THE ETELCO BULLETIN

No. 32
JANUARY, 1956

CONTENTS

Published by

Etelco LIMITED

TELEPHONE WORKS,
BEESTON, NOTTINGHAM
Telephones: Beeston 254831 (6 *Lines*)

Head Office:
22, LINCOLN'S INN FIELDS, LONDON, W.C. 2
Telephones: Holborn 6936 (5 *Lines*)

MODERN POWER PLANT FOR LARGE AUTOMATIC TELEPHONE EXCHANGES

Telephone exchange power plants operating on the " Battery Float " principle and employing motor-generators for battery charging have been widely used for many years. They require, however, a considerable amount of manual supervision. This drawback is overcome in the recently designed plant described below, which incorporates static rectifiers for automatic battery charging in a manner that enables the plant to be left unattended for long periods. The principle involved is known as " Automatic Full Float ".

THE early type of power plant used for operating telephone exchange equipment was known as " Charge Discharge " (Figs. 1 and 2), and comprised two 25-cell Planté-type batteries, with one or more commercial type motor-generator sets and a power control panel.

The plant was so designed that one battery could supply current to the exchange for 24 hours, and the other could be charged in eight hours, i.e. a normal working day, during which the necessary manual control of the charging rate could be exercised.

The disadvantages of such a scheme were as follows :—

(*a*) The requirement that each battery should be able to supply the exchange for the stipulated reserve period, usually 24 hours ; this necessitated a total battery capacity double the effective capacity required ; because of the high cost of battery equipment this was a major disadvantage.

(*b*) The constant subjection of batteries to complete cycles of charge and discharge ; this shortened battery life and made re-plating necessary after about 6-8 years.

(*c*) The wide variation of voltage across the exchange equipment during every 24 hours discharge period ; discharge would commence at 50 volts and finish at about 46 volts.

(*d*) The amount of manual service required to effect the charging and changing over of the batteries.

As the size of exchanges grew, and likewise the demand for a more closely regulated voltage under normal working conditions, power plants operating on the float system were developed. This system enables the total battery capacity to be reduced by nearly half, because virtually all the installed capacity is simultaneously available. To the saving in equipment thus effected is added an equally important saving in accommodation. The float principle also offers the advantage of so prolonging battery life that, under the correct conditions of nominal float voltage and voltage limits, a life of 15 years or more may be expected from Planté type batteries.

There are many types of power plant operating on the float principle embodying 23, 24 or 25 Planté or Fauré type cells, counter e.m.f. cells, end cells and complicated switching arrangements. The most recent type, now to be described, operates on the Automatic Full Float principle. It is the result of the development in the last few years of new types of static automatic rectifiers. These are used with either a single 24-cell battery, or, in the larger exchanges, with paralleled duplicate 24-cell batteries, and will maintain the exchange voltage within $\pm$ 1%, from no load to full load, over most ranges of either the single- or three-phase mains voltage and frequency variations encountered in practice.

With such units it is possible to design power plant that contains the minimum of moving parts, and as the batteries are floating at a voltage below the gassing level, maintenance is greatly reduced ; as a result, a modern " full float " power plant will supply energy to the exchange for a period of 2 to 3 months under normal working conditions without any attention whatsoever, and if the cells are of the enclosed type a separate battery room is not required.

Automatic Full Float Power Plant

Further description will be assisted by reference to a typical duplicate battery full float power plant

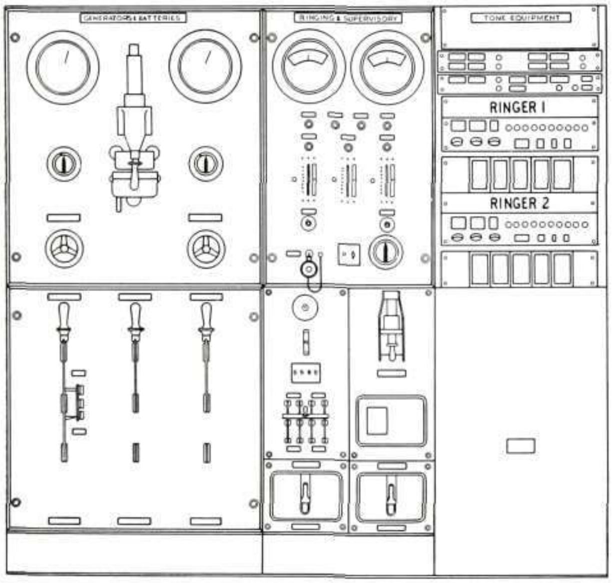


Fig. 2—Power Control and Ringer Panels for Charge/Discharge System Employing Motor-Generator Sets

designed for a 50-volt automatic exchange having equipment for 2000 lines and ultimate capacity for 6000 lines. The exchange requires a positive battery for metering and a 30-volt d.c. supply for P.B.X's in the area. The busy hour current load is stated to be 160, ultimately 480, amperes, the day to busy hour ratio is 6 : 1, and the plant is to operate from a 3-phase local supply.

The ultimate battery capacity would be equal to 480 amps. x 6 + (20%—5%) = 3,312 ampere hours. The increase of 20% is required to offset the final low potential which obtains when 24-cell batteries are used under emergency conditions, the final voltage being the same as for a 25-cell battery. The 5% represents the increase in effective battery capacity, assuming an electrolyte temperature of 70°F. i.e. 10°F. above the normal rating.

It may be many years before the ultimate battery capacity is required, as the initial number of lines is only 2000. Consequently, every effort should be made to ensure that the minimum amount of power plant consistent with reasonable provision for extension is supplied in the early stages. In this instance 3000 lines would be a most suitable basis for the initial capacity, as the charging units to be added later for the second group of 3000 lines would be of the same output as those provided initially.

The total battery capacity at the initial stage would therefore be 1656 ampere hours (half the ultimate), provided by two batteries, each consisting of 24 Planté type cells with a capacity of 828 ampere hours. These batteries would be served by two automatic battery charging units, each having an output of 120 amps. at 51·5 volts and designed to operate from the incoming three-phase supply. The units would be adjusted to maintain an output voltage of 51·5 volts ± 1% from no load to full load conditions, provided the mains voltage variation did not exceed ±6%, and the frequency ± 1%. Special units are available which will maintain the above output regulation with the input voltage varying as much as ± 25% and the frequency ± 10%.

There are various types of automatic charging units suitable for operation from an a.c. supply :

(1) The well known "Cycloc" float chargers, that achieve the regulated output by means of the natural behaviour of normal reactances, suitable transformer core material and metal rectifiers, without the use of any moving parts.

(2) The transductor system, working under the control of a regulator employed as a fast-acting potentiometer regulating the d.c. injection to the control windings of the transductors. A circuit description of this system is given later.

(3) An induction regulator connected directly to the primary of the main transformer and controlled by a contact voltmeter.

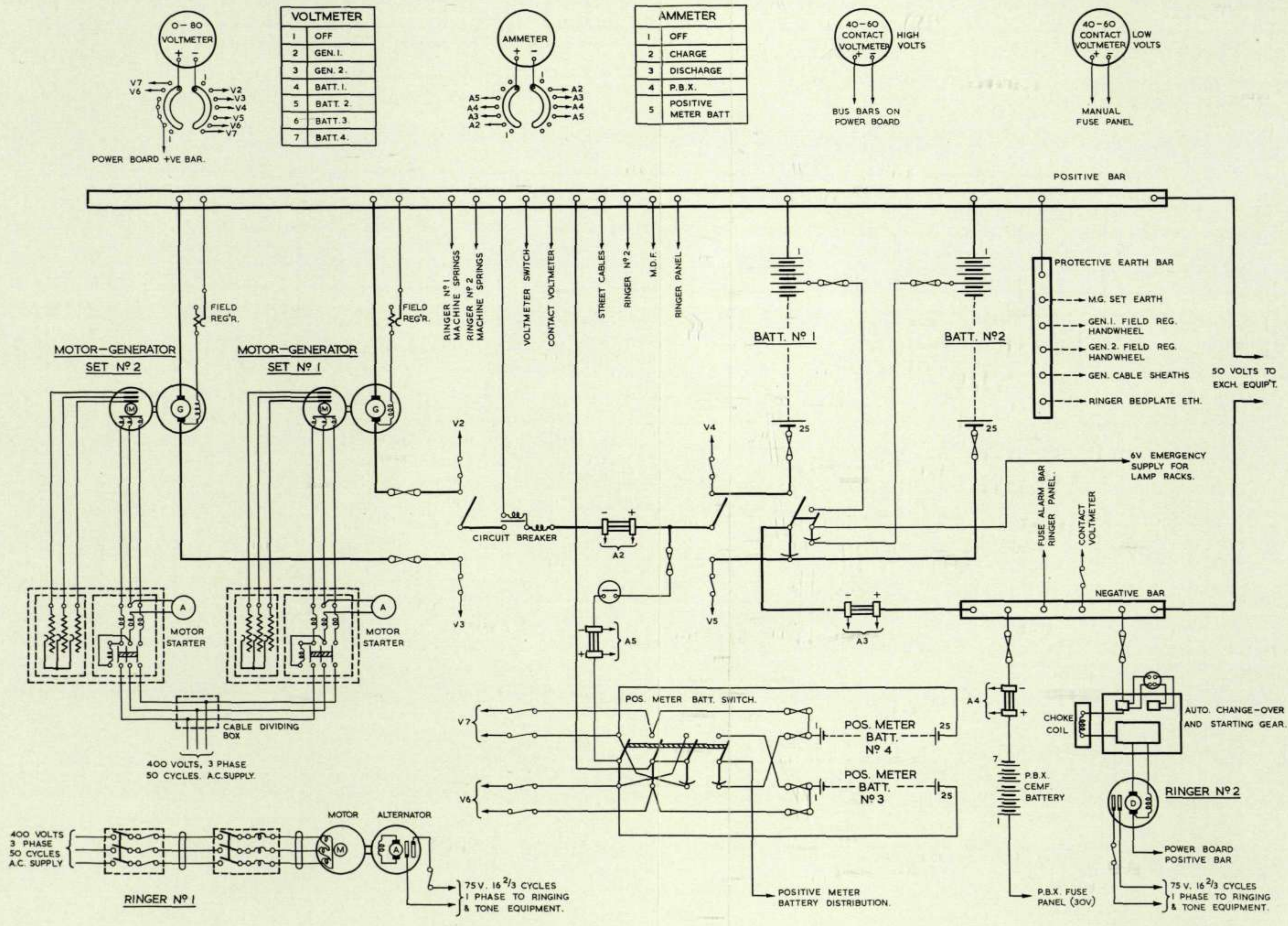
The power control board is equipped with all the instruments, switches, etc., needed to control the ultimate number of automatic charging units, batteries, ringing machines etc. It comprises an angle-iron frame accommodating three highly polished Sindanyo panels, viz. :

The A.C. Control Panel.

The D.C. Control Panel.

The Ringing Panel.

The A.C. Control Panel is equipped with a voltmeter for reading phase voltages, and with all the switchgear required to control the a.c. input to the rectifiers, ringing machines, etc.



VOLTMETER	
1	OFF
2	GEN. 1.
3	GEN. 2.
4	BATT. 1.
5	BATT. 2.
6	BATT. 3.
7	BATT. 4.

