{1}{2} Z_L = OM$

We have therefore got the elements of the equiva- Z_0 and Pl without resort to tables of hyp. functions of complex angles.

Voice Frequency Valve Receiver

With the general introduction of voice frequencies for signalling, the necessity has arisen for apparatus to be used for the reception of such signals; generally speaking, it is required to respond to impulses of voice frequencies. Factors which affect the design are:

(1) It is preferable that the apparatus should operate from the 50-volt exchange battery.

(2) The range of the receiver should be as great as possible to avoid padding of junctions.

(3) The apparatus will be maintained by the exchange staff and therefore must have few and simple adjustments, and telephone relays (3,000 type) with no marginal conditions.

(4) Under certain conditions speech immunity is necessary.

The lowest level at which it will be required to receive signals is about – 20 db. (referred to 1 mW into 600 ohms). It has been found therefore that two valve stages are necessary. The first stage is an amplifying stage designed to avoid cross modulation and accentuation of harmonics. Tuning follows and the voltage developed across one section of the tuned circuit is applied to a further valve, which employs rectified reaction. In the anode circuit of this valve, the relay to be operated is placed. The operating lag of this relay depends on (*a*) the build up time of the tuned circuit and (*b*) the inductance of the relay. The first has been made small by the employment of a condenser-resistance limiter in the first stage. The second has been avoided by the use of a pentode valve in the final stage. This type of valve has the property of adjusting itself so that the anode current tends to remain constant due to the constant space charge. This helps to shorten the time of growth of current in the relay considerably, and moreover enables a relay of more turns and resistance to be used.

The above principles have been employed in the design of a four-frequency V.F. receiver for use in keysending and also a 500/20 receiver to be used side by side with sleeve control equipment, for generator ringing on certain long distance lines. The difficulties in the first are the reception of very small impulses (20 milliseconds) and the avoidance of interference between frequencies. The shape of the grid volts/anode current characteristic of the pentode enables the four grid bias tappings to be commoned. In the case of the 500/20 receiver, speech immunity and small tapping loss are essential. Freedom from voice operation has been obtained by employing the 500/20 tone to impulse a relay in the anode circuit of the pentode valve. The regular interruptions are made use of to operate a further relay which brings in the lamp. Field trials on these models are to be commenced shortly.

Experiments show that the principles employed in the above receivers can be made use of in a receiver for the reception of long distance dialling.

Telephone Transmission Problems

R. M. CHAMNEY,
B.Sc., A.K.C., Assoc. M.I.C.E

III.—Elementary Theory of Transmission *(continued)*

THE transmission of direct currents through lines was dealt with in the April issue. Before proceeding to the alternating current case it is necessary to possess a working knowledge of a subsidiary branch of algebra (Vector Algebra) which very greatly simplifies operations.

In the D.C. case two Primary Constants of a line, *i.e.*, Resistance and Leakance, were found to be sufficient to determine the formulæ required for the complete description of transmission phenomena. In the A.C. case it is necessary to take account of two further Primary Constants, namely, Inductance and Capacity.

Inductance produces a back E.M.F. proportional in amount to the rate of increase or decrease of the electromagnetic field produced by the transmitted power. Capacity produces a back E.M.F. proportional in amount to the rate of increase or decrease of the electrostatic field similarly produced. Now examine the sine wave form of voltage shown in Fig. **1**. At the point A the voltage is momentarily

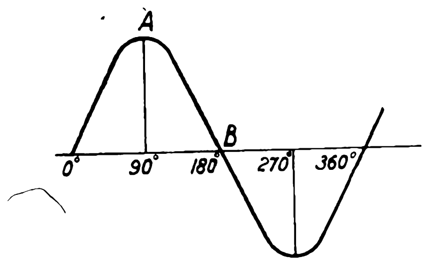

FIG. 1.

constant. Thus there is no rate of change of either electromagnetic or electrostatic field and the back E.M.F. produced by either inductance or capacity will be nil.

At the point B the rate of change is a maximum so that the back E.M.F's will be a maximum.

Between A and B the electromagnetic field is decreasing or collapsing; the inductance effect will therefore be increasing. The capacity effect will be increasing owing to the increase in the rate of change of voltage, but the back E.M.F. will be increasing in a negative sense.

A full description of inductance and capacity effects is given in all text-books on Electricity and Magnetism. It will suffice here to state that the inductance back E.M.F. lags 90° behind the impressed voltage while the capacity back E.M.F. leads by a similar angle. Fig. **2** shows the curves of originating pressure V, the Inductive back E.M.F.(I) 90° behind the curve V, and the capacity back E.M.F.(C) leading the curve V by 90°.

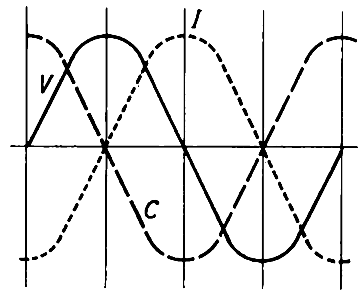

FIG. 2.

It is necessary to have some method of distinguishing between quantities which are out of phase, so that no confusion can arise. In Vector Algebra the symbol generally used to indicate a phase difference of 90° between two quantities is " j." If two voltages A and B are to be described algebraically and these voltages are 90° out of phase the idea can be stated mathematically thus: $A + jB$. This expression, since it involves two dimensions graphically, is called a " complex " quantity. Diagrammatically this is shown in Fig. **3**.

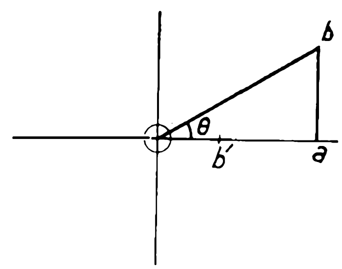

FIG. 3.

Firstly, A is measured along the axis ($0a$) and then $a\ b$ is drawn to right angles to $0a$ and in length equal to B.

Suppose now that the voltage B be considered an additional 90° out of phase with A, making a total of 180°. jB must be multiplied again by the operator j and thus we get j^2B. Looking at the diagram again, A is measured as before, but B being rotated a further 90° must be measured in the reverse direction of $0a$ and we get b'. Clearly the effect of $j^2B = -B$.

From this we can argue a numerical value for j, since

$$A + j^2B = A - B$$
$$j^2 = -1$$
$$\text{or} \quad j = \sqrt{-1}$$

This numerical value has no real meaning since the square route of a negative quantity is an impossibility. This does not, however, prevent the use of a very useful operator whose function it is to tell us in what phase relation the quantities dealt with must be considered.

Take now the diagram in Fig 4. The four quadrants each have a separate meaning. These are shown in Table IV.

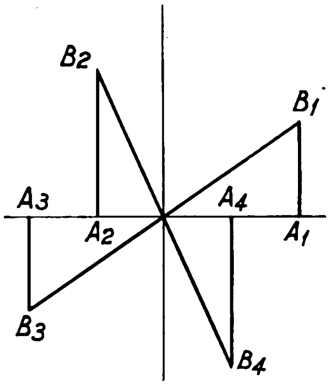

FIG. 4.

TABLE IV.

Quadrant	Sign of		Algebraic expression.	Angle of Vector.
	A	B		
1	+	+	$A_1 + jB_1$	0 —90°
2	−	+	$-A_2 + jB_2$	90°—180°
3	−	−	$-A_3 - jB_3$	180°—270°
4	+	−	$A_4 - jB_4$	270°—360°

The actual angle of the vector is obviously dependent on the values of A and B and is capable of direct calculation in the following manner. Since B is always measured at right angles to A the triangle formed by $0a$, ab, $b0$ (see Fig. 3) is a right angled triangle. The value of the ratio $\frac{B}{A}$ is thus a constant quantity for any given angle, and is therefore a measure to some scale of the angle. In mathematical language this ratio is called the "tangent" of the angle, usually written as "tan."

The point b (Fig. 3) can be described in two ways; (1) by measuring $0a$ and setting up ab at right angles, (2) by measuring $0b$ direct at an angle θ. In vector algebra the descriptions are (1) $A + jB$ and (2) $C \underline{/\theta}$, where $C = \sqrt{A^2 + B^2}$ and

$$\theta = \tan^{-1}\frac{B}{A}$$

The expression $\tan^{-1}\frac{B}{A}$ means "the angle whose tangent is $\frac{B}{A}$."

The following rules must be learned in order to perform operations in vector algebra.

To add or subtract, the form $A + jB$ must be used.

To multiply or divide, the form $C \underline{/\theta}$ must be used. For example

$$(A + jB) + (C + jD) = (A + C) + j(B + D)$$

and $M \underline{/\theta} \times N \underline{/\phi} = MN \underline{/\theta - \phi}$

The symbol $\angle$ denotes a positive angle and $\overline{/}$ a negative angle.

$$(A + jB) \div (C + jD) = \left(\sqrt{A^2 + B^2}\tan^{-1}\frac{B}{A}\right)$$

$$\div\left(\sqrt{C^2 + D^2}\tan^{-1}\frac{D}{C}\right)$$

$$= \sqrt{\frac{A^2 + B^2}{C^2 + D^2}}\tan^{-1}\left(\frac{B}{A} - \frac{D}{C}\right)$$

The notation of Vector Algebra is immediately applicable to alternating current problems. The reactive voltage produced by an inductance is directly proportional to the frequency of the current (see text-book on Electricity and Magnetism). The reactance is actually ωL where $\omega = 2\pi f$ and is 90° out of phase with the impressed voltage. Hence the complete impedance of a circuit containing resistance (R) and inductance (L) in series (see Fig. 5) can be expressed as $R + j\omega L$. The corresponding expression for the admittance of a circuit containing capacity (C) and resistance (M) in parallel (see Fig. 6) is

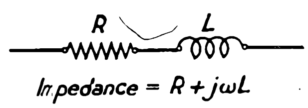

FIG. 5.

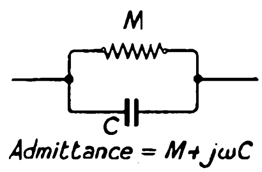

FIG. 6.

$$\frac{1}{M} + \frac{1}{\frac{1}{j\omega C}}$$

$$= \frac{1}{M} + j\omega C$$

$$= G + j\omega C$$

where G is the leakance as in the D.C. case.

Consider the line represented in Fig. 7.

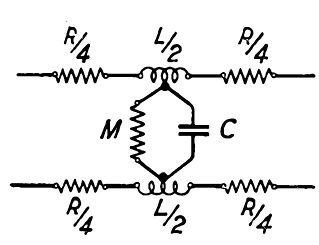

FIG. 7.

resistances which served to represent a line artificially in the D.C. case must now be supplemented by inductance and capacity. The series element instead of being R now becomes R + $j\omega L$. The shunt element correspondingly becomes G + $j\omega C$. In the D.C. case, it was shown experimentally that the characteristic resistance was $\sqrt{\frac{R}{G}}$. In the A.C. case, the quantity becomes the characteristic impedance (Z_0), and by substitution

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}} \quad \ldots\ldots(1)$$

The attenuation constant likewise is altered in the A.C. case to a complex quantity and becomes the propagation constant (γ or sometimes P) and by substitution from the D.C. formula $\sqrt{RG}$ becomes

$$\gamma = \sqrt{(R + j\omega L)(G + j\omega C)} \quad \ldots\ldots(2)$$

These formulæ are the well known results of much mathematical labour when established by rigid proofs.

Characteristic Impedance.

The characteristic impedance being a complex quantity consists of a vector having a modulus and an angle or it can be expressed as two linear quantities at right angles to each other, *i.e.*, the effective resistance and the reactance. The latter is always negative for unloaded lines, but may become positive on loaded lines depending on the position of the first loading coil as viewed from the testing end.

Propagation Constant.

The propagation constant can also be split up into two parts, at right angles to each other, the " in phase " and the " out of phase " components. The former is known as the attenuation constant and the latter as the phase or wave-length constant. When alternating power is transmitted along a line a definite time is taken for a wave to reach any given point. It therefore follows that there must be a time at which the voltage or current is completely out of phase with the original impressed value. This may also be expressed in another way. The current impressed on the line at a given instant is, say, a positive maximum (see Fig. 1). Owing to the time taken in transmission down a line, at a given point, say n miles distant, the current has reached a minimum value and is about to start on the rise of the curve; it is in fact 90° behind the impressed current and has just reached the value impressed one quarter cycle previously. At $2n$ miles the current will be a negative maximum. At $3n$ miles the current will be zero and about to increase in a negative sense. At $4n$ miles the two currents, impressed and received, will be on the same point of the cycle. At $4n$ miles therefore an entire cycle of operations has been completed and the length is described as one wave-length of propagation. A physical conception may perhaps be given which will further assist in understanding the wave of propagation.

