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TRANSISTOR SINGLE CHANNEL CARRIER SYSTEM ETL 14

E. H. NORMAN, Grad.I.E.E. — Carrier and H.F. Development Department

This equipment enables an extra speech circuit to be superimposed on an existing circuit without mutual interference. The use of transistors has made possible a remarkable reduction in power consumption; less than ¼ watt per terminal is required, as against 60 watts for the previous thermionic valve operated apparatus. The voltage at which the power is supplied has also been reduced, and the new equipment can be operated from a 6-volt dry battery for long periods. Greater robustness is among the other advantages resulting from the employment of transistors, and a high degree of reliability has been obtained by suitable design. Some of the units use printed wiring, which adds to reliability and saves space. The ETL 14 *equipment uses New Equipment Practice mountings.*

OPERATING PRINCIPLES AND SYSTEM FEATURES

WHEN it is necessary to add a speech circuit to a system of open-wire or cable-pair circuits, the cost of installing extra lines or cables is high. It is often better to employ terminal equipment which enables one of the existing connections to carry the additional circuit without interference between the original circuits and the one added. The Company has for some time manufactured equipment for this purpose which makes use of thermionic valves and consumes about 60 watts at each terminal.

The newly-developed ETL 14 system employs transistors which confer many advantages, the most notable being that the power requirement is reduced to less than ¼ watt per terminal. The power is supplied at 6 volts d.c. and a dry battery which gives six months' continuous operation is available. As an alternative, a transformer and rectifier unit can be provided for mains operation, and if required a floated nickel-cadmium secondary battery can be included to maintain service during mains failures lasting up to 48 hours. Arrangements can also be made to cause a mains failure to transfer the equipment to an external 6-volt supply. The power supply components are accommodated within the equipment case.

Operation is satisfactory over circuits with attenuation not exceeding 38 db at 8·7 kc/s; equalization is provided to compensate for the variation of attenuation with frequency. For 200 lb. copper open-wire line the system provides a carrier circuit over distances up to 380 miles. This is about 30% less than the corresponding figure for the valve equipment, but such a reduction in range is a small price to pay for a 240-fold decrease in power consumption. For line lengths exceeding 50 miles it is usually more economical to use the single channel carrier system than to install an extra line.

Absence of mutual interference is ensured by translating the speech frequencies of the added circuit to a region not occupied by the original circuit. The equipment at each terminal includes a 6000 c/s carrier oscillator which is modulated by the speech signals. The speech frequencies lie between 300 and 2,700 c/s, so that an upper sideband extending from 6,300 to 8,700 c/s and a lower sideband extending from 3,300 to 5,700 c/s are produced. At one terminal, designated terminal A, the upper sideband is transmitted and the lower sideband from the other terminal (designated terminal B) is received. Terminal B transmits the lower and receives the upper sideband. The complete equipment for one terminal is shown in Fig. 1, and Fig. 2 shows the apparatus with the case removed.

DESIGN CONSIDERATIONS

Transistors are more robust than valves, and are lighter, so that transistor apparatus can be designed to have a high degree of resistance to shock and vibration without great expense. The units of the single channel carrier equipment which use printed wiring have their transistors mounted in rubber grommets secured by tinned copper wire to the panel. This arrangement gives resilience at very low cost. The transistor wire ends are soldered directly to the appropriate points on the printed wiring. The first cost of a transistor is greater than that of a valve at present, but this can be more than offset by the economies brought about by proper electrical and mechanical design in applications for which transistors are suitable; moreover,