AMMETER	
1	OFF
2	CHARGE
3	DISCHARGE
4	P.B.X.
5	POSITIVE METER BATT

Fig. 1—Power Circuit for Charge/Discharge System

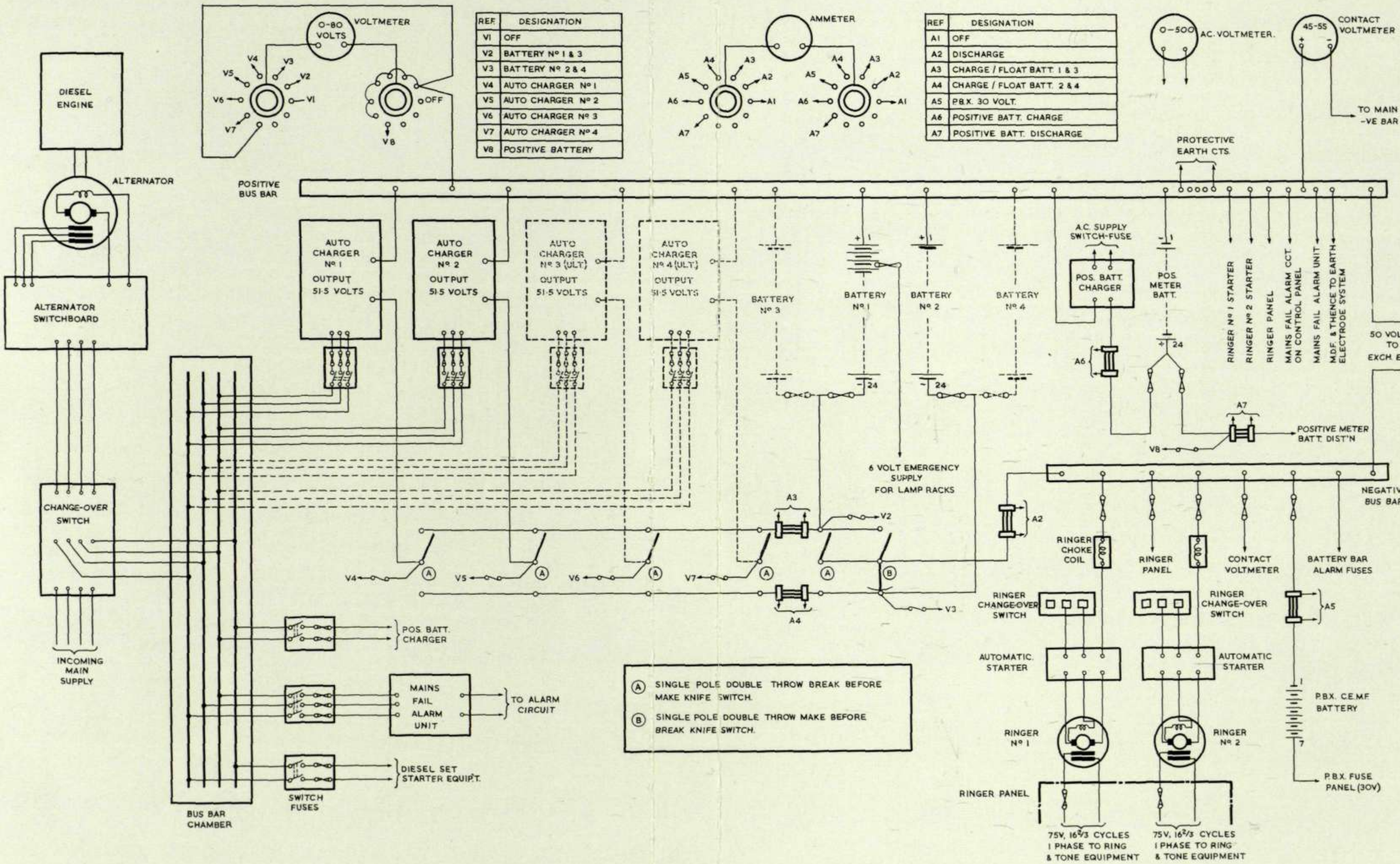


Fig. 3—Power Circuit for Duplicate Battery Automatic Full Float System

The D.C. Control Panel accommodates a voltmeter and ammeter which register the charging or floating voltages and current, knife switches to connect or disconnect as required the rectifiers and batteries, and such alarm fuses, keys and lamps as are necessary for the efficient operation of the power plant.

The Ringing Panel is equipped with the apparatus which controls ringing and tone and effects automatic changeover from the normal machine to the standby, should the ringing supply fail.

Provision against mains failure is made by installing a cold starting diesel engine directly coupled to a self excited alternator having an output of 45 kVA, the engine and alternator being mounted on a common bedplate provided with anti-vibration supports. Such sets are designed for electric push-button starting from a self-contained battery and charging rectifier, or can be provided with automatic start-stop and changeover from mains to standby, or *vice-versa*. For standby purposes, medium-speed sets are usually supplied, for reasons of economy; the

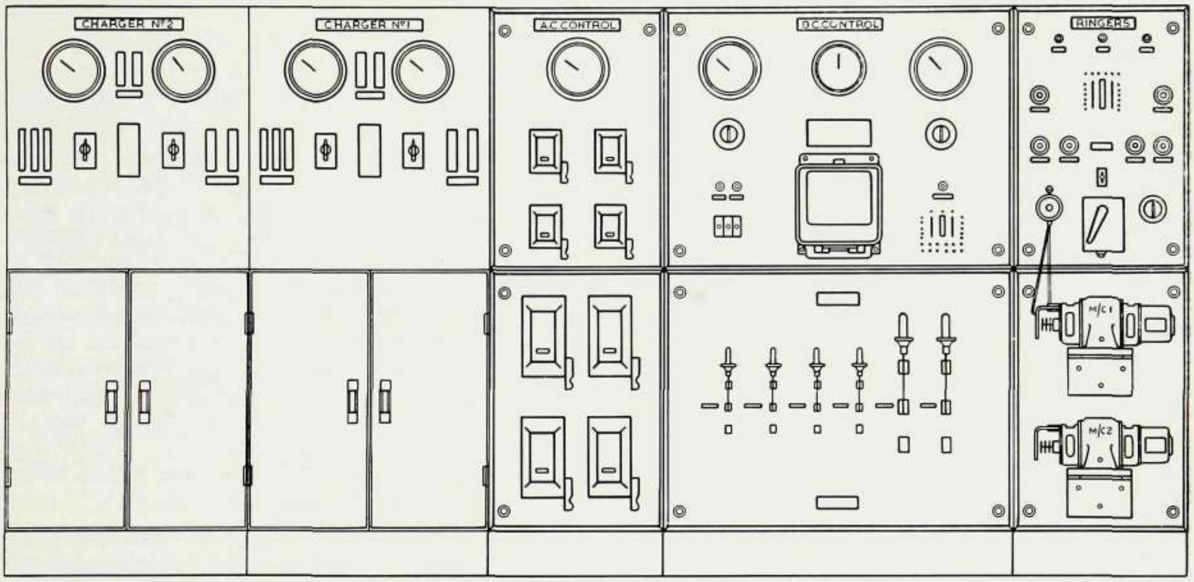


Fig. 4—Power Control and Ringer Panels with Initial Charging Units for Duplicate Battery Automatic Full Float System

set instanced here would run at 1000 r.p.m. The alternator control panel accommodates a voltmeter, ammeter and circuit breaker, as well as hand operated and automatic regulators that will maintain the output voltage to an accuracy of $\pm$ 6%.

Until recently it was customary for the normal machine to be mains driven and the standby, battery driven. However, the latest engineering practice is to have both machines designed for operation from the exchange battery. It will be readily appreciated that the provision of two identical dynamotors greatly eases replacement and spares problems, whilst the use of a dynamotor as the normal machine in no way increases the battery capacity, since this is designed to meet, if necessary, the needs of the usual standby dynamotor for the full 24-hour period.

The 30 volts supply required for operation of the P.B.X.s in the exchange area is obtained from the main battery via 7 counter e.m.f. cells, and the positive battery supply from a 24-cell, 10 ampere-hour battery floated across a small charging unit.

The distribution of the 50-volt d.c. supply to the exchange equipment is so designed that the total voltage drop in the entire system, lead and return, including switchgear and fuses, does not exceed one volt under ultimate full load conditions.

A carefully balanced progressive distribution is essential to ensure maximum economy of aluminium or copper bus bars. At the same time, the mechanical layout must be such that, under short circuit conditions when thousands of amperes may flow, the bars are not displaced.

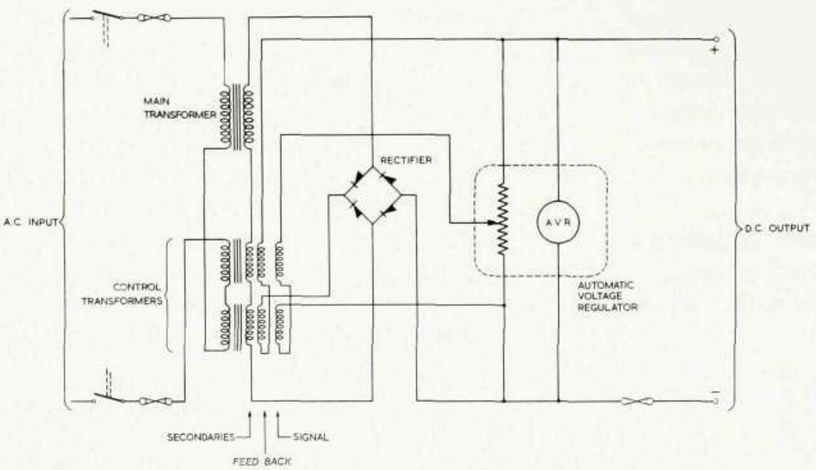


Fig. 5—Circuit for Single Phase Automatic Charging Unit. Transductor System

Operation of the Plant.

The operation of the plant is as follows. With the batteries fully charged and all the cells automatically brought up to the same voltage by the charging units operating under boost conditions, the batteries and rectifiers, now operating under automatic float conditions, are paralleled by the control gear on the d.c. panel, their output being fed direct to the exchange.

To increase the efficiency of the plant, an automatic selecting device can be provided ; this enables one or more charging units to be switched in or out of service according to the exchange load requirements. As previously stated, the plant will supply energy to the exchange for a period of two to three months under normal working conditions, without any attention. At the end of this time each battery should be given a boost charge for a few hours during the light load period. A similar boost charge should be given after a prolonged mains failure, indicated by the mains fail alarm unit, when the batteries are discharged by 20-30% of their full capacity.

A satisfactory exchange operating voltage is maintained during such periodic boost charges by division of the normally-paralleled batteries ; one battery and charging unit may then feed the exchange, whilst the other receives the boost charge. Separation of the batteries and charging units is readily achieved by the operation of the knife switches on the D.C. Control Panel. Should a charging unit become faulty, a most unlikely contingency, the plant can be operated satisfactorily with one or more charging units on a semi-charge-discharge principle, with a slightly reduced reserve battery capacity.

Notes on the Transductor System.

One of the advantages of the transductor system of automatic battery charging is its flexibility, for it will operate satisfactorily over wide variations in input voltage and frequency. Since the system may not be as well known as the more orthodox systems employing "Cycloc" chargers and induction regulators, this description of modern power plant may fittingly be concluded with a brief explanation of the circuit principles (Fig. 5).

The main transformer and two control transformers, which together comprise the transductor, have their primary windings connected in series opposition across the a.c. supply, the rectifier being fed from all three secondaries connected in series. Thus the input rectifier voltage is the vector difference of the main transformer secondary voltage and the two control transformer secondary voltages. The resistance element of the automatic voltage regulator is connected as a potentiometer across the rectifier output, and this supplies the signal windings on the control transformers. Since the control transformers are a matched pair and are working under identical conditions, the vector difference of the a.c. voltages induced in the signal windings is zero, so that no a.c. is induced in the signal circuit.

When the d.c. output falls, the automatic voltage regulator alters its potentiometer setting to increase the d.c. current flowing in the signal windings. This increases the saturation, reducing the primary impedance of both the control transformers and the secondary voltages. The primary and therefore the secondary voltage of the main transformer rises, and the opposing control transformer secondary voltages fall, so that the a.c. input voltage to the rectifier rises to correct the d.c. output voltage. The reverse effect occurs when the d.c. voltage rises. The d.c. output current is caused to flow through feed-back windings on the control transformers. These windings are so connected as to maintain the d.c. output voltage as the load current rises. If the d.c. output terminals of the charging unit are shorted, then the output voltage is zero, and the automatic voltage regulator reduces the signal current to zero. The primary impedance of the control transformers increases and the main transformer primary voltage falls. The nett effect is to reduce the a.c. input voltage to the rectifier. By suitable proportioning of the windings, the short circuit current can be controlled, the local current then being cut off at a predetermined value.