In the D.C. case it was shown how leakance introduced a logarithmic element into the proceedings. The effect of inductance and capacity is to introduce a time element. The current in passing along a line has to satisfy the absorption powers of inductance and capacity; that is it has to spend energy in establishing the inductive and capacity fields before it can reach full strength and pass on. There is therefore a time lag. In the case of pure resistance, current passes with the speed of light. If, however, inductance and capacity be present the larger their value the greater will be the slowing up of the speed of transmission.

It also follows that the more heavily a line, having a definite capacity, be loaded with inductance the slower will be the time of transmission and in consequence the distance separating the complete waves of propagation will be smaller. In other words the value of " n " used above to describe the wave-length will be less.

The importance of transmission speed will be considered later when complete transmission systems are discussed.

The propagation constant as derived is in complex form and it is desirable for purposes of calculation to translate this into such a form that the attenuation and wave-length constants can be calculated separately. It is the attenuation constant only which the engineer uses to compare the relative transmission efficiencies of lines in nepers or decibels.

$$\gamma = \sqrt{(R + j\omega L)(G + j\omega C)}$$

Let $\gamma = \beta + j\alpha$

where β = attenuation constant

and α = wave-length constant.

Then $\beta + j\alpha = \sqrt{(R + j\omega L)(G + j\omega C)}$ ......(3)

The square of $\beta + j\alpha = \beta^2 + 2j\beta\alpha + j^2\alpha$

but since $j^2 = -1$

$$(\beta + j\alpha)^2 = \beta^2 + 2j\beta\alpha - \alpha^2$$

Squaring both sides of the equation

$$\beta^2 + 2j\beta\alpha - \alpha^2 = (R + j\omega L)(G + j\omega C)$$
$$= RG - \omega^2 LC + j\omega(RC + GL)$$

equating the " in phase " and " out of phase " components (which is quite permissible since the two components must be the same for equality)

$$\beta^2 - \alpha^2 = RG - \omega^2 LC \quad \ldots\ldots(4)$$

and $2\beta\alpha = \omega(RC + GL)$ ......(5)

the j cancelling out of both sides of the equation.

Now $(\beta^2 - \alpha^2)^2 = \beta^4 - 2\beta^2\alpha^2 + \alpha^4$

and $(\beta^2 + \alpha^2)^2 = \beta^4 + 2\beta^2\alpha^2 + \alpha^4$

therefore by adding $4\beta^2\alpha^2$ to $(\beta^2 - \alpha^2)^2$ we get $(\beta^2 + \alpha^2)^2$

Taking the values obtained above for $\beta^2 - \alpha^2$ and $2\beta\alpha$

$$(\beta^2 - \alpha^2)^2 + 4\beta^2\alpha^2 = (RG - \omega^2LC)^2 + \omega^2(RC + GL)^2$$

$$\text{or} \quad (\beta^2 + \alpha^2)^2 = R^2G^2 - 2\omega^2LCRG + \omega^4L^2C^2 + \omega^2R^2C^2 + 2\omega^2LCRG + \omega^2G^2L^2$$

$$= (R^2G^2 + R^2\omega^2C^2) + (\omega^2L^2G^2 + \omega^2L^2\omega^2C^2)$$

$$= R^2(G^2 + \omega^2C^2) + \omega^2L^2(G^2 + \omega^2C^2)$$

$$= (R^2 + \omega^2L^2)(G^2 + \omega^2C^2)$$

$$\therefore \quad \beta^2 + \alpha^2 = \sqrt{(R^2 + \omega^2L^2)(G^2 + \omega^2C^2)} \quad \ldots(6)$$

From equation (5) we get a value of $\beta^2 - \alpha^2$ and from equation (6) we get a value for $\beta^2 + \alpha^2$

By adding equation (5) to equation (6)

$$\beta^2 + \alpha^2 + \beta^2 - \alpha^2 = \sqrt{(R^2 + \omega^2L^2)(G^2 + \omega^2C^2)} + RG - \omega^2LC$$

$$\text{or} \quad \beta^2 = \tfrac{1}{2}\sqrt{(R^2 + \omega^2L^2)(G^2 + \omega^2C^2)} + \tfrac{1}{2}(RG - \omega^2LC)$$

$$\text{or} \quad \beta = \sqrt{\tfrac{1}{2}\sqrt{(R^2 + \omega^2L^2)(G^2 + \omega^2C^2)} + \tfrac{1}{2}(RG - \omega^2LC)} \quad \ldots(7)$$

Similarly by subtraction of equation (5) from equation (6)

$$\alpha = \sqrt{\tfrac{1}{2}\sqrt{(R^2 + \omega^2L^2)(G^2 + \omega^2C^2)} - \tfrac{1}{2}(RG - \omega^2LC)} \quad \ldots\ldots(8)$$

Over the usual speech range on unloaded cables ωL is a very small quantity compared with R and C and may be neglected without appreciable loss of accuracy. G is also negligible and a simplification of formulæ (7) and (8) is then possible. The terms under the single root disappear and

$$\beta = \alpha = \sqrt{\tfrac{1}{2}\sqrt{R^2\omega^2C^2}} = \sqrt{\tfrac{1}{2}R\omega C} \quad \ldots\ldots(9)$$

Errata.

The following corrections should be made to the article which appeared in the April issue :—

Page 57. The formula should read

$$R_{f_2} = \frac{R}{2} + \frac{M\times\left(R_{f_1} + \frac{R}{2}\right)}{M + R_{f_1} + \frac{R}{2}}$$

Page 58. The same misprint of $\frac{2}{R}$ instead of $\frac{R}{2}$ has occurred as on page 57.

Page 61. Two square root signs have been omitted, *i.e.*, $h = \sqrt{\frac{R_c}{R_f}}$

and further down $h = \sqrt{\frac{815}{4280}}$

Proposed Design for Speaking Clock

For some time past a speaking clock has been installed in Paris. On dialling a special number, a subscriber is routed to this and, when connected, hears the time announced in the form :

" Thirteen hours, forty-five minutes,
thirty seconds."

Similar announcements are made at intervals of ten seconds except at 50 seconds past each minute when a special announcement is made in the following form :

" On the third pip it will be exactly Thirteen
hours, forty-six minutes."

This is followed by three high-pitched pip signals, the last of which indicates the exact minute.

The clock consists of a brass cylinder carrying round its circumference three banks (respectively for hours, minutes, and seconds) of sound records printed photographically upon paper. At any instant a narrow transverse slit of light is focussed on one record of each bank and the light reflected therefrom falls on a photocell followed by an amplifier. The cylinder rotates three times in ten seconds and switching is arranged to pass the output from the three photocell amplifiers in turn to one main amplifier and thence to the exchange wiring. During successive two-thirds of each 10-second period each photocell output is suppressed so that the output from the main amplifier takes the form of one continuous phrase as given above. The optical systems and photocells are moved to reproduce from the respective records the required phrases by means of cams and the operation of the whole mechanism is under the control of a synchronizing device operated from the Observatory.

In the clock now being designed in the Research Section reproduction will be effected by means of transmitted light by using two glass plates carrying the sound tracks in the form of concentric rings. One plate will carry the tracks corresponding to the minutes and the other the tracks for hours, seconds, and the preliminary phrase which will precede each announcement. The apparatus is being designed to use only one amplifier and to eliminate all switching (except, of course, in the distributing circuits to subscribers) in speech circuits. This will be effected by means of mechanically-operated shutters which allow of the illumination of only one photocell at a time. These features, in conjunction with the employment of transmitted light for reproduction, are expected to result in better articulation and a considerable reduction in background noise.

It is proposed to drive the mechanism from batteries and synchronize by means of signals from Greenwich Observatory. In the event of any failure of this portion of the clock, stand-by drive and synchronization will be effected by means of the time-controlled A.C. Mains.

Notes and Comments

Journal Changes

JUDGING by the verbal and written appreciations of the changes made in the format of the Journal which were introduced in the April issue, the alterations have won the approval of our readers. With this issue, a bolder type is used in the list of Contents printed on the front cover and doubtless other minor changes will be made from time to time. The changes have made it possible to include a still greater amount of material in a given number of pages, and now, more than ever, the Journal represents excellent value for its purchase price.

Death of Sir George Sutton

It was with regret that we heard of the death of Sir George Sutton on April 30th, at his residence, Park House, Walmer, Kent. Sir George began his career with Messrs. W. T. Henley's Telegraph Works Company, Ltd., in March, 1881, when—a young man of twenty-four years of age—he was appointed Secretary to the Company. At that time, Henley's was a small struggling concern, but almost from the time of Mr. Sutton's appointment the Company began to progress. Mr. Sutton negotiated all the earlier contracts for submarine cables which the Company secured and which helped to put it on a sound financial basis. He was appointed Manager of the Company in 1886 and in 1893 he joined the Board and became Managing Director. He was appointed Chairman of the Company in 1918, retaining also his position of Managing Director, which latter position he voluntarily relinquished in 1927. When he also voluntarily retired from the position of Chairman on April 1st, 1932, he became President of the Company by the unanimous wish of his fellow directors.

Sir George received his baronetcy in the King's Birthday Honours in 1922, and the staffs of W. T. Henley's Telegraph Works Co., Ltd., and Henley's Tyre and Rubber Co., Ltd., to mark their appreciation of him and of the honour conferred upon him, presented him with an illuminated address to which contributions were made by every member of the staffs, commercial and technical, including the shop staffs at the works and the staff at the branches.

Sir George was one of the founders of the Cable Makers Association which was formed in January, 1900, and he was very greatly interested in the work of the Royal Society of Arts of which Association he was a vice-president.

The Institution of Post Office Electrical Engineers

Institution Library Facilities

T. C. GOODWAY, *Librarian.*

A new catalogue of the Institution Library will be issued shortly and, as it is felt that the full extent of the library service is probably not generally realized, the opportunity is taken to bring to notice the nature of the facilities offered. As a result of affiliation with other libraries, a very wide range of technical and scientific literature, including works on economics and allied subjects is now accessible to members and some particulars are given in the following notes.

MESSRS. H. K. LEWIS & CO., LTD., MEDICAL AND SCIENTIFIC LIBRARY.

An arrangement has been made which enables members to borrow books from the extensive library of Messrs. H. K. Lewis & Co., Ltd., through the Librarian of the Institution. This brings within the reach of members practically all technical and scientific works of any importance (English, American and translated foreign publications). It is important to note that new books and later editions of books are added immediately on publication to Lewis's Library, a catalogue of which is available on loan to members. Lewis's Library is so comprehensive, however, that a member requiring a particular scientific or technical book not included in the Institution Library is invited to requisition the required volume (using an ordinary library requisition form) from the Librarian without reference to Lewis's catalogue.

THE MANAGEMENT LIBRARY.

A similar arrangement exists which enables members to borrow books from "The Management Library" which contains an exhaustive collection of literature relating chiefly to management and organization, general economics, cost accounting, cost control, and industrial psychology. A more complete list of the main subjects covered by this library is given in the new library catalogue. The Management Library catalogue, which is also available on loan to members, is a very interesting and useful publication in that it includes a subject index containing short descriptions of the library's books published during 1932 and 1933. Reviews of books added to the library subsequently are given in monthly addenda.

NEW CATALOGUE OF THE INSTITUTION LIBRARY.

A copy of the new catalogue will be issued to each member and two copies to each of the **Junior** Section

Centres. The lay-out of the catalogue has been completely revised with the object of facilitating reference and the books are now listed under subject headings. Books considered to be particularly suitable for students have been marked with an asterisk. Another important feature of the new catalogue is that space will be available under each subject heading for the insertion of particulars of books added to the library from time to time. To assist members to keep their catalogues up to date, a quarterly circular will be issued giving details of additions to the library.

For the information of Junior Section members, who will not receive personal copies of the catalogue, a brief summary of the contents of the library will probably prove helpful. The Institution Library contains an extensive collection of books on chemistry, civil, electrical and mechanical engineering, mathematics, physics (including magnetism and electricity), radio, telegraphy, telephony, and various other technological and scientific subjects, together with books on economics, finance, psychology, statistics, etc., and copies of examination papers for the City and Guilds of London Institute, Probationary Assistant Engineers and Probationary Inspectors examinations and University of London intermediate examination in engineering and B.Sc. examination. Printed Papers of the Institution, Essay Competition Prize Essays, Prize Papers read by members of the Junior Section, bound volumes of the Post Office Electrical Engineers' Journal, and copies of the Journal of the Institution of Electrical Engineers are also available on loan to members.