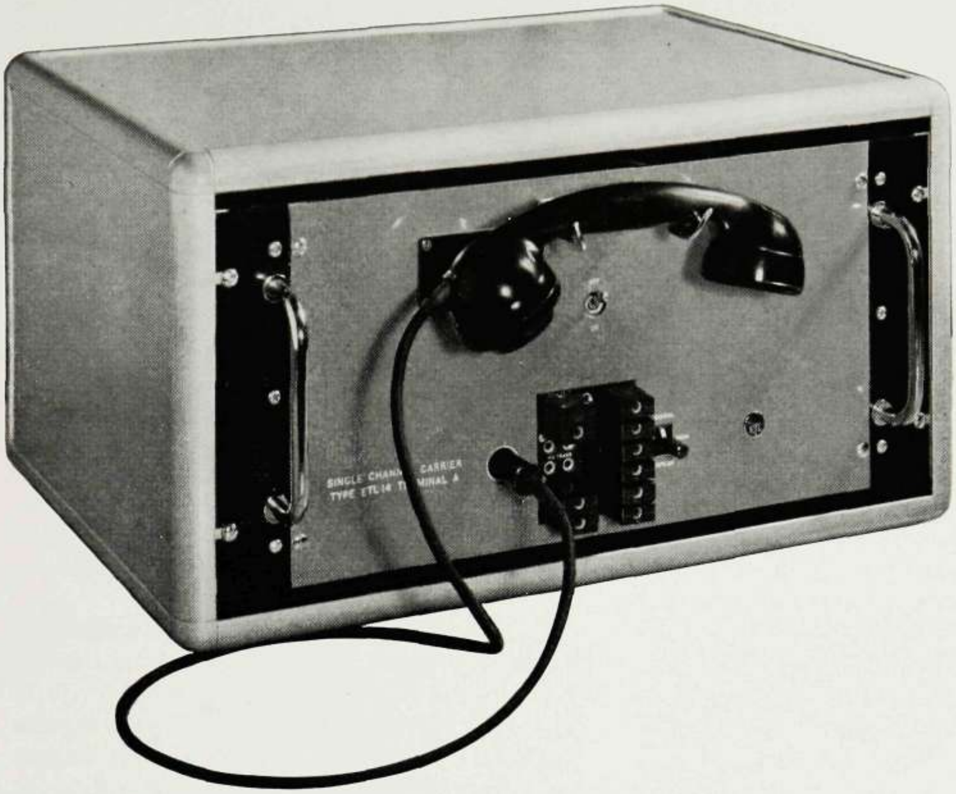


Fig. 1—Type ETL14 Terminal Unit

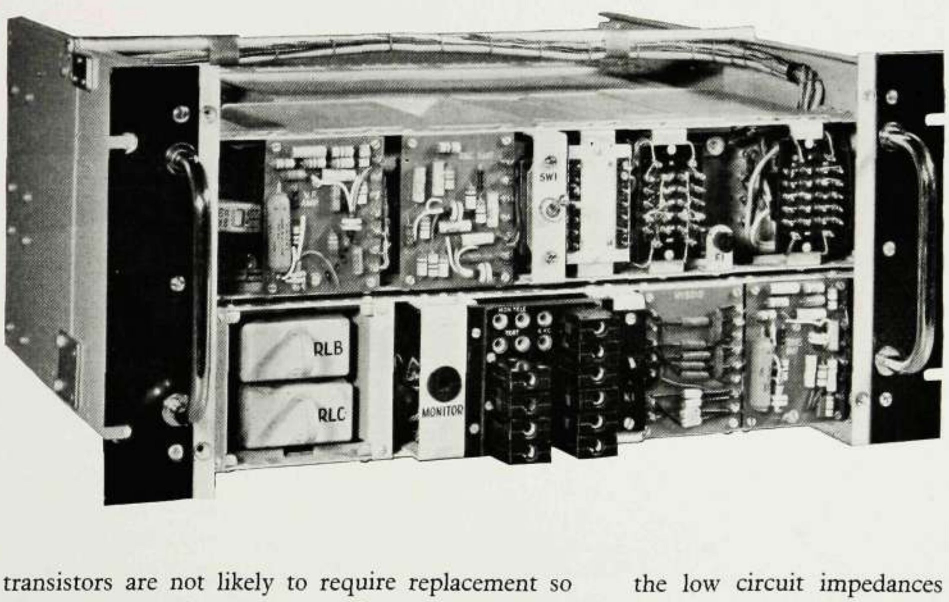


Fig 2—Front view of the Unit with case removed

transistors are not likely to require replacement so frequently as valves. The low impedance level at which transistor circuits operate is a great advantage in the single-channel carrier equipment. Although the random noise generated by the transistors themselves is greater than with valves, the freedom from externally induced interference conferred by the low circuit impedances results in the overall noise level being lower than that of the previous valve-operated apparatus.