AUTO/C.B. INTERMEDIATE AND EXTENSION TELEPHONES

BATTERY RINGING TYPE

The telephones described in this article are designed for short-distance internal lines where the length of cable required is such that the provision of extra line wires for internal battery ringing does not involve high cable cost. Novel circuitry in these sets simplifies operating procedure for intermediate switching, and ensures that the extension has access to the exchange, whether the intermediate telephone is attended or not, provided that the line is not engaged.

History

THE intermediate telephone is for use in a system where two, sometimes three, people share a common exchange line, access to which may be required by any one of them at any time. Such a system may be likened to a very small private exchange where provision must be made for answering incoming calls and switching them from the exchange to the person required. In other words, there must be the equivalent of a small switchboard, i.e., the intermediate telephone.

Small systems of this kind are economic in line rental charges and have been in demand for many years. The earliest examples comprised two ordinary telephones and a separate bell set containing also an extension switch, the bell set being installed near one of the instruments. Later, a special telephone incorporating the extension switch was designed, and was termed the " intermediate " telephone because of its location between the other instrument in the system—the " extension " telephone—and the exchange line.

Such a system has various applications, two of which may be cited :

(*a*) for the executive and his assistant in separate offices in the same building, the assistant having the intermediate telephone ;

(*b*) for the physician having an intermediate telephone at the surgery and an extension at his private residence.

In application (*a*) the distance between the two offices, and the cost of the cable between them, is small, and battery signalling offers advantages which are not outweighed by the cost of the extra wires necessary for the signalling circuit. Short-distance systems of this type are known as " Internal Systems ", although they may not, strictly speaking, be internal, since the telephones may be in separate though not widely separated buildings.

In application (*b*), on the other hand, the distance between surgery and residence may be considerable and may necessitate magneto signalling, which reduces cable cost by using the same wires for speech and ringing.

The Company's earliest intermediate and extension telephones, current in the nineteen-twenties, were all provided with hand generators. They were metal cased instruments supplied with or without a dial, as automatic or manual c.b. working required. Switching was effected by means of a rotary key incorporated in the intermediate telephone.

The more modern version of this telephone, developed in the post-war period, had a moulded plastic case, an " Alnico " hand generator and four push-button keys for switching. A battery ringing model developed at the same time had a similar case, but two extra push-button keys to permit the selective ringing of two extensions connected in parallel. These two post-war models were described in Bulletin No. 17, July 1948.

The latest intermediate and extension telephones described below have been designed solely for internal, i.e., battery signalling systems, and are supplied with or without a dial, for connection to different types of exchange line. The Type numbers of the instruments, and of those which they supersede, are as follows :—

Type N.1047H Auto Intermediate Telephone **Type N.1048H Auto Extension Telephone**

Fig. 1—The Old Type Telephones which are now superseded

	Type No.	
	Old	*New*
Auto Intermediate telephone	N.1047H	N.1051A
Auto Extension telephone	N.1048H	N.1052A
C.B. Intermediate telephone	N.1322H	N.1323A
C.B. Extension telephone . .	N.1327H	N.1324A

Physical Features

For purposes of comparison, the old and new auto sets are shown in Figs. 1 and 2 respectively. These show clearly the reduction in the size of the intermediate telephone (now no larger than the extension telephone) and the improvement in the appearance of both instruments. These normally have black moulded cases, but ivory, Chinese red or jade green plastic mouldings are available if preferred. The trigger type automatic dial has a stainless steel finger plate and standard numbering, as illustrated, unless other numbering is requested.

The instruments are tropicalized ; viz : they have varnish impregnated coils, cord conductors and connecting wires insulated with p.v.c., the cords having nylon outer braidings, ventilation holes with gauze screens to prevent the ingress of insects, a dial mechanism fitted with a plastic cover, and metal parts protected from the effects of humidity by special finishes.

Type N.1051A Auto Intermediate Telephone **Type N.1052A Auto Extension Telephone**

Fig. 2—The New Instruments

It will be observed that the new intermediate telephone has four plastic push buttons ; the two in the centre are black and are designated " Ring 1 " and " Ring 2 ", respectively. The left-hand outer button is white and is labelled " Extension ", while the right-hand button is red and is labelled " Exchange ". This is the standard provision and marking. Should there be only one extension, the " Ring 2 " button is spare. Below the dial—or the dial dummy on the c.b. set—is a small star indicator which acts as a supervisory signal to show when the exchange line is engaged by the extension ; this indicator is more clearly seen in the interior view of the telephone, Figure 3.

All the interior apparatus is so arranged on the removable metal baseplate as to afford free access to the parts for maintenance. Adjustments to the buzzer mounted beside the indicator, or to the push-button and cradle-switch springsets at the back end of the plate, can readily be made ; cord and wire terminations are also conveniently placed.

The buzzer is operated only from the extension telephone, an incoming call from the exchange ringing an a.c. bell in the moulded wall case seen in Fig. 2. This bell set also contains twelve screw terminals for the connection of the line wires and, if required, an extension bell. A flexible cord connects the telephone to the bell set, which is supplied with the instrument under the one Type number.

The extension telephone closely resembles the intermediate telephone in external appearance but has only two push-button keys, one designated " Ring ", the other " Bell On-Off ". The latter key has an attachment by which it may be pressed and turned clockwise to lock in the "Bell On" position. This action enables the extension to receive incoming exchange signals, a facility usually needed only when the intermediate telephone, which normally receives such calls, is unattended. The Bell key may be restored to the unoperated (" Off ") position by pressing and turning it anti-clockwise.

Fig. 4 is an interior view of the extension telephone, which contains both the bell for exchange signals and the buzzer for signalling calls from the intermediate telephone. The leads from the latter are brought in via a cord from a moulded desk terminal block which also contains terminals for connecting an extension bell if required.

Power Supply and Length of Line

Current for ringing and speech circuits is obtained from a 6-volt battery of ordinary dry cells which can be bought locally and is, therefore, not normally supplied with the telephones.

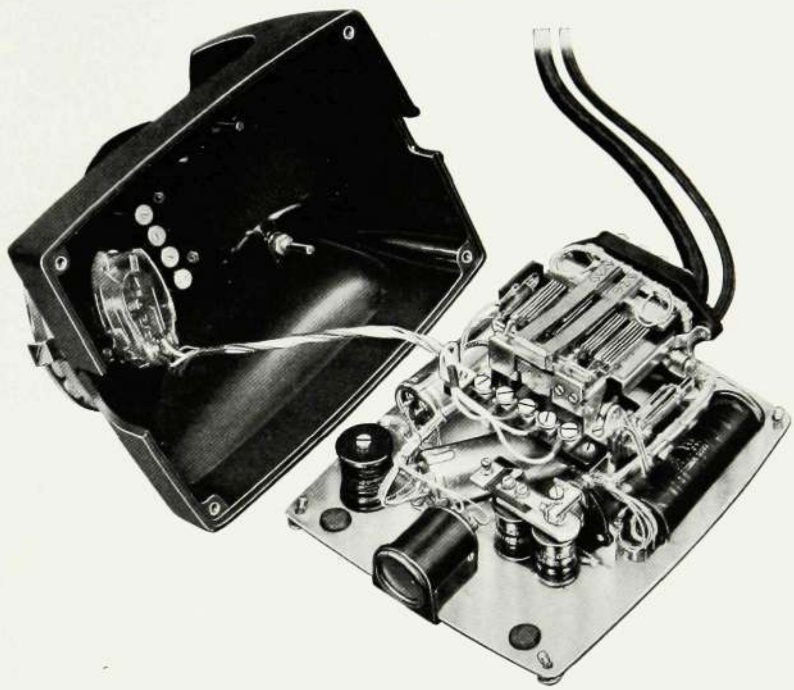


Fig. 3—Intermediate Set with Case off

The system will operate on any auto. or manual c.b. exchange line of up to 1,000 ohms loop resistance and does not introduce any earthed or unbalanced line conditions, nor is there any appreciable insertion loss when the star indicator on the intermediate telephone is in circuit.

As has already been indicated, the system is designed for conditions in which the lines between intermediate and extension telephones are relatively short, the maximum line length being determined by economic rather than technical considerations.

Fig. 4—Extension Set with Case off

8. Terminals for connecting an extension bell for the reception of exchange ringing are available at the intermediate and the extension telephones ;
9. Extension can always make outgoing calls to exchange, whether intermediate is attended or not ;
10. Extension can, when required, receive exchange ringing without switching at intermediate.
11. Extension cannot overhear intermediate to exchange conversation.

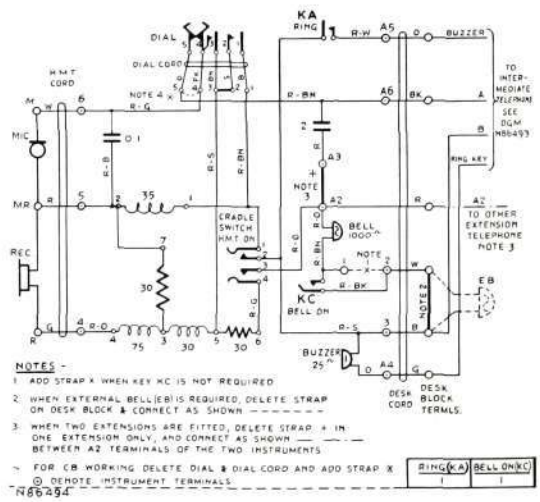


Fig. 5—Extension Telephone Circuit

Facilities

The various connections established when the appropriate push-button keys on the intermediate telephone are in the specified positions are shown diagrammatically in Fig. 6, there being four conditions of switching. These constitute Numbers 1 to 4 of the following facilities provided by the system :—

1. Intermediate to exchange ;
2. Intermediate to extension ;
3. Information call (intermediate to extension with exchange held) ;
4. Through connection of exchange to extension on replacement of the intermediate handset, but with incoming exchange calls normally answered by intermediate ;
5. Extension to exchange conversation can be made secret, or non-secret, from intermediate by terminal strappings ;
6. Indication is given at intermediate when the exchange line is engaged by extension ;
7. Provision is made for two extensions, with selective ringing from intermediate ;

Circuit Notes

The design of the circuits shown in Figs. 5 and 7 reveals a new approach to the problem of providing the facilities usually associated with intermediate-extension working ; simpler operation with fewer keys is the result. Notable improvements have been effected, firstly, in the method of transfer to the "through" or "extension to exchange" connection, secondly, in the way in which the information call, i.e. " intermediate to extension with exchange held ", is obtained. With the new circuitry, all switching at the intermediate telephone can be effected with two keys, whereas four keys were formerly necessary. Switching procedure is thereby simplified and operational reliability improved.

The " through " connection (Facility No. 4) is set up automatically when the handset of the intermediate telephone is replaced. As a result, the extension is given a through connection to the exchange whenever the intermediate telephone is not on the line. This eliminates a difficulty commonly experienced in earlier systems, in which the extension could be left without service if the intermediate attendant neglected to operate the necessary keys to set up the through condition before leaving the telephone.

The other improvement, i.e., in the " information call" (Facility No. 3), has been achieved by arranging for the Extension key to interlock with the Exchange key, so that when the latter is pressed for intermediate-exchange conversation the attendant need only press the Extension button to be able both to hold the exchange line and to speak to the extension, with the two keys locked in the operated position.