Copies of the catalogue (price 6d.) may be purchased from The Librarian, I.P.O.E.E., Engineering Department, Alder House, Aldersgate Street, London, E.C.1.

The following papers have recently been added to the Library :—

1. *Labour Costs, by H. W. Powell.*

A paper dealing with observations made on works in Post Office Engineering Sections, with special reference to costs and the extent to which they are affected by the use of transport and special tools, and the employment of Installation Groups.

2. *Rural Automatic Exchanges—Site Selection and Building Erection, by H. Shaw.*

A paper dealing with the various stages of the procedure for providing an R.A.X. Preliminary procedure. Vital considerations in site selection. Negotiations for purchase of site—land values, restrictions and conditions attached to ownership. Building tenders—site plan. Standard building specification—type of building, structure, materials, elevation, special features. Supervision of building erection—matters calling for special attention.

ESSAY COMPETITION, 1933-34.

The Judges have reported to the Council that the Prize Winners in the recent Essay Competition, arranged in order of merit, are as follows :—

H. M. Yells, Circuit Laboratory.
"Remote Control for Power Stations using Automatic Telephone Apparatus."

G. S. Edwards, Oxford.
"P.B.X. Final Selectors A.T.M. Types."

J. L. Tough, Wigan.
"Primary and Secondary Cells."

J. H. Sundewall, Repeater Station, Fenny Stratford.
"Internal Combustion Engines."

W. S. Whitehead, Preston.
"Suggested aids to maintenance in Automatic Exchanges."

The Council has decided to award Certificates of Merit to the following four competitors who were next in order of merit :—

W. E. C. Roberts, Plymouth.
"Cable Balancing."

F. L. Randall, Southport.
"Progress in Loud Speaker Design."

F. Brock, Manchester.
"Copper—From Ore to Wire."

W. G. Morris, Preston.
"The Discovery, Theory, and Development of Radio Communication."

The Judges reported that the general standard of the essays was good.

LIST OF PRIZE ESSAYS HELD IN THE LIBRARY.

1927-28.

E27 The design of an Automatic Telephone System.—H. A. Longley.
E28 Ventilation and Humidity.— C. A. Maggs.
E29 Efficiency methods in relation to emergency.—S. H. Johnson.
E30 The Alternating Current Bridge.—F. W. G. Dye.
E31 The Cadmium Electrode.—H. W. Satterthwaite.
E32 Coder Call Equipment in practice.—A. J. Allison.
E33 Automatic Dials and relevant details of auto exchange apparatus.—R. N. Renton.
E34 Training of Youths.—N. V. Knight.
E35 Evolution of the Thermionic Valve and its application to Modern Telephony.—F. V. Padgham.
E36 Development Studies.—E. S. Davies.

1928-29.

E37 Modern Theories of electricity and magnetism.—G. Franklin.
E38 Telephone Transmission Measurement on repeater circuits.—F. E. Wright.
E39 Maintenance of subscribers' apparatus in automatic areas.—C. H. Hartwell.
E40 Radio methods of telegraphy and telephony.—N. V. Knight.
E41 General analysis of Faults in a Director Automatic Exchange.—W. H. Owens.
E42 Photo-copying and the Post Office Engineering Department.—R. E. Gray.
E43 The preparation of Development Schemes.—S. B. Iles.
E44 Landing the Shore End of a Submarine Cable.—W. E. Everson.
E45 The Study of the Oak.—H. Chapman.

1929-30.

E46 Photo-telegraphy.—W. A. Strip.
E47 The Thermionic Valve as a Speech Frequency Amplifier. —W. H. B. Cooper.
E48 The Thermionic Valve.—R. G. S. Tuddenham.
E49 The Nature of Electricity.—A. F. Street.
E50 The Siemens No. 16 Key Sending Position.—H. W. Jarvis.
E51 The Physics of the Thermionic Valve.—W. H. Maddison.
E52 Inter-connection of Automatic and Manual Exchanges.—R. N. Renton.
E53 Notes on Exchange Construction by Contractors.—T. A. Marks.

1930-31.

E54 Modern Aspects of Electricity and Magnetism.—L. F. J. Brunel.
E55 An Introduction to the Electronic Theory and the Conduction of Electricity in Matter.—J. C. Alexander.
E56 The Piezo-electric Crystal.—G. E. Clarke.
E57 Sound and Hearing.—W. E. T. Andrews.
E58 The Faultsman and the Subscriber.—H. Miles.
E59 Insulation in Automatic Areas.—A. A. Hard.
E60 The Development of A.C. Apparatus in Telegraphy and Telephony.—R. N. Renton.
E61 Radio Frequency Waves in Space.—C. G. Wardrop.
E62 The Electron.—W. H. Maddison.

Charles Whillis, M.I.E.E.

By the retirement on the 30th April of Mr. Charles Whillis, M.I.E.E., Superintending Engineer, Scotland West District, the Department loses yet another of the rapidly diminishing number of Officers who have by personal acquaintance with most phases of the Post Office Engineering work, acquired that all round practical experience which is the envy of the present day specialists. Mr. Whillis entered the Department in 1889 and leaves with 45 years' service to his credit. During this period he has climbed the promotion ladder, step by step, from Telegraphist to Superintending Engineer. His early years were spent at Newcastle as Telegraphist, Junior Clerk and Sub. Engineer, respectively. He came to London as 2nd Class Engineer and was there seven years, part of which time was spent in the Headquarters Telephone Section. He then returned to his old district as Executive Engineer, first at Carlisle, and then at Newcastle. He became Assistant Staff Engineer in 1926, and was attached to the Headquarters Construction Section for two years and to the Lines Section for a further two years before advancement to Superintending Engineer's rank at Glasgow. During his latter years at Headquarters, Mr. Whillis served on the Comprehensive Railway Agreement Committee and on the Engineer-in-Chief's Office Staff Re-organization Committee.

His four years control of Scotland West District has resulted in marked technical developments and improvements in organization, including conversion of the telegraph Instrument Room at Glasgow H.P.O. to Teleprinter working with rack-mounted equipment, the provision of up-to-date Repeater Room, Phonogram Room, Pneumatic Tube and Band Conveyor Equipment. The conversion work was personally directed by Mr. Whillis and the general recognition of the Glasgow Telegraph Instrument Room as the most up-to-date in the country, reflects great credit to his activities. The reconstruction of the Trunk Exchange to provide for the modern "on demand" service also received a good deal of Mr. Whillis's personal interest and direction.

In other fields of activity he has left his mark. The setting up of a district development staff probably saved the district from a "breakdown" due to lack of spare line plant for new subscribers demands. The new development organization has now completed schemes covering the whole of the Glasgow auto. zone, and its output has avoided the necessity for discharging a single man throughout the district on account of shortage of work.

Mr. Whillis's retirement was the occasion of a presentation to him at the Royal Technical College of a radio gramophone in the presence of a large number of the staff and local press representatives. In making the presentation Mr. Harvey Smith, Assistant Superintending Engineer, detailed Mr. Whillis's career and the developments in the district which had engaged his attention.

Other speakers expressed the general esteem in which Mr. Whillis has been held in the district and the regret of the staff that his useful work in the district has drawn to a close.

Those who only knew Mr. Whillis in his Official capacity may not be aware that he is an expert swimmer and trick diver and that he possesses considerably more than the layman's knowledge of medical and surgical work, in fact, to use his own words, "Had I not been a Post Office Engineer I could have had no better desire than to have been a surgeon."

H.S.

Mr. T. T. Partridge, M.I.E.E.

Mr. T. T. Partridge, who has been in charge of the Northern Ireland District during the past eighteen months, has been promoted to the grade of Superintending Engineer at Belfast. The Partridge family holds the unique record of having supplied two members to the grade of Superintending Engineer. Mr. Partridge's father, Mr. George Noble Partridge, was well-known as Superintending Engineer of the South Wales District. In addition, Mr. Partridge's brother, Mr. George Partridge, reached the rank of Executive Engineer. Mr. Partridge has had a wide experience of all classes of Post Office Engineering work. Mr. T. T. Partridge was in charge of the Carmarthen Section in the South Wales District from 1904 to 1908 when he was transferred to the Survey Section of the Engineer-in-Chief's Office to take part in the inventory and valuation of the National Telephone Company's external plant prior to the transfer of the undertaking to the State. Mr. Partridge was engaged on this and other Headquarter's duties on Mr. A. L. DeLattre's staff until 1914, when he was transferred to Nottingham as Executive Engineer. He served under Mr. Gomersall in the North Midland District in charge

of the Technical Section of the Superintending Engineer's Office and also as Sectional Engineer in charge of the Nottingham Section. During his period of service in the North Midland District Mr. Partridge was intimately associated with the introduction of automatic telephone working at Sheffield, Nottingham and Coventry.

In 1930 he was promoted to the rank of Assistant Superintending Engineer, South Lancashire District, and was specially engaged, apart from other duties, on the Manchester, Stockport and St. Helen's change-overs to automatic telephone working, which included the opening of more than 20 new exchanges.

In November, 1933, Mr. Partridge was transferred to Belfast as Assistant Superintending Engineer in charge of the Northern Ireland District. He has been actively engaged since that date in connexion with the change-over of the old Belfast Central Magneto system to automatic working and the opening of 10 automatic telephone exchanges. This work, together with an extensive system of underground cable distribution in Northern Ireland is now in hand and the whole series of transfers are expected to be completed by September, 1935.

These brief references to Mr. Partridge's official activities indicate that he has always been " in the thick of the fight " and it seems natural to one of his energetic temperament that his programme of work is likely to be completely filled up to the close of his official career. Mr. Partridge is endowed with abundant energy and vitality. It is of interest to note that, as a relaxation, he greatly enjoys " driving down the fairway."

His promotion to the rank of Superintending Engineer is a fitting reward for good work done in many spheres of communication engineering.

A.O.G

Mr. H. A. Smith

Mr. Harvey Smith began his professional career in 1900 as pupil and then assistant surveyor with a firm of land surveyors and constructional engineers, and the experience then gained has since proved of much value. In 1905 he entered the National Telephone Company and was employed for some years on external construction work. Subsequently he was engaged at headquarters on survey work for development schemes and also on transmission and traffic routing studies.

After transfer to the Post Office in 1912, he was engaged for some years on similar work and took a leading part in the preparation of a comprehensive scheme for laying out the whole of London on a manual basis and afterwards on an automatic basis. This entailed a large amount of detailed investigation, as the proportions of costs for sites and buildings, line plant, apparatus, power plant, operating, etc., varied with the different possible schemes. For work of this character, Mr. Harvey Smith has peculiar aptitude and he is responsible for many of the ingenious methods which are still employed. His mind is of the analytical type and he was never happier than when faced with a heterogeneous mass of statistics which had to be reduced to a form on which a reliable judgment could be based.

He was subsequently employed on external work and prior to leaving London was the Executive Engineer of the City Section. In 1932, he went to Glasgow as Assistant Superintending Engineer of the Scotland West District, upon which he will doubtless leave his mark.

J.G.H.

Capt. N. F. Cave-Browne-Cave, B.Sc.(Eng.), M.I.E.E.

Capt. Cave graduated at Birmingham University and entered the Department's Service in 1908, taking up his first appointment in the Stafford Section. After the transfer of the late National Telephone Co's staff in 1912, Capt. Cave moved with the headquarters of the Stafford Section to Hanley where he was employed until his transfer to the Birmingham External Section in 1914. During the War, Capt. Cave had nearly four years' foreign service with the Royal Engineers (Signals); in 1924 he was transferred to the Birmingham Testing Branch where he later became Executive Engineer. The adoption of a policy of automatic working, and the developments in transmission engineering increased considerably the scope and specialized nature of the work controlled by the Testing Branch. Capt. Cave took a big part in these developments and in 1931, when he was promoted to Assistant Superintending Engineer of the Eastern District, the staff at Birmingham had grown from about 60 to over 200.