The transistors used in the ETL 14 equipment are Mullard OC71 and OC72 types. (The recently published P. O. Transistor No. 3 Specification corresponds approximately with the OC71). The amplifiers in the equipment employ printed wiring, and the transistors are connected in the common emitter configuration. Design has aimed at minimum power consumption consistent with reliable functioning under all operating conditions. Negative feedback is used to stabilize performance against transistor and other component tolerances, against variation in transistor characteristics with temperature, and against change in supply voltage during the life of the battery. The transistors used will give satisfactory operation in ambient temperatures up to 55°C and when the nominal 6-volt supply has fallen to 4½ volts.

The equipment contains a Transmit Amplifier, a Receive Amplifier and a Voice Frequency Amplifier. Each of these is mounted on a separate printed wiring panel. In addition, a Ringing Receiver and an Oscillator Unit mounted in standard cans are provided, and if no external source of 17 c/s ringing current is available a Ringing Generator Unit mounted on a printed wiring panel can be supplied assembled in the case with the other units.

A block diagram of the terminal equipment is shown in Fig. 3.

Amplifiers

Fig. 4A shows the Transmit Amplifier assembled on its printed wiring panel. A gain of 37 db with a maximum output level of +12 dbm (16 mW) is obtained for a consumption of about 10 mA from the 6-volt supply. The normal output level is +10 dbm (10 mW). The input and output impedances are controlled by negative feedback to give a return loss against 600 ohms of more than 20 db. over the working frequency range of 3·3 to 8·7 kc/s. The design is such that no imput transformer is required ; this saves space, weight and expense. The dimensions of the printed wiring panel are approximately 3" x 2½" x 1/16".

The Receive Amplifier (Fig. 4B) uses two OC71 transistors and provides 22 db. gain with negative feedback. It draws a current of 4 mA. from the 6-volt supply, and the maximum output level is —6 dbm (¼ mW). No transformers are used in this amplifier, which is only required to raise the signal to a suitable level for application to the demodulator.

The Voice Frequency Amplifier gives a maximum output of +7dbm (5 mW) for frequencies in the range 300 c/s to 2·7 kc/s. The gain of 37 db. is provided by one OC71 and one OC72 with negative feedback. A separate winding on the output transformer couples the unit to the Ringing Receiver. No input transformer is used, and consequently the standard printed wiring panel is employed.

Oscillator Unit

In the Oscillator Unit (Fig. 5), an OC71 transistor functions as the 6000 c/s generator. This stage operates in the common-base mode, so as to minimize