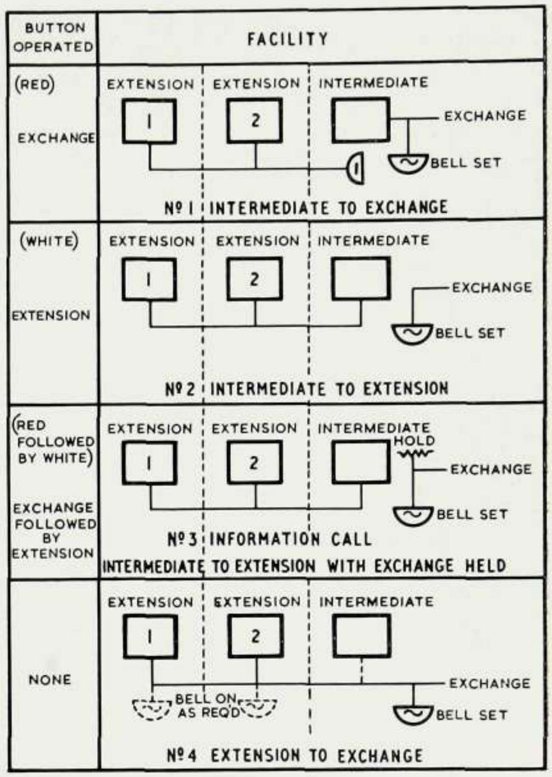


Fig. 6—Connections Set Up by Operation of Switching Buttons

Operating Procedure

The operating procedure for the intermediate attendant is governed by two simple rules, namely :

For Exchange press the red button ;

For Extension press the white button.

These rules apply in all circumstances, as will be seen in the description of the procedure. Here, then, is another advantage of the new system over its predecessors, since it was formerly necessary for the attendant to remember two ways of calling the extension, one with the exchange held and another without.

The following description makes no reference to dialling or similar operations which are common telephone practice.

Intermediate Telephone

Exchange ringing is always signalled on the bell in the wall case. The star indicator should be observed to verify that the line is free (indicator unoperated) before the handset is removed to commence operations.

1. To call exchange : press red button.
2. To call extension : press white button, then the appropriate black " ring " button.
3. Information call to extension during intermediate-to-exchange conversation : with red button already down, press white button and appropriate " ring " button.
4. To transfer exchange call to extension : replace handset when extension is ready to accept call.
5. To return to exchange line after an information call : press red button to release white button.
6. To take part in a through conversation : after operation 4 above, take up handset.
7. Intermediate unattended : before leaving telephone unattended, inform extension so that calls may be received at extension telephone.

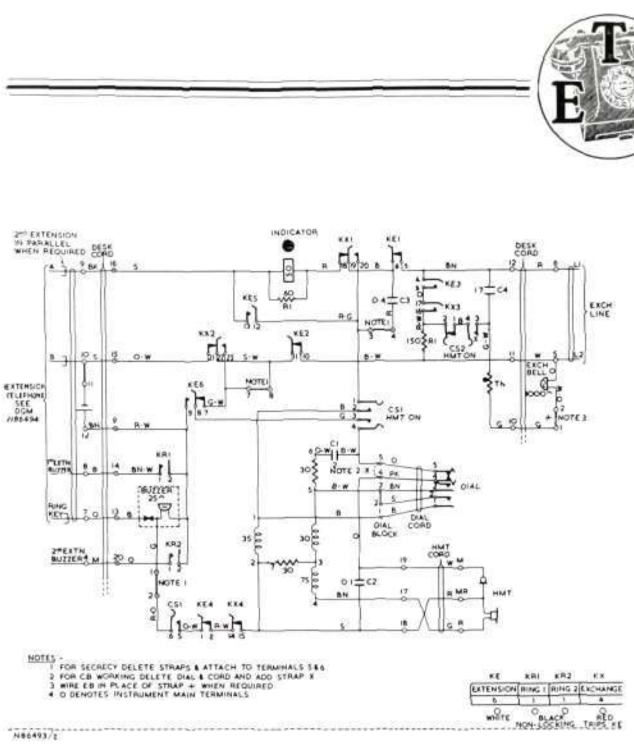


Fig. 7—Intermediate Telephone Circuit

Extension Telephone

1. To call exchange : follow normal telephone procedure.
2. To call intermediate :
   (*a*) If exchange is auto, take up handset, press " Ring " button and await reply.
   (*b*) If exchange is c.b. manual, press " Ring " button and await responding buzz from intermediate before taking up handset, thereby avoiding needless calling of exchange operator.
3. To receive exchange calls when intermediate is unattended : press and turn " Bell " button to " On " position. To restore, turn button in reverse direction.

Circuit Explanatory

The following notes on circuit operations during switching procedure refer to the diagram, Fig. 7.

(*A*) *Intermediate to Exchange.* When the red button is pressed, contacts KX1 and KX2 disconnect the extension and connect the intermediate telephone circuit to the exchange, KX1 short-circuiting capacitor C3. KX3 prepares a circuit for holding the exchange line during information calls.

(*B*) *Intermediate to Extension.* When the white button is pressed, contacts KE1 and KE2 disconnect the exchange line, leaving the exchange bell connected to signal incoming calls. KE5 and KE6 connect the speaking circuit via the 6-volt battery to the extension line. The ring button, KR1 or KR2 applies negative battery to the buzzer in the extension telephone.

(*C*) *Information Call.* With the red and white buttons pressed, condition (*B*) obtains, but the exchange line is held via R1, KE3 and KX3. The bell remains across the line in case the exchange wishes to break down the call in favour of a trunk call.

(*D*) *Transfer.* When the handset is replaced, the buttons restore to normal. During this time the cradle-switch contacts CS2 maintain a noise suppression circuit to reduce the click heard by the waiting exchange subscriber.

(*E*) *Return to Exchange Line.* This is achieved by further pressing the already operated red button, in order to release the white one and thus restore the circuit to condition (*A*). The release is effected by a cam associated with the red button.

(*F*) *Intermediate Joins " Through " Conversation.* With the appropriate terminals strapped for non-secret working, the intermediate can lift the handset and take part in an extension to exchange conversation, the 6-volt battery providing microphone current via the buzzer coils, KE4 and KX4, to enable the attendant to speak on the exchange line via capacitor C3. This arrangement does not reduce the transmission from the extension telephone as would a simple parallel circuit.

(*G*) *Secrecy.* The intermediate can be prevented from overhearing a through conversation by a change of terminal strappings, as stated in Fig. 7, Note 1.

With the development of the instruments herein described, the Company can now offer a comprehensive range of modern-style intermediate and extension telephones. The range comprises not only the respective auto and manual c.b. types for external and internal working which have been mentioned, but also an intermediate telephone designed solely for magneto exchange lines. This is a moulded set equipped with a hand generator, an indicator and three push-button keys. Its Type number is N.2140A. The associated extension uses an ordinary magneto telephone.

THE WORKS' "PAINTS DIVISION"

Thirty years ago the Company erected a factory for the production of paints, lacquers and varnishes, primarily for its own industrial needs. The specialized nature of these products attracted a demand from our own and kindred industries, consequently this Paints Division has had to be extended from time to time, culminating in an entirely new factory, equipped with the most modern plant and technique of which a brief description is given in the following article.

THE finishes which are applied to telecommunication equipment must give adequate protection for long periods of service under normal and sometimes adverse conditions.

The processes employed in enamelling or electroplating such equipment are governed by many limiting factors, not the least being the high degree of precision demanded in the application of coatings or deposits of the requisite thinness ; the techniques adopted are therefore necessarily of a specialized nature.

The manufacture of paints, enamels and lacquers was initiated at the Beeston Works in 1925, so that materials possessing the special properties required for our industry might be developed. In addition to the manufacturing plant, a paints laboratory and development unit was installed, together with all the equipment necessary for the evaluation and life testing of the products and coatings. These facilities provided a basis for the study of new materials and of the best methods of preparing surfaces and applying finishes ; they were of especial benefit in the succeeding years when the range of organic coatings widened very rapidly.

In consequence of the dearth of certain materials during and after the War, a great deal of original work was done in the formulation of synthetic finishes and insulating materials ; as a result, the post-war years have been most fruitful in new and improved raw materials for the paint manufacturer. There are now available highly resistant, durable finishes which have virtually replaced the earlier air-drying nitro-cellulose or oleo-resinous based varnishes, and appreciably improve the protection of telephone equipment.

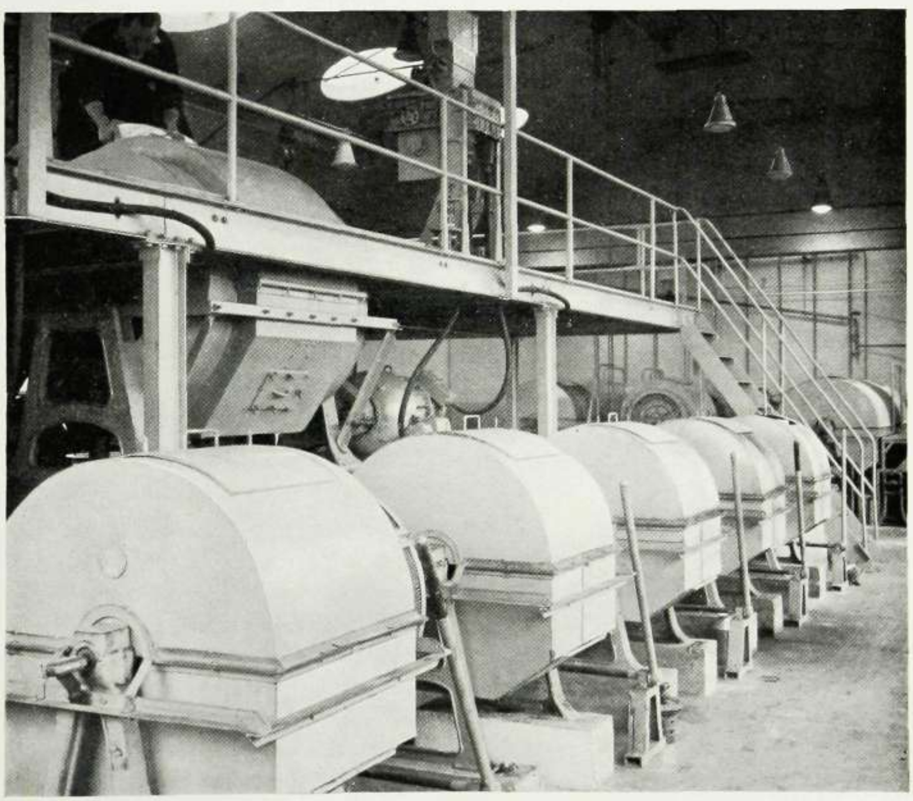


Fig. 1—Battery of Small Ball Mills with Loading of Larger Mill in Operation

Early in 1955 an entirely new paint factory, replacing the original one and adequately sustaining our progressive policy, was completed. The unit incorporates the most up-to-date manufacturing plant, and the general arrangements are such as to ensure maximum efficiency, cleanliness and safety, particularly freedom from fire hazard. In short, the buildings, plant and operational methods conform to the latest trends in the paint manufacturing industry.