The I.P.O.E.E. has no keener supporter than Capt. Cave. In addition to contributing about a dozen papers on widely different subjects, he served on the Council of the I.P.O.E.E., on its Selection, Rules and Library Committees, and on the Committee which led to the formation of the Junior Section. During recent years, he has also been a member of several Headquarter Committees dealing with returns, motor transport efficiency, graphical statistics, and internal performance ratings.

Mr. W. H. Powell

Mr. W. H. Powell, who was recently promoted to Staff Engineer in charge of the Power Section, E.-in-C.'s Office, was educated at the Royal College of Science, London, and served his apprenticeship at the London and North Western Railway Co's Works at Wolverton.

He entered the Department's service in January, 1905, as a 2nd Class Technical Officer by open competitive examination and became Asst. Staff Engineer in July, 1911.

His experience in the Department is unique in that his entire service has been in the Power Section. This has enabled him to obtain a highly specialised knowledge of the Department's requirements as regards mechanical appliances, and in the great increase in aids during the last decade, he has been the acknowledged expert.

The friendly relations maintained by Mr. Powell with his staff and with all persons with whom he comes into contact should ensure the smooth working of the section under his control with all the other sections of the Department.

J.H.K.

District Notes

Northern District

CIVIC VISIT TO THE MODERNIZED TELEGRAPH INSTRUMENT ROOM — NEWCASTLE-ON-TYNE.

Scenes of an unusual character were witnessed in the Newcastle Instrument Room on the afternoon of Friday, the 15th December, 1933. One imagines that the feeling which dominated the older members of the staff who were present must have been one of mild wonder that representatives of the public had at last penetrated to the holy of holies of the Post Office. Indeed, with the green curtained divisions of the portions of the room, which up to the 3rd of December, 1933, had been devoted entirely to telegraph purposes, the scene assumed a somewhat pontific aspect.

The occasion was the visit of the Lord Mayor (Councillor J. Leadbitter), other civic dignitaries and representatives of industry, commerce and public utility companies to mark the bringing into use of modernized telegraph plant in the Newcastle Head Post Office. The alterations which had been carried out during the previous five months have resulted in the concentration of the entire telegraphic apparatus in the East portion of the Instrument Room, leaving spare the West half which is to be devoted to other purposes. It was in this latter portion, suitably cleared and garnished, that the ceremony was staged.

The Postmaster Surveyor (Mr. Ferguson) who with the Public Relations Officer at the G.P.O. (Sir Stephen Tallents, G.C., M.G., C.B., C.B.E.) and the Superintending Engineer (Mr. F. G. C. Baldwin, M.I.E.E.) represented the Post Office, welcomed the guests and drew attention to the developments in the Telephone, Telegraph and Postal services which were taking place in Newcastle-on-Tyne. In January, 1931, he said, the change over to automatic working of the telephone system of Newcastle-on-Tyne occurred. The modernization of the telegraph service had now been given effect to, and next year it was hoped to see the completion of the new Sorting Office.

The Superintending Engineer (Mr. F. G. C. Baldwin), after adding to the welcome on behalf of the Engineering Department, gave the visitors some interesting information regarding what had been accomplished. He mentioned the supersession of morse instruments by teleprinters, the extension of the use of conveyors in the Instrument Room itself and the use of pneumatic tubes for transmitting messages to Branch Offices in the City. He also referred to the economy in line plant effected by the voice frequency system of transmission.

Mr. Baldwin stated that a pleasing feature of the work was the fact that the whole of the apparatus was of British manufacture and that the installation of the whole of the elaborate equipment, apart from the conveyors, had been carried out by the local staff of the Post Office Engineering Department. In drawing his remarks to a close Mr. Baldwin gave a signal, on which the working of the apparatus in the Instrument Room was entirely suspended. It was a moment not without its dramatic side, during which the noise of the instruments in the adjoining room gradually subsided, fell almost to a whisper and finally ceased. When the noise had faded away, the Lord Mayor was invited to operate a switch which would again set in motion the apparatus and so cause the normal working of the Newcastle telegraph system to be resumed.

The Lord Mayor, in operating the switch, stated that this was the first occasion on which he had been asked to pass behind the counter of a Post Office and to assist in any Post Office activity.

The guests then divided into groups which, under guides, were shown around the instrument room and phonogram room. In order to show the development of telegraphic apparatus from the earliest types up to the modern, a number of museum exhibits had been obtained from Headquarters and were displayed on a table. These exhibits attracted a good deal of interested attention.

On reassembling in the reception room, the visitors were handed tea and light refreshments. The Lord Mayor then addressed the gathering and after complimenting the Post Office on the initiative and enterprise displayed in developing the Post Office services, remarked that he thought the visitors had that afternoon seen what he described as a revelation, not only to business men, but even to experts in other branches of electro mechanics. He referred to the accelerated services both as regards telegraphs and telephones and mentioned that he had sent a long telegram to the Postmaster-General on commencing the tour of the Instrument Room that afternoon and had received a reply before finishing the circuit of the room. He concluded by expressing his pleasure as the Lord Mayor of the city upon the fact that Newcastle is again in the forefront of progress in telegraph matters.

Sir Arthur Munro Sutherland, Bart., K.B.E., D.L., J.P., President of the Newcastle and Gateshead Incorporated Chamber of Commerce, also added his congratulations to the local officials on keeping Newcastle ahead regarding telegraph facilities. He said that on asking the Commercial Exchange for matters to mention at that meeting he had expected to hear a number of grumbles, but that apart from a few minor matters he had received no matters of complaint. He said he was delighted to see Sir Stephen Tallents there and to know that the Postmaster-General had appointed someone to whom business men could make approach on postal affairs.

Sir Stephen Tallents expressed the thanks of the Postmaster-General to the Lord Mayor, Sir Arthur Sutherland, and the many other distinguished citizens of Newcastle who had honoured that afternoon's ceremony with their presence. He said the Post Office cordially welcomed opportunities such as this for taking representatives of the public whom it served, behind the scenes of its activities, and thought the fact that the familiar initials G.P.O. were the badge of the greatest and most varied single group of business undertakings in the country was not fully appreciated. He emphasized the importance of Newcastle as a telegraphic centre and added that one of the factors which had made the Post Office eager to complete the installation which they had just seen in operation was that this District had borne rather more than its fair share of hard times. In thanking the Lord Mayor and the rest of the Company for their presence he expressed the earnest hope that

Newcastle and Tyneside might enjoy a full share in the return to national prosperity of which signs were now appearing.

Telegram from the Lord Mayor of Newcastle-on-Tyne to the Postmaster-General.

To H.M. Postmaster-General,
G.P.O., London.

I have very pleasant recollections of your visit to our City a few months ago when you told us of your endeavours to make the services under your control as efficient as possible.

The extension we are witnessing to-day is an indication that you and your staffs are working energetically and harmoniously in that direction. The ramifications of your department are extending and your methods are much more in keeping with modern enterprise.

Early this month I was impressed by learning from the lips of one of our most honoured titled ladies that in a time of anxiety she was enabled, in the space of half an hour, to be put into direct telephonic communication with a hospital in India, and to hear, with distinctness, a reassuring message from the Medical Superintendent regarding the condition of her son.

I must also compliment you upon the more attractive and cleaner appearance of the branch offices, and upon the publicity methods you are employing to extend, in particular, the use of the telephone as a means of communication.

The people of the North will be glad if your 1933 margin of profit proves to be substantial, and will hope that it may help the Chancellor of the Exchequer to give some relief to the much-worried taxpayer.

JOHN LEADBITTER,
Lord Mayor of Newcastle-on-Tyne.

Telegram from the Postmaster-General to the Lord Mayor of Newcastle-on-Tyne.

Lord Mayor, Post Office, Newcastle-on-Tyne.

I am much obliged to you for your telegram which recalls very happy memories of my visit to your City. Please accept my sincere thanks for honouring us by opening the remodelled Telegraph Department at Newcastle-on-Tyne. Your presence is a happy symbol of the all-important spirit of co-operation between the Post Office and the Public which it exists to serve and your appreciative remarks are very encouraging to all of us in the Post Office. I am confident that the rearrangement of the Telegraph Department at Newcastle-on-Tyne will make for even greater efficiency and so assist your City in its progress along the road to renewed prosperity.

KINGSLEY WOOD,
Postmaster-General.

South Western District

TELEPHONE "SHOP" IN BRISTOL.

A great deal of local interest in telephone matters was aroused during the period between 6th November and 25th November last by "The Telephone Shop" which was established at the Tramways Centre, Bristol.

Many Civic and Post Office officials were present at the opening. Col. Dainton, the Postmaster Surveyor, who presided, started the proceedings. He was followed by the Superintending Engineer, P. T. Wood, Esq., who gave a brief description of the developments that had taken place in the Bristol Area in automatic switching and underground cable extensions and referred to the highly efficient trunk lines and radio links of modern times. The Lord Mayor, T. A. Wise, Esq., then formally opened the "Shop" and wished it every success. A vote of thanks was proposed by A. J. Bristow, Esq., the District Manager, and seconded by A. G. Highet, Esq., the Asst. Controller of Sales and Publicity.

The lighting, fittings and furniture were carried out in modern style. The first of these was provided by the local engineering department, and included luminous tube lighting, flashing arrangements and coloured neon-tubes shaped in the form of a pedestal-type telephone. The shop window contained, beyond the advertising matter, an exhibit of telephones of many types including valuable specimens from the Engineer-in-Chief's museum and also the "Millionth" telephone. A working two-motion switch and working teleprinter No. 7A also proved attractive in the window. Inside the shop the following working apparatus was provided :—an automatic demonstration set, a two-motion switch which could be operated and released by the public, another teleprinter 7A, a P.B.X. floor pattern switchboard having a glass back-panel and internal illumination, a complete kiosk with prepayment coin-box specially arranged for free local calls by the provision of a return-coin-shute in lieu of the coin box, and a series of Plan Number extension installations—each one being carried out with "Handy" instruments of a different colour. There were also miscellanous exhibits including all types and coloured types of subscribers' instruments.

Members of the Engineering Operating and Sales Staff were in attendance and contributed largely to the success of the enterprise. There will be no doubt of the success when it is stated that, during the three weeks, 10,735 visitors were "entertained," while 69 exchange lines and 33 extensions (representing an annual rental of just over £470) together with orders for 53 "Handy" instruments (that is—a revenue of £55) were obtained.

CHELSTON AUTO EXCHANGE.

This new exchange, serving a residential portion of Torquay between Torre and Preston, was brought into service on the 3rd January with 248 working lines. The equipment installed by the A.E. Co. has an initial capacity of 400 lines and consists of 200 point Line Finder Discriminating Satellite Type Apparatus with key routining facilities. The opportunity has been taken to centralize the whole of the Torquay External maintenance and construction staff, Transport, Section Stock and Pole Stack on the one site in premises built by the Office of Works to conform with the residential nature of the district.

CHURSTON-DARTMOUTH-COMPASS COVE CABLE.

The extension of the Torquay-Paignton-Churston cable to Dartmouth and Compass Cove—a route distance of just over seven miles—has been completed, and was brought into use early in May. Armoured type cable was employed, except where duct space was available in Churston and Dartmouth. The river Dart was crossed by means of a P.C. lead-covered submarine section, nearly 500 yards long, the cable being laid alongside the two earlier Dart cables near the Dartmouth-Sandquay Chain Ferry. The cable is of 2 pr/20 lb. screened + 34 pr/40 lb. quad type between Churston and Dartmouth and reduces to a 2 pr/20 lb. screened + 10 pr/40 lb. quad between Dartmouth and Compass Cove. The screened pairs are loaded throughout with 120 mH Grade I coils at a nominal spacing of 1.136 miles, and will carry the TSX-Guernsey trunk with TS-Jersey as sub-audio. Twenty-four pairs are loaded between Churston and Dartmouth with Grade 2 coils of similar inductance, whilst the remainder have been left unloaded for telegraph purposes and will carry the TS-Jersey and the TS-Guernsey circuits. The completion of this cable enables a wholly underground route between London and Compass Cove to be used for telegraph and telephone services to the Channel Islands.

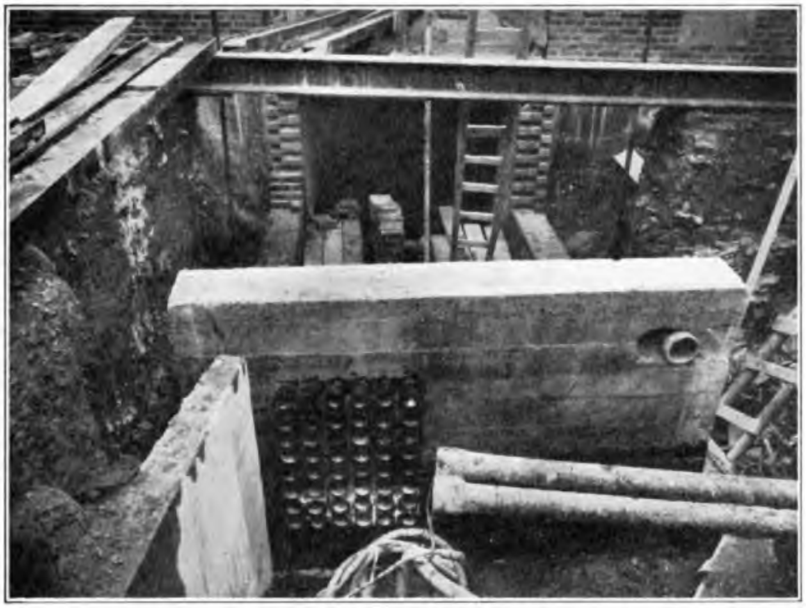

FIG. 1.—VIEW LOOKING TOWARDS THE EXCHANGE PRIOR TO CONSTRUCTION OF GREASE CHAMBER.

PLYMOUTH NEW AUTO EXCHANGE.

Special precautions to prevent ingress of water to cable chamber.

It became apparent during the early stages in the construction of the fine new exchange building in Ebrington Street, Plymouth, that some special means would be necessary to ensure that water did not enter the cable chamber and basement of the building *via* the leading in ducts. The arrangements adopted are unique as far as this District is concerned and may be of general interest.

A nest of 48 octagonal ducts was laid into the exchange site several years ago, and terminated temporarily in a small box. When excavation and pumping were commenced, it was found that there was a very considerable flow of water from these ducts into the site, estimated initially at about 300 gallons per hour. Owing possibly to the continued dry weather, the flow has now dropped considerably, but may increase at any time from seasonal variations or other cause. The water presumably entered the ducts from a spring somewhere between the temporary chamber and the street manhole, and after full consideration of the position it was decided that the most economical and practicable method of overcoming the difficulty would be to construct a grease chamber and a water chamber, with a drain, external to the end of the cable chamber. The general arrangement is shown in the photographs, Figs. 1, 2, and 3, which are almost self explanatory.

There is a drain in the floor of the water chamber, with an anti-flood ball valve arrangement, connected to a sewer some 60 yards distant, and a separate small grease chamber is constructed which will be filled with hot petroleum jelly which will completely enclose the cables. If, therefore, the drain is insufficient to carry off the inflowing water, the latter will be effectively prevented from entering the cable chamber by the grease barrier, which will of course be supplemented by the normal plugging of the ducts in the cable chamber.

FIG. 2.—VIEW OF GREASE AND WATER CHAMBERS.

RADIO LINKS IN TRUNK CIRCUITS.

Consequent on the successful operation of the Weston-Super-Mare-Cardiff radio link (described in the January, 1933, issue of the *P.O.E.E. Journal*) as part of a normal trunk circuit for the past twelve months, further experimental plant is being installed at Backwell near Flax Bourton which, in conjunction with similar equipment on the Cardiff side of the Severn, will ultimately provide six ultra-short-wave radio links.

The work of erection of the necessary buildings, the lighting and power arrangements, and provision of the antennæ has been undertaken by the staff of this District and in spite of the difficulties caused by the absence of water and the bleak nature of the site, which is on a rocky hillside forming a spur of the Mendips, the work is now sufficiently advanced to permit of the installation of the equipment which is being manufactured by the Department.

Antennæ arrays are being provided for this installation which will show a gain over the simple horizontal dipole used on the original installation.

Considerable interest in the use of radio as part of the normal inland trunk network has been evinced by the public and on the 12th May a conversation between the Lord Mayors of Cardiff and Bristol conducted over the trunk of which the radio link forms part was broadcast by the West Regional Station of the B.B.C. This conversation was preceded by an introductory talk by the Superintending Engineer, Mr. P. T. Wood.

FIG. 3.—SIDE VIEW OF GREASE AND WATER CHAMBERS.

South Lancs.

INAUGURATION OF DEMAND WORKING AT MANCHESTER.

The Postmaster-General, Sir Kingsley Wood, on Tuesday, 6th February, formally opened the new Trunk Exchange in the presence of some 200 guests representative of the commercial and civic activities of Manchester and District.

Prior to the actual opening ceremony, the Postmaster-General in a speech referred to the many new features and improvements incorporated in the new Exchange. He also spoke to and received replies from several of the Manchester M.P's in the House of Commons over special circuits. These conversations were made audible to the assembled audience by means of a public address system which had been installed by the Engineer-in-Chief's office (Radio Section). After the opening ceremony the Postmaster-General and the guests made a tour of the new Switch Room.

Manchester was the last of the zone centres to be converted to Demand Working and was unique in so far as it was the only centre at which the Trunk Exchange was transferred to another building simultaneously with the introduction of the Demand service. The transfer from the Head Post Office, Manchester, to Telephone House, Salford, was successfully effected at 1.30 p.m. on Saturday, 3rd February, 1934. The Trunk switchboard comprises 99 positions, of which 27 are Incoming and the remainder Demand and Delay positions. The Main Frame, which serves all the exchange units in the building, that is, Blackfriars, Deansgate, Toll and Trunk is accommodated on the ground floor. The lamp racks and V.I.I. apparatus are placed on the 6th floor, with a view to keeping the leads as short as possible as, owing to the V.I.I. lamps being worked from 6 volts A.C. supply, the voltage drop, due to the leads, must of necessity be kept low.

The ticket tube system is worked from a 20 h.p. centrifugal blower which has been provided in the basement. Two main air ducts 12″ in diameter have been erected between the basement and the 7th floor, an overall length of 163 feet. Some difficulty was experienced with these tubes during the testing out period, but this was satisfactorily overcome by means of adjustments to the valve heads.

The new equipment being installed in a separate building probably rendered the conditions under which the installation of the new boards was carried out somewhat easier, but it also served to complicate the transfer scheme since extensive rearrangements of external cables became necessary. The Repeater Station, although due to be transferred from the Head Post Office to Telephone House in the near future, was retained in its present position at the time of the transfer. This involved the extension of all terminating trunks on repeater circuits from the Head Post Office to Telephone House. It was found possible, in order to facilitate the transfer, to duplicate certain of the short trunk and junction circuits and this was done so that the pre-transfer testing could be undertaken without dislocation of traffic. In several cases the method of working the groups of long distance trunks had to be changed simultaneously with the introduction of Demand Working and this led to considerable complication at the distant ends. The testing of the local junctions and demand circuits (TRU lines) was rendered more easy by the duplication of the circuits already mentioned. As a subscriber dialled TRU for a trunk call under Delay conditions and would continue to do so under Demand conditions a special testing code of AUT was used for the Automatic Exchanges, thus precluding any possibility of a subscriber obtaining access to the new switchboard during the pre-transfer period. To enable the testing to be carried out from a central point, a number of telephones equal to the number of TRU lines from each exchange was provided, except in the case of Blackfriars, where 48 TRU lines were concerned, and a proportion of these were busied out by the Engineering Staff as required.

The decision to install the trunk switchboards in the same room as the Toll Exchange was not reached until the end of May, 1933, and the whole of the equipment was installed by the Contractor and tested out by the Engineering Department between that date and the 6th January, when it was handed over to the Traffic Staff.

Northern Ireland

THE POSTMASTER-GENERAL'S VISIT TO BELFAST.

Here in Northern Ireland, cut off from the Mother Country by the Channel, we are inclined to feel isolated and somewhat of an outpost of the Empire, and for this reason the honour of a visit by the Postmaster-General on 18th January last was doubly appreciated.

Sir Kingsley travelled by the Stranraer route and was met at Larne by our Superintending Engineer, Mr. Partridge, and Mr. Ardern, Postmaster Surveyor. A representative of the Prime Minister of Ulster and other distinguished people welcomed the visitor at the Belfast Terminus.

The Postmaster-General occupied the morning in visiting the more important Post Office buildings in Belfast, accompanied by Mr. Partridge, Mr. Ardern, and Mr. Maskrey, the District Manager. At the H.P.O. Sir Kingsley was specially interested in the Belfast telegraph instrument room which has lately been reorganized on the most up to date lines; teleprinter working being almost universally employed. Here some time was spent, the various apparatus being described by Mr. Partridge, Mr. Jacquest the Sectional Engineer, and Mr. Gillespie the Telegraph Superintendent. The stamping machines and conveyors also claimed the Postmaster-General's attention.

At the existing Central Telephone Exchange at Queen Street, Sir Kingsley spent some time in the Belfast Repeater Room inspecting the various trunk repeaters, carrier wave apparatus and voice frequency plant, the details of which were explained by Mr. Partridge. The party then toured through the Trunk Switchroom, the three separate units which make up the Belfast Central Exchange switchboard, and finally through the main battery and power rooms.

Sir Kingsley was then conducted to the new building at May Street which will accommodate the new automatic Central Exchange. Although this fine edifice will not be completed for some months, it was sufficiently advanced externally to be worth seeing, and with its six stories towering above adjacent buildings forms an impressive landmark. Sir Kingsley viewed the building with enthusiasm and displayed much interest in plans of the lay-out of the different floors.

During a broadcast speech delivered at 6.30 the same evening, the Postmaster-General made a special reference to the work which was being carried out by the Engineering Department under Mr. Partridge in connexion with the new automatic telephone system to be introduced in 1935.

It is difficult to estimate the value of the benefit, both concrete and psychological, resulting from this personal touch. Practically every member of the staff met with during the tour was greeted with a word of cheerful encouragement.

Also it is no exaggeration to say that the Postmaster-General's broadcast address and the speeches at various social functions which were ventilated in the press, have done much to further that "better understanding" with the Irish public we serve.

We hope we shall see Sir Kingsley again in Belfast.

THE INTRODUCTION OF CARRIER WAVE WORKING ON THE BALLYHORNAN-BLACKPOOL CABLE.

One of the telephonic links between Northern Ireland and the Mother Country consists of the submarine cable which connects Ballyhornan with Blackpool, being routed *via* Port Erin (I.O.M.) where repeater apparatus is provided. There are two cables each made up of four cores. The circuits were set up in 1929; and before the introduction of carrier wave working the arrangement was as shown in Fig. 1. It will be seen that there were two Belfast-London circuits; two Belfast-Liverpool; two single phantom circuits (one to Manchester and one to Liverpool); two double earth phantom circuits (one to Douglas, I.O.M.) and one speaker circuit between Port Erin and Belfast). All of these circuits operated on a two-wire basis, and in the case of the Belfast-London circuits it was not possible to obtain a better transmission standard than five decibel loss without approaching critical repeatering conditions. With the introduction of Trunk Demand working in the country, Zone to Zone requirements called for zero circuits, and to obtain this with the Belfast-London circuits it was necessary to resort to four-wire conditions. As the cables were being worked to their utmost capacity Carrier Wave working was introduced in order not to reduce the number of channels. Fig. 2 shows the present arrangement.

The carrier frequency used on the London circuits is 5780 p.p.s. and filters are fitted on the physical circuits to prevent any interference between the two channels. The technical details of carrier wave working have already been described in an article in this Journal.[1]

The additional apparatus required at the Cable Hut at Ballyhornan included two sets of 132 volt 24 Ah anode batteries and two 22 volt 200 Ah filament batteries. Separate petrol engine charging plant was provided for each type of battery.

The modulator and demodulator arrangements require nine valves. Certain of these valves are used for rectifying purposes, but, it is understood, these will be replaced in due course by metal rectifiers.

[1] "A Simplified Carrier Telephone System for Open Lines." R. J. Halsey, B.Sc., A.C.G.I., D.I.C. *P.O.E.E. Journal*, Vol. 26, page 90.