To make the best possible use of the available

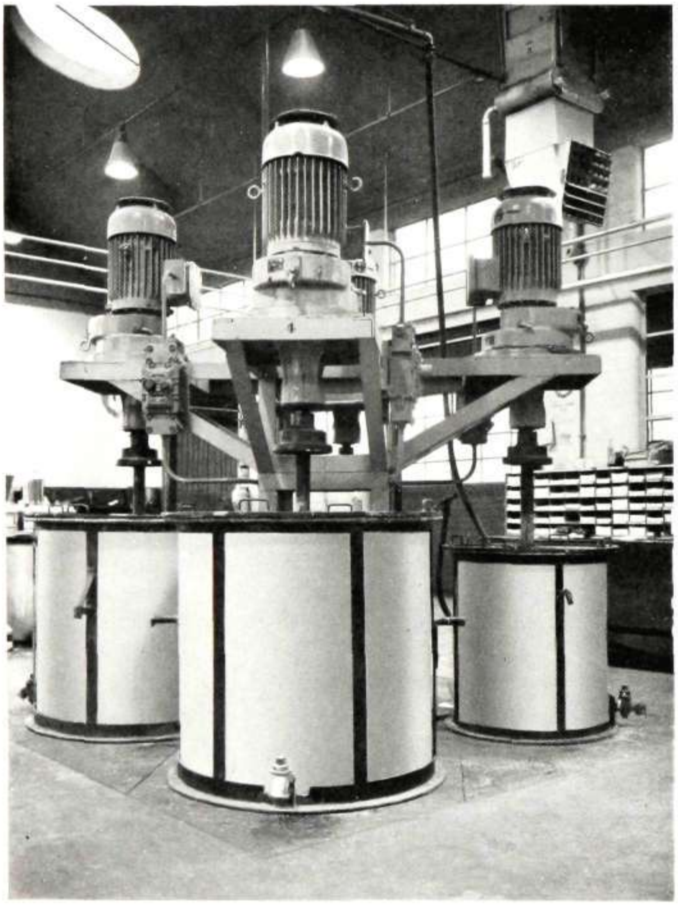


Fig. 2—Portable Tanks in Position for Mixing

space and eliminate obstructions which might prevent a satisfactory layout of the plant, a barrel-vault roof requiring no suporting pillars was chosen for the main structure, i.e. the manufacturing block. Other sections of the paint factory comprise stores, a varnish-making block and a tank farm, the last being underground. The main solvents stored in the tanks are pumped and metered to appropriate points within the buildings.

Individual drive has been adopted for the major plant units.

Ball mills of various capacities are largely used for the initial dispersion of pigments in the media (Fig. 1) and are housed in a separate room adjacent to the raw material store. The mills are filled manually from overhead platforms, and the larger mills empty direct into tanks for transport to the next stage in the process.

After the requisite grinding period, the charge from the ball mills will comprise a concentrate of pigments, finely dispersed either in synthetic resin media and solvents for ultimate conversion into stoving enamels or in one of the cellulose bases required for air-drying cellulose finishes.

The charges are transferred in mobile tanks to the mixing room where subsequent reduction involves the addition of further resin bases, solvents and toning colours which are introduced by means of the paddle mixing heads illustrated in Fig. 2. High gloss enamels are subjected to a further finishing process carried out by high speed roll mills, shown in Fig. 3.

At this final stage, check samples are examined for viscosity and, after being stoved or dried under controlled conditions, for colour, whilst various physical tests are also carried out. When results for a batch are satisfactory, it is ready for filtration, packing and despatch.

The manufacture of clear lacquers and dopes commonly involves the dissolving of cellulose ester solids, resins and plasticisers in suitable solvent mixtures ; for this purpose high-speed mixers (Fig. 4) or the slower paddle mixers already mentioned are employed. Coloured lacquers are prepared in a similar manner, concentrated pigment stocks ground finely in roll mills being added to them.

Impregnating and finishing varnishes for the insulation and protection of electrical windings have long been a speciality of the Company ; the aluminium and stainless steel vessels used for cooking them are sited in a separate building, where synthetic resins are introduced into the oils, and precise control is exercised to determine the time and temperature cycles governing the processes.

The range of the plant's products is considerable, and is representative of the majority of industrial finishes now in general use. To the conventional nitro-cellulose and synthetic stoving enamels, wood fillers, light-fast stains and lacquers, have been added styrenated alkyd materials, catalysed coatings, hammer finishes and epoxy base enamels ; the latest copolymer lacquers for wire and cable are also manufactured, together with the well established acetate types.

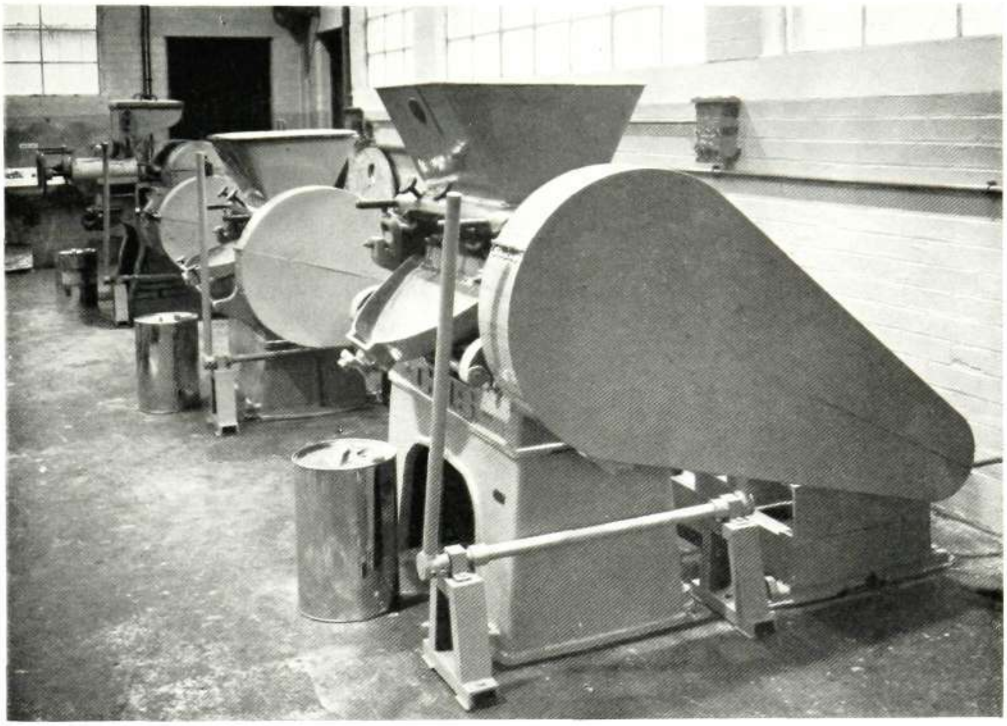


Fig. 3—Single Roll Finishing Mills

Many of the products are supplied to customers who have finishing problems similar to our own. The advantages accruing from our experience in their manufacture and use are obviously considerable, whilst the knowledge gained empirically, when studied in conjunction with current developments in technical knowledge and raw materials, has proved invaluable in the formulation of new finishes and techniques of application.

Although the Works' Paints Division was established to meet our own domestic needs and its investigations have therefore subscribed to the improvement of finishes in the telephone and electrical industries, it should be emphasized that its activities are not confined to meeting the requirements of these industries. Speciality coatings for numerous purposes are developed and manufactured. The new modern plant will not only permit an increase in the output of current products but will also facilitate the development of entirely new finishes.

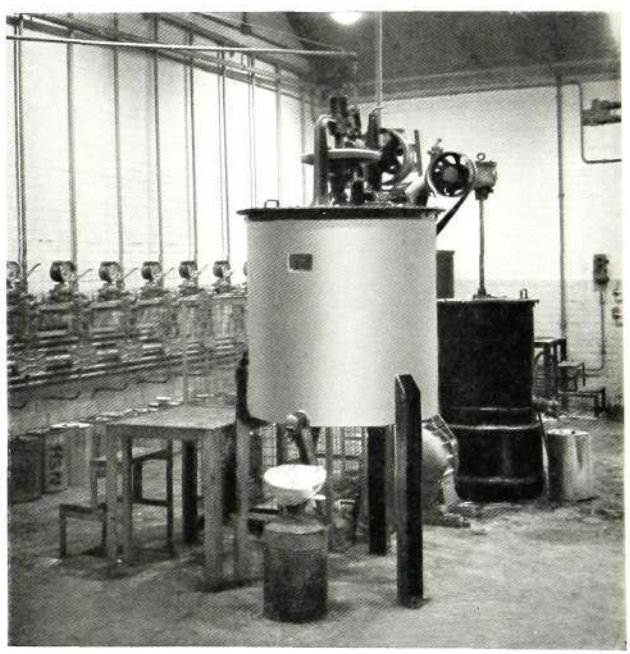


Fig. 4—Dissolving Tanks and Solvent pumping System

KARACHI—SUI V.H.F. COMMUNICATION SYSTEM

This article describes the communication equipment supplied and installed jointly by the Company and Pye Telecommunications, Ltd., along the Sui Gas Transmission Company's gas pipeline route between Karachi and Sui, a distance of 350 *miles.*

The radio survey of the route and the installation will be described in a later article.

GEOLOGICAL surveys in the lower foot-hills to the north of the Upper Sind frontier have revealed a large source of natural gas at Sui, some 285 miles N.N.E. of Karachi. By early 1954 the plans of the Sui Gas Co., Ltd., to construct a pipe line to carry this gas from the Sui pumping station to Karachi were well advanced, and sites had been selected along the proposed 349-mile pipe line route for the installation of gate valves and cathodic protection equipment. There was a clear need for a very reliable and comprehensive communication network, to permit the swift transmission of pumping information between Sui and all the other stations along the pipe line, and to handle the considerable amount of administrative traffic. To meet this need, in the Spring of 1954 a communication scheme was planned by the Burmah Oil Company (Pakistan Trading) Ltd. in conjunction with Pye Telecommunications, Ltd., and ourselves, the two latter companies being jointly entrusted by the Oil Company with the surveying of the route and the manufacture and installation of the equipment. This article outlines the facilities incorporated in the scheme, and includes a description of the channelling and telegraph equipment. A more comprehensive description of the complete scheme, including an account of the radio equipment and a report on the survey and installation, will appear in a later issue of the Bulletin.

Fig. 1 shows the station locations, with the terminal stations at Karachi and Sui, and Section Headquarters at Rohri, Daur, and Hyderabad, designated S.H.Q. Nos. 1, 2 and 3 respectively. One radio repeater is sited between each pair of stations, except in the link section Karachi—S.H.Q. No. 3, which, owing to the hilly terrain to the north-east of Karachi, requires two repeaters.

Carrier Channel Allocations

The channel allocations are shown in Fig. 1, the equipment being our type ETR31A described in Bulletin No. 24, January 1952, under the title " Multi-Channel V.H.F. Radio Telephone Systems."

Carrier Channel 1 carries a through speech circuit from Karachi to Sui, terminating at both stations as an exchange line on the switchboard. At the Section H.Q's the channel side band is selected by the appropriate band filter and then re-amplified by the group amplifier working towards the next station.

Carrier Channel 2 carries the inter-station speech circuits, viz., Karachi to S.H.Q. No. 3, S.H.Q. No. 3 to S.H.Q. No. 2, S.H.Q. No. 2 to S.H.Q. No. 1, and S.H.Q. No. 1 to Sui. These circuits terminate as exchange lines on their respective switchboards, there being one channel end at Karachi, one at Sui, and two at each Section H.Q., one working towards Karachi and the other towards Sui.

Carrier Channel 3 carries two v.f. telegraph circuits, to be described later, linking up the same stations as the speech channels. Both the through and inter-station circuits are terminated by individual teleprinters, all stations being equipped with two machines.

The Engineer's Channel, which occupies the audio band 300–2700 c/s, is connected as a party line circuit at all repeater stations, being terminated at a magneto extension telephone. At all other stations it terminates as an exchange line on the switchboard, where the operator effects any necessary through switching. The circuit, besides being used for routine maintenance, may be used by the pipe line staff at any station to communicate with any other.