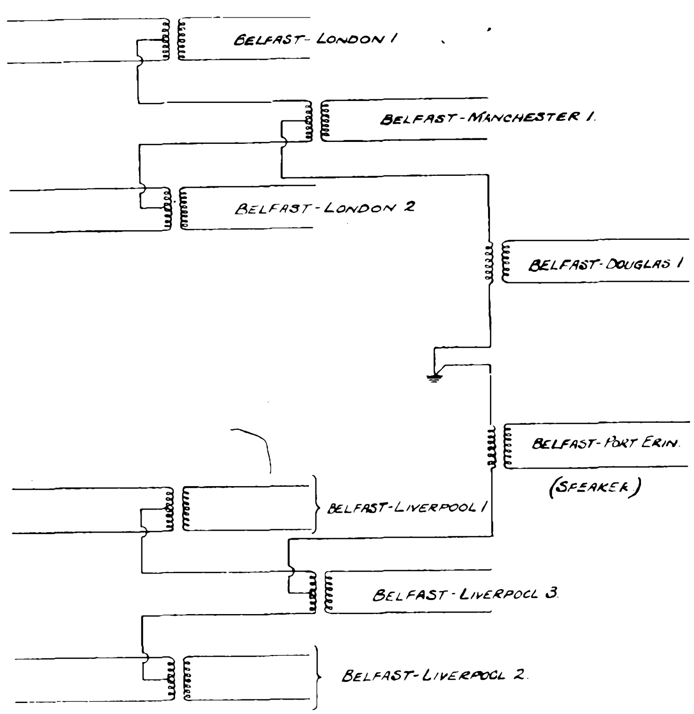

FIG. 1.—ARRANGEMENT BEFORE THE INTRODUCTION OF CARRIER WAVE WORKING.

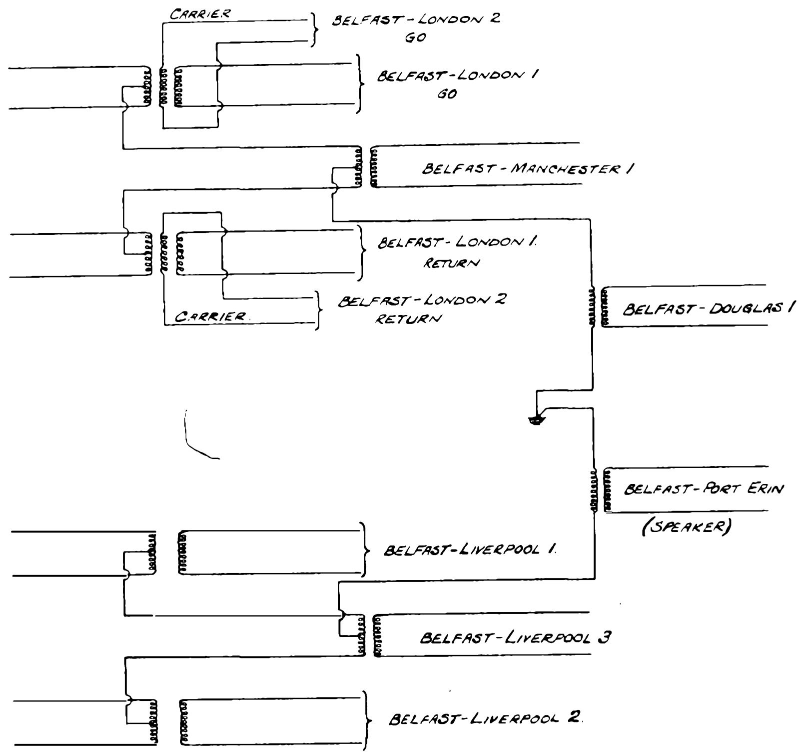

FIG. 2.—ARRANGEMENT AFTER THE INTRODUCTION OF CARRIER WAVE WORKING.

South Midland District

RETIREMENT OF MAJOR E. CLIFFORD HARRIS, A.M.I.E.E.

Major Harris entered the Post Office Service as Telegraph Learner at Dover 1/1/1890, almost simultaneously with the absorption of the Submarine Telegraph Company. He had an early opportunity of observing testing and kindred work and qualified for the Engineering Department to which he was promoted in 1899 with Headquarters at Cambridge. During this period he also served in the 1st V.B. East Kent Regiment and was one of the Battalion representatives in the 1897 Jubilee procession.

Further promotion followed to Sub-Engineer at Richmond in 1902, where he was engaged in the Telephone Development work of that portion of outer London.

After further short periods at Wandsworth and Brighton he was promoted second class Engineer at Guildford in 1910, and proceeded to the rank of Assistant Engineer in 1911.

On the outbreak of War in 1914 Major Harris was offered a commission in the Royal Engineers, and after assisting in training operations proceeded overseas in 1915 with No. 33 Air Line Section. He became an area officer and co-ordinated the forward cable and exchange operations on Kemmel Hill for the Battle of Messines. He was later transferred to the Air Force Signals Special Force in the Vosge, and finally commanded No. 2 Telegraph Construction Company.

Upon demobilization in June, 1919, Major Harris returned to Guildford. In March, 1926, he took over the Oxford Section and was promoted Executive Engineer later in the year. In the meantime the transfer of Oxford City from Magneto to Automatic was in hand and was successfully carried out under a time limit to clear the old premises by December.

North Midland District

NEW AUTOMATIC TELEPHONE EXCHANGE, PETERBOROUGH.

The opening of the new Automatic Telephone Exchange at Peterborough took place on April 28th. The automatic equipment, which is of the standard step by step type, was provided and installed by Messrs. Ericsson Telephones Ltd., Beeston. The exchange is designed for an ultimate equipment of 2,800 subscribers' lines. The equipment at present installed is for 1,300 lines, of which 960 are already connected.

A Civil Ceremony was arranged in connexion with the public opening on May 3rd when Lord Burghley, M.P., declared the new exchange open, and cut the last pair of wires connecting the old exchange to the new with a pair of gold plated pliers presented in a mahogany case by the Superintending Engineer, Mr. A. Wright. Sir E. Bennett, M.P., Assistant Postmaster-General, and other distinguished guests were received by His Worship, the Mayor of Peterborough, at the new Town Hall.

Arrangements were made by the Engineering Department for parties of guests to be conducted throughout the exchange and the working of the apparatus explained to them. The ceremony was followed in the evening by a dinner attended by the Mayor of Peterborough, Mr. Jay, Post Office Surveyor, Mr. A. Wright, M.I.E.E., Superintending Engineer, Mr. Millard, Head Postmaster of Peterborough, Mr. A. Broomhead, M.I.E.E., Sectional Engineer, and other prominent officials of the Post Office.

Junior Section Notes

London Centre

Another year is past and we are able to review it and deliver our judgment—Very good. Another year in which the programme, as set out below, certainly maintained the high standard previously attained.

- H. M. Yells—" Some Commercial Applications of Automatic Switching Plant."
- J. E. Martin—" Replacement Depots."
- G. T. Wright—" The Bypath System."
- R. W. Palmer—" Service Aspects of Automatic Telephony."
- R. W. Alford—" Subscribers' Group Service."
- E. H. Bolus—" Siemen's Number 17 System."
- L. W. Lovegrove—" Outline of Design of Moving Coil Measuring Instruments."
- H. M. Yells—" A Power Station and its Working."
- A. H. White—" Recent Developments in External Construction."
- H. M. Yells—" Your Wireless Set and How it Works."
- C. W. Brown—" Some Notes on Recent Automatic Developments " and Annual General Meeting.

Even more popular than the meetings were the visits to Brookmans Park Wireless Station, Baldock Receiving Station, The Department's Cable Ship, and Deptford Power Station. These visits attracted numbers that proved to be embarrasing and in two instances necessitated repeat visits.

The Session closed on May 17th with the Annual General Meeting. A full meeting, where the spirit of enthusiasm and keenness which prevailed bodes well for the future of the Centre.

After the business of the evening had been dealt with, the Superintending Engineer was warmly welcomed and talked to us on the aims of the Institution, setting forth in masterly and telling manner why it is essential for all members of the staff to join the Junior Section of the Institution.

The evening was completed with a paper from the President, Mr. C. W. Brown, who outlined for us the progress of Automatic Telephone Equipment from the original Epsom Exchange, opened in 1912, to the present Syetems using Line Finder and Common Control, the adoption of A.C. for sending over Junctions, and the introduction of the Post Office 3000-type Relay. A most instructive and enjoyable paper and a thoroughly good evening was the general opinion.

Our sincere thanks are due to the Superintending Engineer, our President, and the other Engineers and members of the Senior Section, who supported the meeting.

In conclusion, may we call upon all who are not members to enrol now; we are aiming at a membership of 2000 and see no reason why we should not reach that figure.

Shrewsbury Centre

The members of the Shrewsbury Branch held the final meeting of the 1933-34 session, at Castle Foregate, on March 22nd. A paper, entitled " The Lineman and His Load," was read by Mr. D. F. Geldart, and was followed by an interesting discussion between the members, relating to faults and their associated peculiarities.

An outing to Liverpool has been suggested, and by the time these notes appear in print, the outing will doubtless have taken place, and, it is hoped, will have proved both instructive and entertaining.

Further notes relating to future plans of this Branch will appear at a later date; will members please watch this column.

Gloucester Centre

The success of the Junior Section at Gloucester has been fully maintained during the 1933/34 Session. Since our last notes, papers have been given by Mr. A. J. Hodgson on " Some Aspects of the 1933 Storm," the chair being taken by Mr. W. Day, M.I.E.E., and an interesting discussion took place. Some unique features of the restoration work were explained, one of which was the restoration of the poles and wires over the River Wye at Chepstow, and the difficulties experienced in the erection of the 300-yard span of wires due to the difficulty of access owing to the wind and the height of the cliffs were described. The method of laying the temporary cable from Milford Haven to Carmarthen was also explained.

Mr. J. C. Cox gave his paper on " The Installation and Maintenance of Satellite Exchanges." As this meeting took place at Barnwood Satellite Exchange, Mr. Cox was able to illustrate his points in a practical manner, and to explain in detail the operation of the exchange equipment.

There has been a number of applications for books from the Central Library, and it is hoped that members will take full advantage of this facility.

The last meeting of the 1933-34 Session was held at Stroud on Friday, May 11th, 1934. Before reading his paper, which was entitled " Faults I have met with," Mr. J. A. Chiswell proposed a vote of congratulation to our Sectional Engineer and Branch Chairman, Mr. W. Day, M.I.E.E., on his promotion. This proposition was carried enthusiastically. Mr. Day replied and expressed his regret at having to sever his direct association with the Junior Section, but at the same time he wished the Branch continued success. The lecturer then read his paper before a very representative and interested gathering and was accorded a hearty vote of thanks.

Altogether a very successful Session has just terminated and it is our endeavour to make our third Session even more pleasing.

The Annual General Meeting was held in Gloucester on Friday, May 25th, 1934. A very good attendance seems to indicate another successful Session ahead.

The following were elected as officers :—*Chairman,* F. W. Gill; *Vice-Chairman,* A. J. Hodgson; *Secretary,* R. A. Kibby; *Treasurer,* S. B. Foote; *Committee,* J. A. Chiswell, G. A. Rutland and A. J. T. Counsell; *Auditors,* B. Frood and J. V. Lugg.

Mr. W. Day, M.I.E.E., the Sectional Engineer and retiring Chairman, was thanked for his services to the Branch and also congratulated on his promotion to Headquarters. Hearty votes of thanks were also passed to the retiring Vice-Chairman, Secretary, and Treasuer. Mr. E. Blewitt (retiring Secretary) was also congratulated on his promotion to Inspector.

The enthusiasm among the members is very strong and the standard of the papers very high. Much help and knowledge are gained from the reading of the lectures by those who attend the meetings.

Preston Centre

A UNIQUE PERFORMANCE.

The Preston Section has gained four of the nine awards in the recent essay competition. The successful competitors (from left to right) are F. L. Randall, W. S. Whitehead, W. G. Morris and J. C. Tough.

Leicester Centre

The Leicester Centre of the I.P.O.E.E. Junior Section has just concluded a very successful Session.

The interest of the membership was retained last summer by visits to places of interest in the neighbourhood.

In May we visited the Rugby Wireless Station. We were very kindly received by the Engineer-in-Charge and spent a most instructive and interesting afternoon.

The South Leicestershire Colliery was the venue of another enjoyable outing. This is the most up-to-date colliery in the county. The Management were good enough to retain a skeleton staff to enable us to see the actual working of the coal cutting and hauling machinery. This also proved an interesting afternoon.