As there must be the minimum interruption of service, all radio units and aerials are duplicated, the standby equipment being brought into use on the receipt at Karachi of a link failure alarm. This alarm is given and remote changeover effected by the transmission of tone signals in the 3–6 Kc/s band. A continuous pilot tone is transmitted over the link

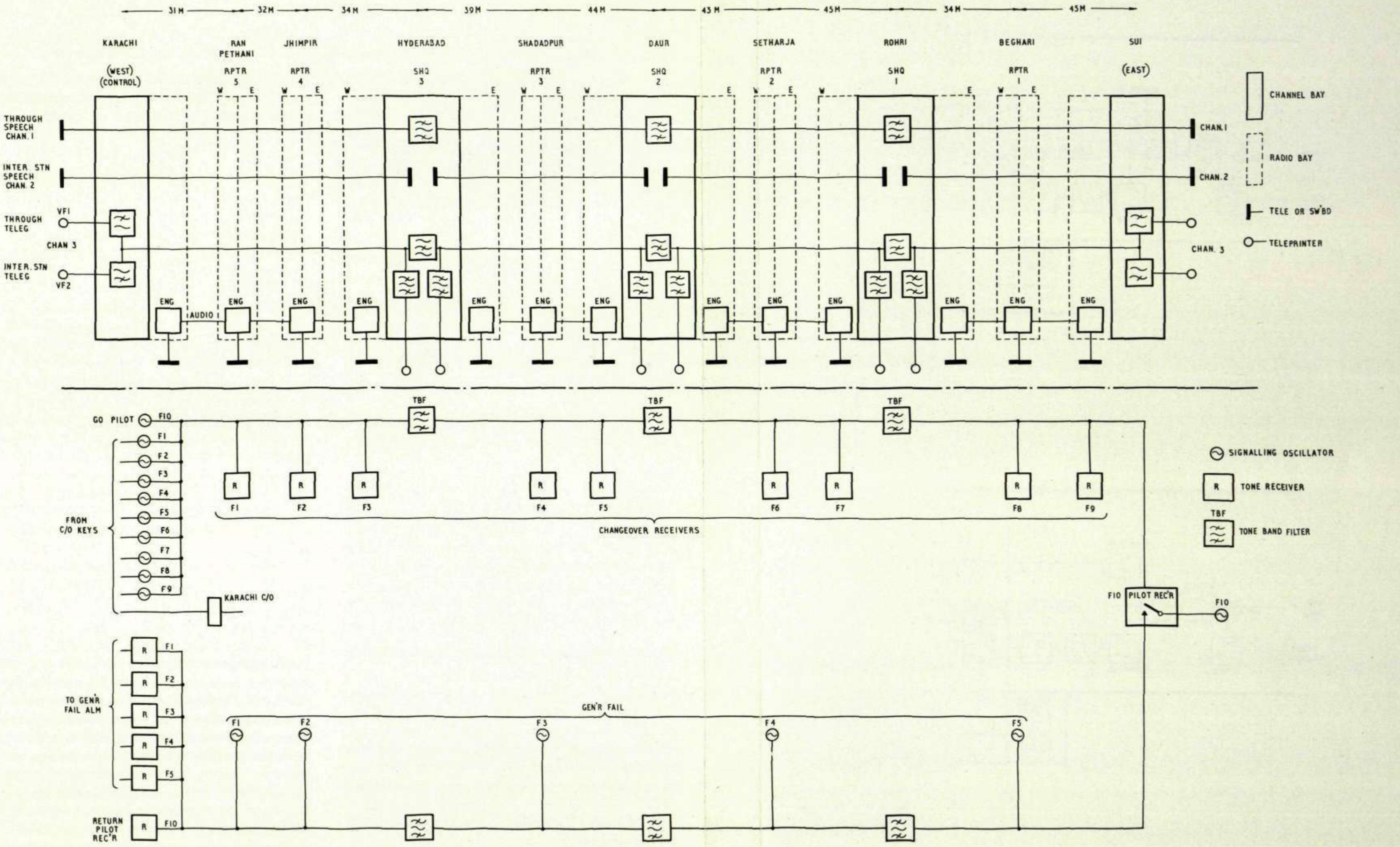


Fig. 1—(*Top*)—Station Positions and Carrier Channel Allocations
Fig. 2—(*Bottom*)—Allocations of Alarm and Changeover Equipment

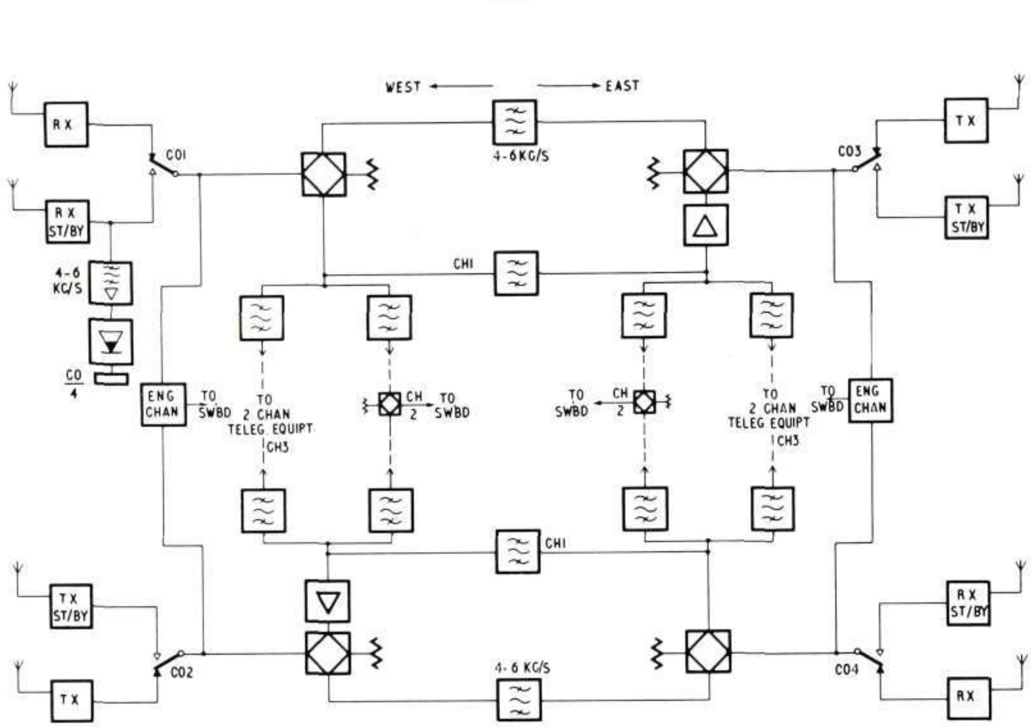


Fig. 3—Schematic of Station Equipment at a Typical Section H.Q.

from Karachi to Sui, where it is detected by a pilot receiver which re-transmits the tone to Karachi. Any failure of the radio equipment which causes a break in service results in a pilot failure at Karachi. This releases the Karachi pilot receiver relay, which lights an alarm lamp and rings the bell on the control panel. The engineer at Karachi then proceeds to change over to standby radio equipment along the link until the pilot has been restored.

Remote Changeover to Standby Radio Working

The control panel at Karachi is equipped with a row of keys and alarm lamps, each key being associated with the remote changeover function for one station. To change over to standby working, the engineer operates the appropriate key and transmits a tone which is detected only by the station concerned, as an individual tone frequency is allocated to each station. The tone input level to the transmitter is −11 dBm, i.e. 11 dB below sideband levels, and the frequency allocations are as shown in the following table (see also Fig. 2) :—

Key	*Tone*	*Station*
1	—	Karachi
2	3·9 Kc/s	Repeater No. 5
3	4·1 Kc/s	Repeater No. 4
4	4·3 ,,	S.H.Q. No. 3
5	4·5 ,,	Repeater No. 3
6	4·7 ,,	S.H.Q. No. 2
7	4·9 ,,	Repeater No. 2
8	5·1 ,,	S.H.Q. No. 1
9	5·3 ,,	Repeater No. 1
10	5·5 ,,	Sui
11	5·7 ,,	Pilot Tone

All stations normally have both main and standby receivers operating, but the h.t. supply is disconnected from the standby transmitters. Considering any one station : a tone receiver is connected across the output of the standby radio receiver, and upon receipt of the appropriate tone, the tone receiver relay is brought into operation and initiates the changeover. The h.t. is switched from the working to the standby transmitters (east and west working), and the engineer's channel panel and all station alarm equipment is connected to the through pairs associated with the standby radio equipment. Thus, upon receipt of a pilot alarm at Karachi, the engineer locates the fault by changing over each station in turn to standby working until the pilot is restored. The key which, when operated, effects this restoration is that associated with the faulty station.

At the Section H.Q.'s, the tones must bypass the channelling equipment. A filter, with a pass band of 4·0—6·0 Kc/s, is connected by means of hybrid transformers from the receiver output to the transmitter input in both directions of transmission (see Fig. 3).

This manually operated system of remote changeover control with a loop pilot alarm is preferred to purely automatic changeover, because the complexity of the latter system demands a higher standard of maintenance than is necessary with the former, which is simple both to maintain and operate. Further, a manual system makes the routine testing of the standby equipment, and the locating of any noisy link section, easier, whilst its cost is much less than that of an automatic system, the price of which may often be almost equivalent to that of the actual radio equipment. Again, with the greater amount of apparatus required for automatic working there is inevitably a greater liability to faults. It may be argued against the manual system that it necessitates the constant attendance of an engineer at the control station, but as highly reliable communications are essential for the pipe line maintenance staff, the station must, in any case, be continuously manned.

Generator Supply Failure Alarm

Each radio repeater station obtains its main power supply from a gas-driven generator. A similar generator and also a diesel-driven machine are installed as standbys, the latter being used only if a breakdown of the fuel supply to the gas-driven generators occurs. Changeover to standby working is normally effected manually, as there is an engine attendant at each station, but supply failure alarm and automatic changeover equipment is provided, so that stations can be left unattended if required. In the event, if the main generator fails, a no-volt relay connected across its output is released, starts up the standby generator and transmits a tone to a tone detector at Karachi, which operates a relay to give audible and visual signals on the control panel and indicate the station at which the changeover has taken place.

To each repeater station is allocated an individual tone frequency, namely, 4·7, 4·5, 4·3, 4·1 and 3·9 Kc/s respectively for stations No. 1 to 5. Five tone receivers are connected across the output of the radio receiver at Karachi to detect these tones. It should be noted that although these frequencies are also allocated to some of the radio changeover tones, the latter are transmitted in the direction Karachi—Sui, whereas the generator alarm tones follow the direction Sui—Karachi ; further, the radio paths are essentially four-wire circuits , thus there is no danger of any interference or false operation.

V.F. Telegraph Equipment

As already stated, the telegraph equipment provides two v.f. channels, each operated independently by double current teleprinters.

V.F. Channel 1 utilizes a signalling tone of 420 c/s and provides a direct duplex telegraph circuit between Karachi and Sui.

V.F. Channel 2 utilizes a signalling tone of 1020 c/s and provides direct duplex telegraph circuits between any two adjacent stations in the system. Switching facilities are provided at each Section H.Q. to connect stations in tandem, thus making direct communication between any two stations in the system possible.

The Karachi and Sui equipments are of identical type and consist of a power supply panel, a transmit and test panel and a receive panel mounted, together with the radio changeover and alarm equipment, in a cabinet.

The power supply panel provides the h.t. and l.t. supplies for all the valve circuits in the equipment, and 120–0–120 V.d.c. for the teleprinters.

The transmit and test panel contains the channel oscillators, telegraph modulators, transmit filters, and all controls and test access points associated with the transmit path of the circuit. Test facilities provided on the front panel allow measurements to be made of the d.c. telegraph current on either the transmit or receive sides of the teleprinters.

The receive panel similarly contains all units associated with the receive path, namely, filters and amplifier detector units, with test access points

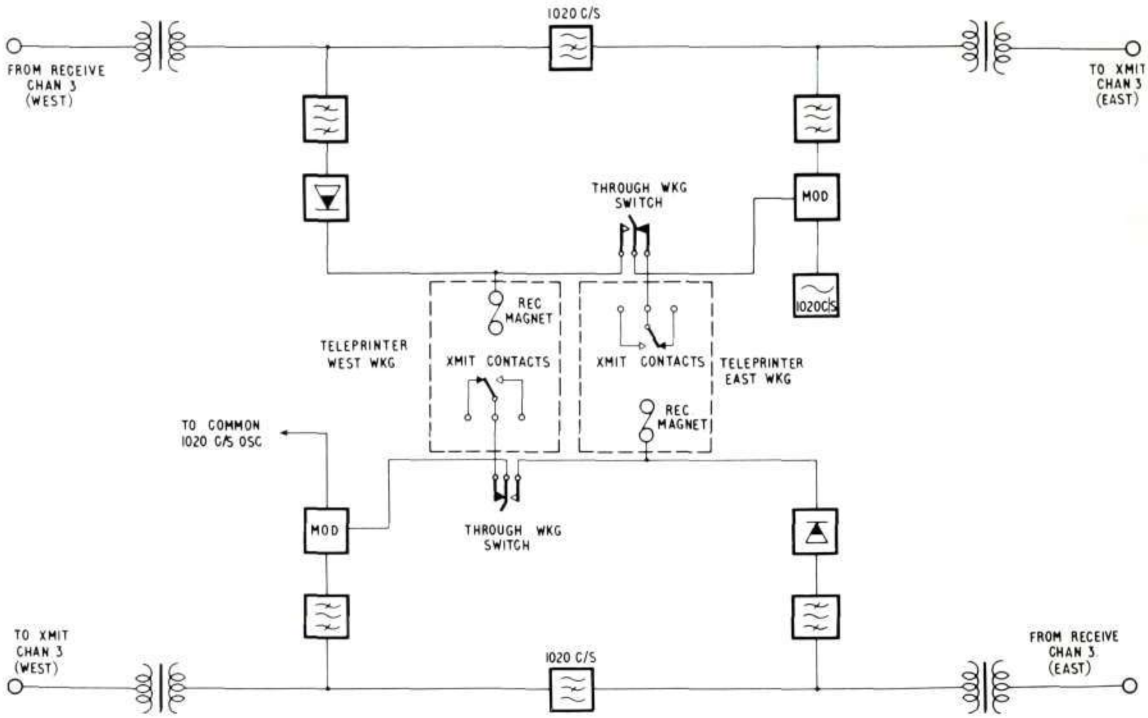


Fig. 4—Schematic of Telegraph Channel Equipment at a Typical Section H.Q.

brought out to the front panel. A valve circuit, consisting of two valves arranged to operate as a both-sides-stable relay, replaces the normal mechanical high-speed relay, and an adjustment is provided to correct any bias distortion of the detected signal.

Similar panels are fitted at the Section H.Q.'s, although the circuit conditions here are a little different from those at the terminal stations (see Fig. 4). V.F. Channel 1 (420 c/s) transmissions are received, with those of V.F. Channel 2 (1020 c/s), at the output of the carrier channel, and are passed direct via a 1020 c/s band stop filter for re-transmission to the next station along the link. V.F. Channel 2, on the other hand, has two channel ends, one working towards Karachi and the other towards Sui. They are effectively isolated from each other by the 1020 c/s band stop filters, but share a 1020 c/s signalling oscillator. Each channel end is otherwise identical with that of a terminal station.

Through switching of V.F. Channel 2 is performed by the operation of tumbler switches which connect the west directional d.c. receive signals to the east directional modulators, and vice versa. The station teleprinter receive magnets remain connected across the through d.c. signalling pairs, thus providing a local record of the message to indicate when the circuit can be restored to normal.

Creed, Model 54, page teleprinters are used throughout the system, each station having two machines mounted on a table with the through-working tumbler switches. They are fully tropicalized teleprinters fitted with radio interference suppression filters, and transmit at a speed of 50 bauds.

Station Switchboards

25-line switchboards are installed at Karachi and Sui, and 10-line switchboards at each of the Section H.Q.'s. The carrier and engineer's channels terminate as exchange lines, the extension lines being for internal communication in the particular station.

The allocation of circuits to the boards is as follows :—

Type of Circuit	*Number of Circuits Equipped* 25-*line switchboard*	10-*line switchboard*
Carrier Channel 1 ..	1	–
,, ,, 2 ..	1	–
Engineer's Channel ..	1	–
Carrier Channel 2 (West)..	–	1
,, ,, 2 (East)..	–	1
Engineer's Channel (West)	–	1
,, ,, (East)	–	1
Fixed Station Radio ..	1	1
Extension Lines ..	21	5

The fixed station radio circuit enables mobile radio equipment in the field to obtain access to the trunk circuits.

The power equipment for the boards is of the automatic float type, consisting of a main battery and an automatic charging unit. The battery has a capacity of 10 ampere-hours at the 10-hour discharge rate, and comprises 12 lead-acid, sealed-in, Planté type cells. It is floated at approximately 2·15 volts per cell across the charging unit, which is operated from the 200/250V, 50 c/s mains supply ; in the event of a mains failure the battery has a reserve of power sufficient to operate the switchboard for a further 24 hours. The charger incorporates equipment which may be manually operated to give the battery an occasional gassing charge. Apart from this service, the power plant can be left unattended.

The final stage of installation of the communication equipment has recently been completed, and full, satisfactory service is being given over the whole route.

This article is published by kind permission of the Burmah Oil Company (Pakistan Trading) Limited.

LOUDSPEAKER INTERCOMMUNICATION TELEPHONE

TYPE N.1747A

The loudspeaker telephone described in this article is designed for use as a master station instrument in intercommunication systems employing Types N.1732/N.1733 moulded cased side station telephones. A description of the latter and an illustration of a typical wall telephone appeared in Bulletin No. 27, July 1953.

THE loudspeaker intercommunication telephone—designed for the managerial office—will afford the executive freedom of movement while he converses by telephone—a particularly welcome facility when it is necessary for him to consult records or make notes. The equipment includes a loudspeaker and a microphone which together enable the speaker to carry on a conversation without engaging either hand. The two equipment items mentioned have not always been incorporated in the instrument; one of the Company's early models contained only the signalling and switching apparatus, the loudspeaker being housed in a separate cabinet, and the microphone in a specially constructed inkstand.

The Type N.1747A loudspeaker telephone recently designed (Fig. 1), contains the loudspeaker, microphone and the switching and signalling components, the only extraneous items being the dry cells required for signalling and speech current.

It will be apparent from the illustration that whilst the design of the new telephone accords well with contemporary styles it has a dignity in keeping with more traditional types of office furnishings.

The wood of the casework, a warm-coloured close grained hardwood semi-matt polished in the natural shade, was specially chosen to tone with the chocolate bronze colouring of the attractive plastic lattice grill and the key mounting plate. Distinction is given to the set by touches of contrasting colour in the form of a polished black strip at the base of the grill, a decorative red "engaged" lamp in the centre of the grill, and wedge shaped mid-Brunswick green key handles. For reasons which will be explained, the key at the left-hand end has a red handle, in certain circumstances.

A black moulded handset with an extensible cord rests on a bronze-finished cradle at the side of the telephone.

An incoming call is signalled by a buzzer in the telephone, and its origin is visually indicated by the glowing of the appropriate lamp behind the designation strip below the keys. This strip comprises a curved transparent plastic window, behind which is a frosted plastic strip on which the names of persons or departments are printed in black characters slightly magnified by the curvature of the window. The construction of the lamp and designation strip assembly is such that when any particular lamp glows, the printed characters in front of it are clearly outlined in a dark-edged rectangle of diffused white light which a plastic shroud screens from any other printing on the strip.

Fig. 1—Type N.1747A Loudspeaker Telephone Equipped for a 15-line System

A valuable feature of the new instrument is the ease of maintenance which its design affords. This is exemplified in Fig. 2, which shows the key and lamp strip assembly drawn forward from the case to allow access to the key springs, etc. The assembly is fastened in the case by four screws incorporated in

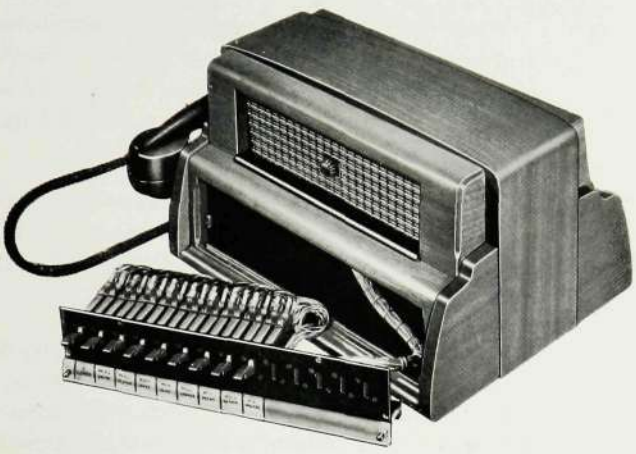


Fig. 2—Showing Key and Lamp Strip Assembly Removed

the key mounting plate. Should it be necessary to replace a lamp, the strip can be drawn forward independently of the key mounting. This is done by releasing the two captive knurled nuts at the ends of the window strip, and removing, successively, the window strip, the designation strip and the plastic shroud (Fig. 3), the last of which has a separate compartment for each lamp. The lamp strip can then be pulled forward.

Access to other internal components is gained by releasing two captive screws and removing the rear portion of the case (Fig. 4). This exposes the instrument terminal block, which is held in position by four screws. When these are released, the terminal block can be withdrawn to reveal the buzzer, loudspeaker, transformer, "engaged" lamp jack and the wooden cover which encloses the microphone. The latter is protected by rubber from contact with the edges of the microphone aperture and is held in position by a tensioned spring.

A multi-conductor flexible cord connects the telephone to a desk terminal block (Fig. 5), which has a case of polished wood to match the instrument and contains screw terminals for the connection of the line wires, battery wires and, when required, a separate external loudspeaker.

The Type N.1732/N.1733 intercommunication side station telephones used with this new loudspeaker master station telephone have facilities permitting their connection to one or two master stations. With one master station there may be a maximum of 14 side stations ; with two, 13 side stations. It follows that the master station must be capable of connection either to 14 side stations or to 13 side stations and one other master station ; in each case, 14 keys are used. The circuit wiring can be so arranged that the key on the extreme left in the loudspeaker telephone may be used for an ordinary or master station line. The necessary wires are connected to the instrument terminal block, the type of connection required being determined solely by the interconnection of the appropriate terminals and the fitting of a 6-volt bulb for a master station line or a 4-volt bulb for an ordinary line. This arrangement offers the advantages, firstly, that only one type of loudspeaker telephone need be stocked, since it can be easily modified to suit the alternative system ; secondly, that telephones already installed in a single-master system can be adapted *in situ* for two-master working. Identical keys are used in all the fourteen positions, except that a red handle is fitted on the first key when this is used for a master station line.

The circuit arrangements are such that calls can be originated or answered with the minimum of manual operation.

To make a call, the appropriate key is pressed to

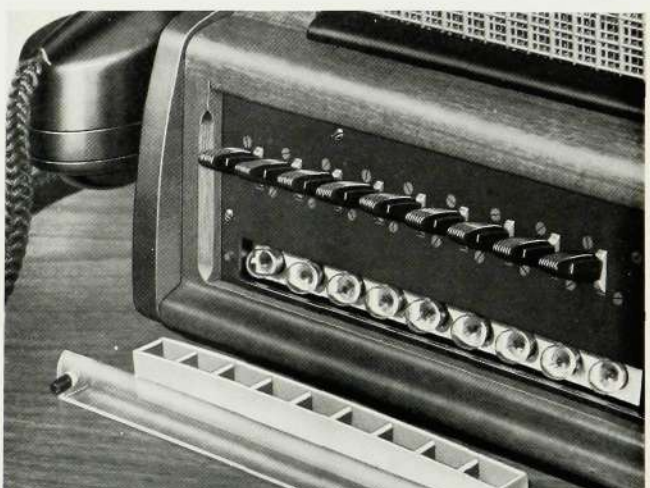


Fig. 3—Showing Lamp Strip with Plastic Shroud and Window Removed

Fig. 4—Rear View with Cover Off

the full extent to operate the buzzer in the distant telephone. When the key is released it returns to an intermediate "conversational" position. To release the connection it is necessary only to restore the key to the normal position ; if this is not done and the person at the other end of the line re-calls, the latter can overhear any conversation taking place at the master station. But the "engaged" lamp glows whilst any key remains operated and serves as a reminder to release the connection.