The following excellent programme was arranged for the 1933-34 Session :—1933, Oct. 17th, " Trunk Demand," Mr. G. J. Griffiths (Graduate I.E.E.), Nottingham. Nov. 7th, " Generation Transmission and Transformation of A.C. Power," Mr. J. W. D. Cooke, M.I.E.E., M.I.C.E., Nuneaton. Dec. 5th, " Voice Frequency," Mr. R. N. Palmer, Derby. 1934, Jan. 2nd, " Some Industrial Applications of Electricity," Mr. H. G. Andrews, M.A., London. Feb. 6th, " Heating Engineering," Mr. H. W. Sharman, Leicester. Feb. 20th (extra), " Group Subscriber System," Mr. G. J. Griffiths (Graduate I.E.E.), Nottingham. Mar. 6th, " Thermionic Repeaters Applied to Long Distance Telegraphy," Mr. D. E. H. Stafford, Leicester.

The appreciation of the lectures and visits was evidenced by the good average attendance throughout the Session. Once again we would like to express our thanks to the Lecturers, the Rugby Wireless Station Engineer and Staff, and the Management of the South Leicestershire Colliery.

Wolverhampton and District Centre

The 1933-34 Session was completed on Saturday, June 16th, when members spent an instructive and interesting afternoon visiting the Shropshire and Worcestershire Power Station at Stourport. On the conclusion of the visit, the Secretary thanked the Power Co. for their very kind and generous hospitality.

During the Session, papers have been given on a variety of subjects and visits have been made to the Birmingham Repeater Station, and Tipton Automatic (Director) Exchange. The Session has been highly successful and we are looking forward to an equally interesting Session for 1934-35. The Secretary will be pleased to receive offers of Papers from members.

Manchester Centre

The Annual General Meeting, held on April 9th, was made the occasion of a presentation by the Superintending Engineer, Mr. T. E. Herbert, of a Certificate of Merit awarded to one of the members—Mr. F. Brock—for his contribution in the Institution's Essay Competition. The Essay—" Copper—from Ore to Wire "—was commended by Mr. Herbert both for its subject matter and its literary standard.

The election of Officers for the forthcoming Session resulted as follows :—*Chairman*, J. Lawton; *Vice-Chairman*, W. Davies; *Hon. Secretary*, W. H. Fox; *Hon. Treasurer*, J. H. E. Smart; *Committee*, J. Barrass, F. Brock, G. Hodson, R. W. Hutton, R. Kibble, and F. Truman. The Session closed with a membership of 83 and a credit balance of over £10.

It has been decided to award two prizes of £1 1s. 0d. each for the best essays contributed by members during the forthcoming Session, the conditions of entry being the same as for the National Competition. The Committee will exert every endeavour to compile as interesting and educative a programme for the 1934-35 Session as the one just completed.

Aldershot Centre

An interesting evening was spent by some 20 members on June 12th, when a visit to the control room of the Aldershot Tattoo was arranged. Captain J. R. Mayne, M.I.E.E., through whom the visit was made possible, very clearly explained the uses of the various switches, the switchboard controlling the searchlight stations being of particular interest. With the idea of assisting the troops to keep correct step, an automatic flashing light is being used for the first time this year; this removes the difficulty arising from the time lag in the music of the band reaching different parts of the arena. A camera, which can be adjusted to take a succession of photographs, separated by intervals of from 5 to 20 seconds, of the whole of the arena, is also used; the photographs are inspected, and any necessary alterations made to the arrangements. This proved of great value during rehearsals.

Book Reviews

" Alternating Currents " (Second Edition), by Albert E. Clayton, D.Sc., M.I.E.E. Longmans, Green & Co. London, 1933. 334 pages. 283 Illustrations. Price 10/6.

This book is written to meet the needs of students in evening classes of Technical Schools and is intended to cover the requirements of an ordinary degree course.

In the second edition two new chapters have been added and the size is increased by about 20% to permit the scope of the book to cater for a full technological course.

The author sets out, and is to a large extent successful, to make a clear presentation of the fundamental principles involved in alternating current practice rather than in detailed descriptions of apparatus, and in order that the student may first obtain a clear mental picture of these principles, the relative chapters are prefaced with illuminating mechanical analogies.

The scope of the work is generally confined to the periodicities met with in power circuits and no attempt is made to deal with the special problems associated with speech or radio frequencies.

The first six chapters deal with the fundamental properties of circuits including Resistance, Inductance, Capacity, Power factor, Phase Displacement and Wave form. The mathematical treatment is simple, whilst derivation of vector and locus diagrams is explained in a straightforward manner. The symbolic treatment of alternating current problems is ably developed and applied to the study of elementary circuits.

Following a chapter on the magnetization of iron, two chapters are devoted to transformer theory and design and the particular requirements of currents and potential transformers are outlined.

It is here perhaps that the first criticism may be offered since with the advent of the Grid system, numerous devices are available for the constant regulation of output voltages of transformers, and a brief outline of the principles of operation would be of value. The next chapter is devoted to polyphase currents and systems, and the relative efficiency of Alternating and Direct current systems of distribution. The principles underlying the measurement of power in A.C. circuits are explained, but the subject of Alternating Current measuring instruments is not included in the scope of the book.

The following four chapters deal with alternators, rotating fields, and synchronous motors. The design and construction of alternators is covered very fully in view of the size of the book, and drawings showing modern forms of construction are included.

No attempt is made to discuss the development of the alternating current commutator motor as the author is of the opinion that the many diverse types and variations now available merit a separate volume for this subject. Two new chapters have been included on the further use of the symbolic method for solving alternating current problems, and a number of practical questions on transmission lines, transformers and Rotary converters, etc., are explained.

A generous number of examples together with a complete set of answers are included at the end of the work.

F.C.C.

" The Physics of Electron Tubes," by L. R. Koller. McGraw-Hill Book Co. 205 pp.

This book forms one of a series of works published under the heading of the International Series in Physics and in the preface the author states that it has been his aim to present the fundamental physical phenomena involved in the operation of electron tubes. The author, who is a physicist in the research laboratory of the General Electric Company of America, has tried to present the subject from the point of view of the physicist in such a fashion that it will be of interest to engineers and to students of physics who have no special training in electronics.

The subject is one on which a good deal has been published in the form of articles and papers in various languages, but such information is generally not in a form which can be readily assimilated by the class of reader for which this book is intended.

The book commences with the theory of thermionic emission and then passes to the consideration of various thermionic emitters including thorium, oxide-coated cathodes, and caesium. Secondary emission, determination of temperature, " getters," and space charge are dealt with in succeeding chapters. The remaining portion of the book is devoted to non-thermionic phenomena and includes discharges in gases, grid-controlled arcs, photo-electricity, photo-conductivity, and the photo-voltaic effect.

The author not only describes phenomena, but also shows how to compute various properties of electron tubes from given data. To this end the book is furnished with numerous useful tables and curves, while many worked out examples are given. Another useful feature is a collection of numerical problems with answers at the end of the book so that a reader can test his knowledge.

The author has been strikingly successful in the presentation of the subject and has produced a work which is easy for the non-specialist to read and understand, but which will prove to be an important addition to scientific literature and a valuable text-book and guide to all interested in the design and operation of electron tubes.

A.J.G.

" Fundamentals of Industrial Administration," by E. T. Elbourne, assisted by K. B. Elbourne and P. J. Amer. 644 pps. demy 8vo. Price 12/6 net. MacDonald and Evans, 8, John Street, London, W.C.1.

Considerable attention has been given during recent years by various authors to particular branches of industry in relation to modern conditions. There remained, however, a need for a comprehensive study of the problems associated with the administration of industrial undertakings as a whole. The author has met this requirement in a manner which should satisfy the need of all students of industrial management.

Part A deals with external factors governing industry and commerce, and contains information in sufficient detail to enable students to obtain a thorough grasp of the scope of modern industry; forms of organization; commercial law; and industrial legislation. The chapters dealing with international trade and exchange, and financial responsibility are of particular interest and include a succinct summary of banking in relation to industry. The notes dealing with combinations and organizations of the monopoly and co-operative type are of moment at the present time.

Part B deals with the conduct of the industrial undertaking and covers in some detail the practical issues of organization of production and distribution; development and research; financial statements and depreciation; industrial accounting; costing principles; control of expenditure; and office organization. There is also a general review of the principles of management including some notes on the development of administrative science. The chapters dealing with standardization, quality of workmanship and material, and industrial research in relation to production are of special interest. Manufacturers have suffered in the past by designing for performance without regard to the productive aspect. Industrial research should bring about the proper blending of these two aspects and attain the results looked for by the author.

The book is well indexed and includes as an appendix a comprehensive bibliography. Appropriate extracts are given in the text from reports of various commissions whilst statistics are given in a concise form and are a useful addition to the subject matter.

In view of the movement towards rationalization in many branches of industry, one could have wished to see this phase of the subject dealt with at greater length, while some comment on the corollary of purchase at agreed prices as distinct from " price maintenance " could have appeared with advantage. The author has covered a wide field in an admirable manner and it would have been difficult to deal with the development of particular phases without affecting the general balance of the book. The work can be thoroughly recommended as a reference book to men engaged in industrial management and to aspirants to such responsibilities.

J.I.

Post Office Engineering Department Technical Instructions " Theory of Radio Communication." Published by H.M. Stationery Office. 158 pages demy 4vo. Price 7/-.

This series of technical instructions, which consist of issues B.1000 to B.1016 of the loose leaf series bound in book form with stiff paper cover, is of a more theoretical character than the usual run of departmental literature and has been issued primarily for use as a second year course in connexion with workmen's correspondence classes.

Although not mentioned in the book a large proportion of the text was actually compiled by Mr. H. Faulkner, formerly a member of the Radio Section of the Engineer-in-Chief's Office, and from the time of opening until 1929, engineer in charge of Rugby Radio Station. Mr. Faulkner joined the section shortly after the war and was associated with most of the important radio developments carried out by the department during the succeeding years. He is particularly identified in conjunction with the late Dr. Hansford in the design of the main radio telegraph transmitter at Rugby.

The instructions form a fairly comprehensive course in radio communication starting from alternating current theory and passing on to coupled circuits, high frequency measurement, electromagnetic waves, aerial and earth systems, production of continuous waves, thermionic valves, amplification, valve oscillation, valve transmitters, radio telephony, detection, radio receivers direction finders, atmospherics and high frequency insulators.

Although consisting of only 158 pages, the subjects are adequately dealt with as the text has been made as concise as possible consistent with clarity and every page pulls its weight. There are over 170 diagrams and figures which help in giving a clear exposition of the subject.

This book differs from the general run of books on radio as this is written by an engineer for engineers rather than by a teacher for students and much that is found in ordinary text-books finds no place here. Methods and practices often cited, but which in actual practice have disadvantages which render them inapplicable, find no reference in these notes.

There is one criticism which can be made, namely, that for issue to the public the material should either have been presented in the form of loose-leaf sections with binder or else, if a bound form were decided on, the book should have been paged consecutively, and an index provided. This would, however, have involved some considerable alterations in the cross references.

The book should form a very useful text-book for engineering students and junior engineers who desire a clear and concise account of modern radio engineering practice.

A.J.G.

" Electrical Technology," by W. L. Horwood, B.Sc. (Hons.). 347 pps. and 120 diagrams. Price 10/6. Charles Griffin and Co., Ltd., 42, Drury Lane, London, W.C.2.

This book, which is divided into two parts dealing with direct and alternating current respectively, is of an intermediate standard and is suitable for students entering for the Graduateship Examination of the Institution of Electrical Engineers and the Grade II. Examination in Electrical Engineering of the City and Guilds of London Institute. The author has assumed that the average reader has studied Magnetism and Electricity to approximately Matriculation standard, although the fundamental theory of electrical work has been emphasized and expanded to make the book completely self-contained. Special attention has been given to alternating current theory. The development and use of vector diagrams have been treated at some length and a section has been included explaining the derivation and use of symbolic methods. At the end of each chapter a number of problems are given, and the answers to them are printed at the end of the book.

To students and others requiring a knowledge of Electrical Technology of an intermediate standard, this book can be recommended.

W.S.P.

Staff Changes

PROMOTIONS.