If privacy of reception is desired, the telephone handset may be used , the action of lifting it from the cradle operates a switch which cuts out the loudspeaker.

Should there be a call to the master station when the latter is already engaged, it will not be audibly signalled but the appropriate call lamp will glow to warn the master that another station is calling.

All calls to and from a master station, whether master-to-master or master-to-side station calls, are secret. Side station-to-side station conversations are non-secret to the extent that a side station calling a party to an established conversation can overhear.

When there are two master stations, one calls the other by pressing the red key. In the ensuing conversation the handset must be used by one of the two ; which shall do so may be pre-determined by mutual arrangement ; alternatively the loudspeaker facility at one station may be restricted, being made available for all except master-to-master calls. Such a restriction is imposed by the removal of a strap from the instrument terminal block.

When the buzzer in the loudspeaker telephone is actuated by an incoming call, it returns a buzzing tone when the master station is free and is receiving the signal. No tone is returned if the master station is engaged.

Simplified elements of the loudspeaker telephone circuit are shown in Fig. 6 to clarify its working under the various conditions. A full schematic diagram may be seen in Fig. 7.

In Fig. 6A, the call lamp in No. 2 telephone is lit by current from the local microphone battery via the primary winding of the loudspeaker transformer at No. 1. When the key at No. 1 is pressed to the full extent, its springs K26-27 operate the buzzer at No. 2, from the "ringing" battery.

In Fig. 6B, the primary of the transformer provides a loop connection for the microphone in the No. 2 handset, the receiver of which completes a battery circuit for the microphone at No. 1. Also in Fig. 6B may be seen the terminals M and N, which in master station No. 2 are disconnected to cut out the cabinet microphone, for the restricted loudspeaker working mentioned above.

When the appropriate button at a side station is pressed to call the master station (Fig. 6C), current from the ringing battery, which is common to all the side stations, operates the master station buzzer, whilst the side station telephone receiver completes a circuit to light the call lamp from the master station ringing battery.

When the call is from master station to side station (Fig. 6D), it is the loudspeaker transformer winding, or the receiver of the handset, if that is in use, that completes the circuit for the master station lamp on the side station telephone, the key springs K26-27 applying current from the ringing battery to the buzzer over lead HL.

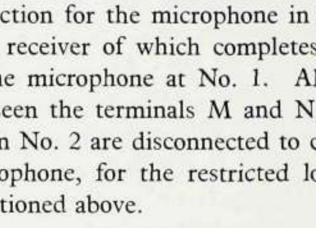


Fig. 5—The Desk Terminal Block for the Loudspeaker Telephone

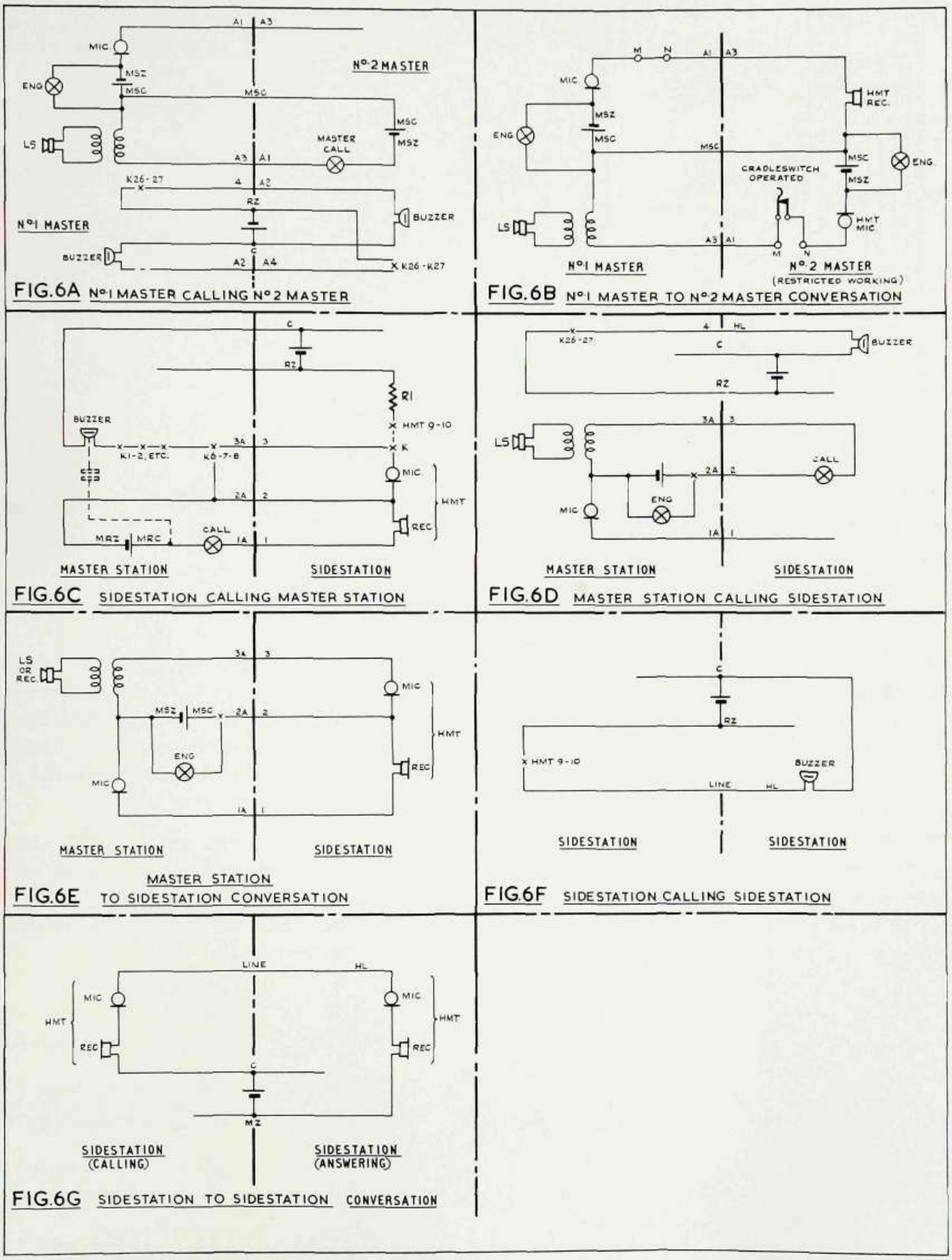


Fig. 6—Simplified Elements of the Loudspeaker Telephone Circuit

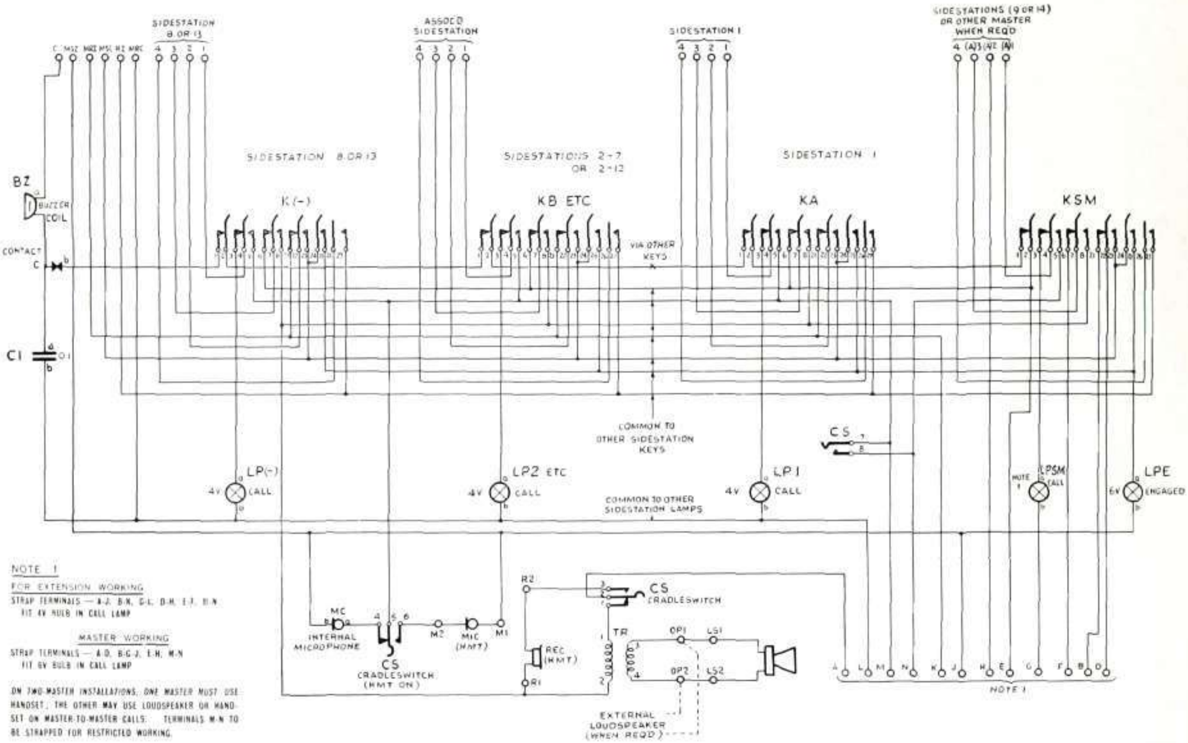


Fig. 7—Schematic of the Complete Telephone Circuit

Under the conditions shown in Fig. 6E, the master station microphone operates in series with the side station receiver via the master station speech battery, and the side station microphone operates via the transformer winding and the same battery.

Figs. 6F and 6G, showing side station-to-side station connections, while not strictly relevant to this article, are included as being of interest.

Loudspeaker master station telephones greatly extend the facilities offered by the intercommunication system, and their usefulness as time-saving devices for the busy executive is being more and more widely appreciated. The Type N.1747A instrument is likely to prove popular because of its simplicity of operation, convenience for maintenance and pleasing appearance.

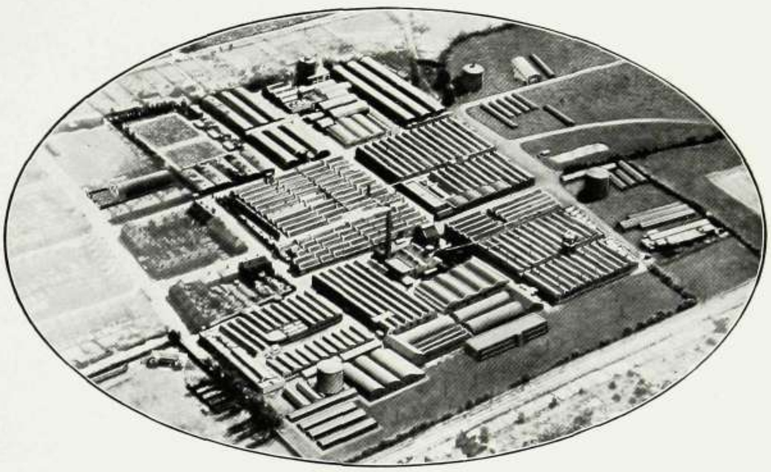
The stock instruments are equipped with either the full complement of fourteen keys or with nine keys and six key dummies as in Fig. 8 ; the respective telephone Type Nos. for the specified systems are as follows :—

Fig. 8—Type N.1747A Telephone Equipped for a 10-line System

Type No.	*Equipped Keys*	*Type of System*
N.1747A1	9	10-line, with 1 master and 9 side stations.
N.1747A2	9	10-line, with 2 master and 8 side stations.
N.1747A3	14	15-line, with 1 master and 14 side stations.
N.1747A4	14	15-line, with 2 master and 13 side stations.

DERRY & SONS, LTD.
PRINTERS
NOTTINGHAM, ENGLAND

Part of the "Model Room" at the Beeston, Nottingham, Works



The Main Works at Beeston, Nottingham, England

Some of the Modern Plant Used in Metal Finishing Processes at Beeston