Name.	From.	To.	Date.
Powell, W. H.	Assistant Staff Engineer, Power Section, E.-in-C.O.	Staff Engineer, Power Section, E.-in-C.O.	1-5-34
McKichan, J. J.	Assistant Superintending Engineer, Scot. West District.	Superintending Engineer, Scot. West District.	1-1-35
Smith, H. A.	Assistant Superintending Engineer, Scot. East District.	Superintending Engineer, Scot. East District.	1-5-34
Watkins, J. H.	Executive Engineer, N. Wales District.	Assistant Superintending Engineer, N. Wales District.	12-8-34
Legg, J.	Executive Engineer, Testing Branch.	Assistant Staff Engineer, Telephone Section, E.-in-C.O.	27-4-34
Gilbert, D. P.	Executive Engineer, Power Section, E.-in-C.O.	Assistant Staff Engineer, Power Section, E.-in-C.O.	1-5-34
Hill, Capt. H.	Executive Engineer, S. Mid. District.	Assistant Staff Engineer, Equipment Section, E.-in-C.O.	24-8-34
Morgan, J.	Executive Engineer, S. West District.	Assistant Superintending Engineer, Scot. West District.	9-5-34
Day, W.	Executive Engineer, S. Wales District.	Assistant Staff Engineer, E.-in-C.O.	1-8-34
McGregor, J. E. M.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	1-5-34
Walton, W. E.	Assistant Engineer, E.-in-C.O.	Executive Engineer, S. West District.	6-5-34
Cradduck, G. W.	Assistant Engineer, S.E. District.	Executive Engineer, S. Lancs. Dist.	1-10-34
Epps, H. F.	Assistant Engineer, London District.	Executive Engineer, London Dist.	1-7-34
Parsons, R. A. E.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	27-4-34
Cox, W. S.	Assistant Engineer, N. Mid. District.	Executive Engineer, N. Mid. Dist.	19-5-34
Taylor, T. A.	Assistant Engineer, London District.	Executive Engineer, S. Wales Dist.	1-8-34
Green, H. W....	Assistant Engineer, N. Wales District.	Executive Engineer, N. Wales Dist.	12-8-34
Moffatt, C. E.	Assistant Engineer, S. Mid. District.	Executive Engineer, S. Mid. District.	20-8-34
Ryall, L. E.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	27-4-34
Morrish, H. E.	Assistant Engineer, London District.	Executive Engineer, London District.	27-4-34
Malcolm, A. L.	Area Transport Officer, London Inner Area.	Motor Transport Officer, Class II., E.-in-C.O.	16-5-34
Clothier, W.	Technical Assistant, London Inner Area.	Motor Transport Officer, Class III., E.-in-C.O.	To be fixed later.
Fraser, A. V. O.	Mechanic-in-Charge, Grade I., Manchester M.T. Area.	Technical Assistant, Manchester M.T. Area.	To be fixed later.
Shields, A V....	Repeater Officer, Cl. II., E. District.	Chief Inspector, E.-in-C.O.	19-5-34
Rayns, F. H....	Telegraphist C.T.O.	Repeater Officer, Class II., Scot. East District.	6-5-34
McClelland, W. C.	S.W.I., Scot. West District.	Inspector, Scot. West District.	8-4-34
Winter, A. V.	S.W.I., S. East District.	Inspector, S. East District.	15-3-34
Rice, S. G.	S.W.I., S. East District.	Inspector, S. East District.	1-5-34
Neal, J. D.	S.W.I., S. East District.	Inspector, S. East District.	6-5-34
Awcock, P. W. J.	S.W.I., S. East District.	Inspector, S. East District.	28-4-34
Preston, I. G.	S.W.I., N. Wales District.	Inspector, N. Wales District.	1-10-33
Tuck, R. F.	S.W.I., N. Mid. District.	Inspector, N. Mid. District.	13-5-34
Moulds, H.	S.W.I., N. East District.	Inspector, N. East District.	8-2-34
Allan, F. W.	S.W.I., N. East District.	Inspector, N. East District.	18-5-34
Smith, C.	S.W.I., N. East District.	Inspector, N. East District.	27-4-34
Birkby, H. W.	S.W.I., S. Lancs. District.	Inspector, S. Lancs. District.	2-6-34
Lester, T.	S.W.I., S. Lancs. District.	Inspector, S. Lancs. District.	18-2-34
Batt, J. J. G....	S.W.I., S. Lancs. District.	Inspector, S. Lancs. District.	18-2-34
Howell, F. W. R.	S.W.I., S. Lancs. District.	Inspector, S. Lancs. District.	3-4-34
Figg, M. H.	S.W.I., Rugby Radio Station.	Inspector, Portishead Radio Station.	5-5-34
Jimpson, S. J.	S.W.I., Rugby Radio Station.	Inspector, E.-in-C.O.	5-5-34
Easterbrook, A. B.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	21-4-34
Coulman, A. H.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	20-12-32
Redington, F. D.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	22-11-33
Webber, F. W. J.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	29-7-33
Russel, J. H.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	17-12-32
Cooke, E. M.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	15-12-32
Henk, A. J. C.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	16-12-32
Wilson, F.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	16-12-32
Sudell, G. R.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	17-7-32
Groome, J. S.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	5-5-33
Facer, J. H.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	8-8-33
Corke, R. L.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	30-7-32
Cope, H. G.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	27-11-32
Queen, J.	S.W.I., E.-in-C.O.	Inspector, E.-in-C.O.	17-5-33
Brown, W. D.	Draughtsman, Cl. II., E.-in-C.O.	Inspector, E.-in-C.O.	6-9-33
Richards, B.	S.W.I., N. Wales District.	Inspector, N. Wales District.	28-1-34
Bulley, G. E....	S.W.I., East District.	Inspector, East District.	To be fixed later.
Lawson, R.	S.W.I., East District.	Inspector, East District.	do.
Snowball, G.	Draughtsman, Cl. II., S. Eastern District.	Draughtsman, Cl. I., S. Eastern District.	2-3-34

Retirements.

Name.	Rank.	District.	Date.
Whillis, C.	Superintending Engineer.	Scot. West.	30-4-34
Gunton, H. C.	Principal Power Engineer.	E.-in-C.O.	30-4-34
Coxon, J.	Executive Engineer.	N. Wales.	30-4-34
Fleetwood, H. O.	Executive Engineer.	London.	20-5-34
Callis, H. J.	Assistant Engineer.	N. West.	31-3-34
Smith, H. D.	Assistant Engineer.	N. Wales.	30-4-34
Padget, W.	Assistant Engineer.	N. Mid.	30-4-34
Grocott, J. R.	Assistant Engineer.	N. West.	28-5-34
Lemont, G. A.	Assistant Engineer.	Eastern.	9-6-34
Woosley, A. C.	Repeater Officer, Class II.	N. Wales.	5-5-34
Clarke, T. M.	Inspector.	S. Lancs.	15-3-34
Williamson, J.	Inspector.	S. Lancs.	31-3-34
Kennedy, J.	Inspector.	Scot. West.	2-4-34
Richings, W.	Inspector.	N. Wales.	30-4-34
Morris, D.	Inspector.	N. Wales.	2-5-34
Ragless, A.	Inspector.	East.	15-5-34
Griffiths, C. E.	Inspector.	London.	31-5-34

Transfers.

Name.	Rank.	From	To	Date.
Fraser, A. R....	Executive Engineer.	E.-in-C.O.	Testing Branch, Birmingham.	27-5-34
Hay, P. G.	Executive Engineer.	N. Mid. District.	N. Wales District.	19-5-34
Cattell, F. T.	Assistant Engineer.	E.-in-C.O.	Scot. West District.	3-4-34
Britton, F. T.	Assistant Engineer.	E.-in-C.O.	N. Wales District.	8-4-34
Bewick, W.	Assistant Engineer.	E.-in-C.O.	N. Mid. District.	8-4-34
MacWhirter, R.	Assistant Engineer.	Scot. West District.	E.-in-C.O.	15-4-34
Brent, W. H.	Assistant Engineer.	E.-in-C.O.	Eastern District.	13-5-34
Lancaster, T. S.	Assistant Engineer.	S. Mid. District.	N. Wales District.	6-5-34
Gray, G.	Chief Inspector.	E.-in-C.O.	London District.	10-6-34
Legood, F. J.	Inspector.	London District.	E.-in-C.O.	1-3-34
Crank, F. G....	Inspector.	Portishead Radio Station.	E.-in-C.O.	21-4-34
Parker, K. L.	Inspector.	N. Mid. District.	Testing Branch.	1-6-34

Deaths.

Name.	Rank.	District.	Date.
Fenn, Capt. E. E.	Executive Engineer.	Testing Branch.	14-4-34
Arnold, A.	Assistant Engineer.	E.-in-C.O.	15-5-34
Leggatt, J.	Inspector.	East.	23-3-34
Maber, A. T. S.	Inspector.	East.	21-4-34
Shave, E. J.	Inspector.	Testing Branch.	12-5-34
Goodfellow, R.	Inspector.	Scot. East.	29-5-34

Appointments.

Name.	From.	To.	Date.
Robinson, R. T.	Motor Transport Officer, Class II., E.-in-C.O.	Executive Engineer, E.-in-C.O.	1-5-34
Mitchell, C. W. A.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	1-5-34
Gardner, F. W.	Probationary Inspector, London Dist.	Inspector, London District.	1-5-34
Greenwood, E. C.	Probationary Inspector, East Dist.	Inspector, East District.	1-5-34
Pitts, H. E.	Probationary Inspector, London Dist.	Inspector, London District.	1-5-34
Hoare, E.	Probationary Inspector, London Dist.	Inspector, London District.	1-5-34
Beaumont, E. B. M.	Probationary Inspector, S. Lancs. District.	Inspector, S. Lancs. District.	1-5-34
Todd, D. W.	Probationary Inspector, London Dist.	Inspector, London District.	1-5-34
Woods, A. E....	Probationary Inspector, London Dist.	Inspector, London District.	1-5-34
Mayo, S. J.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	1-5-34
Atkin, E. W.	Probationary Inspector, S. East Dist.	Inspector, S. East District.	1-5-34
Trimmer, W. J.	Probationary Inspector, London Dist.	Inspector, London District.	1-5-34
Peddle, H. W.	Probationary Inspector, N. Mid. Dist.	Inspector, N. Mid. District.	1-5-34

PROMOTIONS—*Continued*.

Name.	From.	To.	Date.
Palmer, R. N.	Probationary Inspector, N. Mid. Dist.	Inspector, N. Mid. District.	1-5-34
Thompson, A. J.	Probationary Inspector, East Dist.	Inspector, East District.	1-5-34
Hart, J. A.	Probationary Inspector, London Dist.	Inspector, London District.	1-5-34
Crooks, R. H.	Probationary Inspector, London Dist.	Inspector, London District.	1-5-34
Burton, J. P.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	1-5-34
Robertson, C. D. S. G.	Probationary Inspector, London Dist.	Inspector, London District.	1-5-34
Robins, A. G.	Probationary Inspector, S. Mid. Dist.	Inspector, S. Mid. District.	1-5-34
Venus, W. A. H.	Probationary Inspector, London Dist.	Inspector, London District.	1-5-34
Lawson, A. J.	Probationary Inspector, London Dist.	Inspector, London District.	1-5-34
Spooner, J. W.	Probationary Inspector, N. East Dist.	Inspector, N. East District.	1-5-34
Parker, K. L.	Probationary Inspector, N. Mid. Dist.	Inspector, N. Mid. District.	1-5-34
Arnold, A. F.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	1-5-34
Herbert, L. J.	Probationary Inspector, London Dist.	Inspector, London District.	1-5-34
Roy, D. W.	Probationary Inspector, Scot. W. Dist.	Inspector, Scot. West District.	1-5-34
Bealby, G.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	1-5-34

CLERICAL GRADES.

PROMOTIONS.

Name.	From.	To.	Date.
Camp, A. W. K.	Clerical Officer, London District.	Higher Clerical Officer, London Dist.	11-3-34
Doe, E. J.	Clerical Officer, London District.	Higher Clerical Officer, London Dist.	1-4-34
Pine, T. F.	Acting Higher Clerical Officer, Eastern District.	Higher Clerical Officer, Eastern Dist.	16-4-34
Tutton, E. B....	Clerical Officer, S. Wales District.	Higher Clerical Officer, S. Wales Dist.	25-4-34
Eachus, R. S.	Clerical Officer, N. Wales District.	Acting Higher Clerical Officer, S. Mid. District.	1-5-34

RETIREMENTS.

Name.	Rank.	Location.	Date.
Turner, A. A.	Higher Clerical Officer.	London District.	31-3-34
Campbell, F. B.	Higher Clerical Officer.	N. Eastern District.	15-3-34
Gibbins, S.	Higher Clerical Officer.	S. Wales District.	24-4-34

TRANSFER.

Parkin, E. B. ... ... Higher Clerical Officer. S. Mid. District to N. Eastern District. 1-5-34.

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