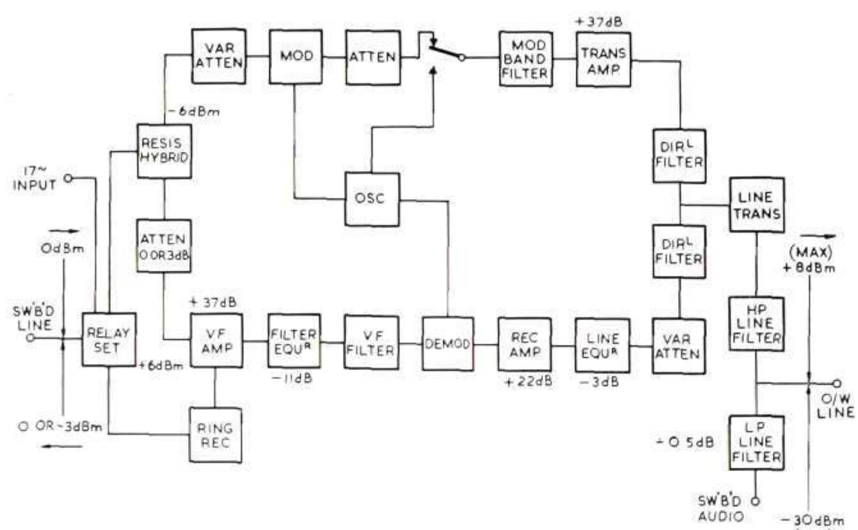
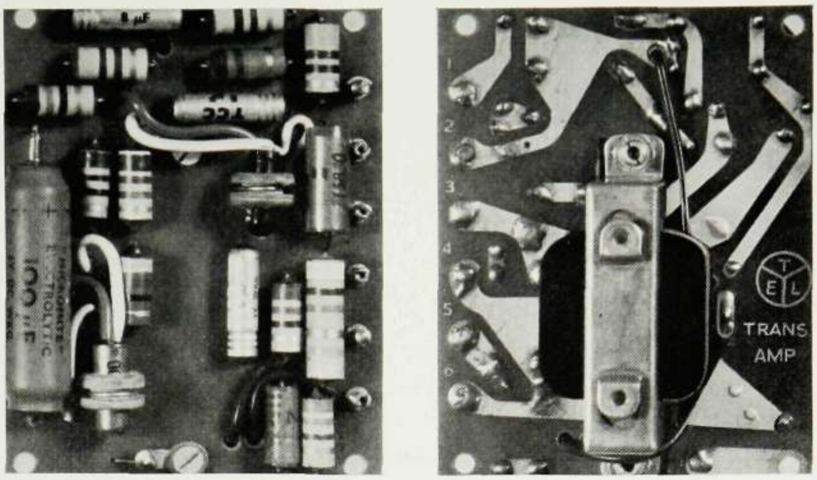
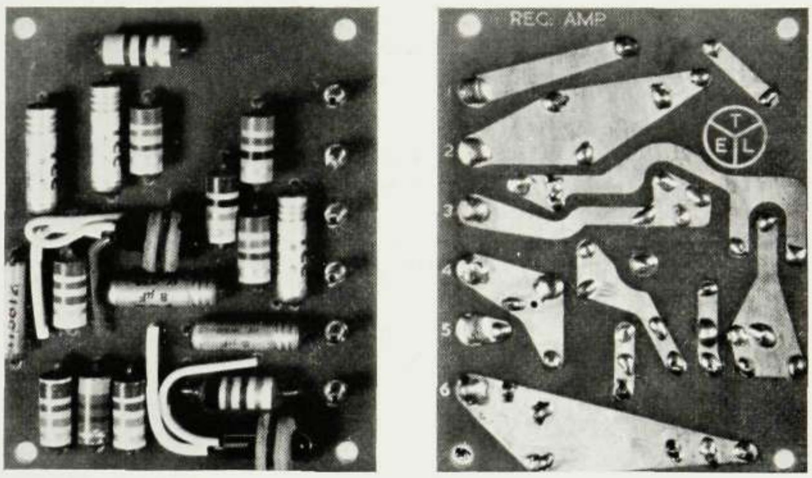


Fig. 3—Block Diagram of the Terminal Unit



FRONT REAR

Fig 4A—Transmit Amplifier Panel



FRONT REAR

Fig. 4B—Receive Amplifier Panel

the phase shift introduced by the transistor. The effect on the oscillator frequency of the changes in internal transistor capacitances with temperature and supply voltage are thus kept as small as possible. The frequency is controlled by a tuned circuit consisting of a close tolerance polystyrene dielectric capacitor and a Ferroxcube inductor. The temperature coefficients of these components are of approximately equal magnitude but opposite sign, so that little change in resonant frequency occurs as the temperature varies.

To prevent load variations from affecting the oscillator frequency, an OC72 transistor is used as a buffer amplifier, coupled to the oscillator stage by way of a high resistance, and the complete unit is mounted in a standard can.

RINGING RECEIVER

Fig. 6 shows the circuit of the Ringing Receiver, which is also mounted in a standard can. When 17 c/s ringing current is applied to one of the carrier system terminals, a relay is operated which changes the carrier frequency by 500 c/s, increasing the frequency in the case of the A terminal and decreasing it if ringing is applied to the B terminal. Hence in either case demodulation at the other terminal results in the production of a 500 c/s signal. This

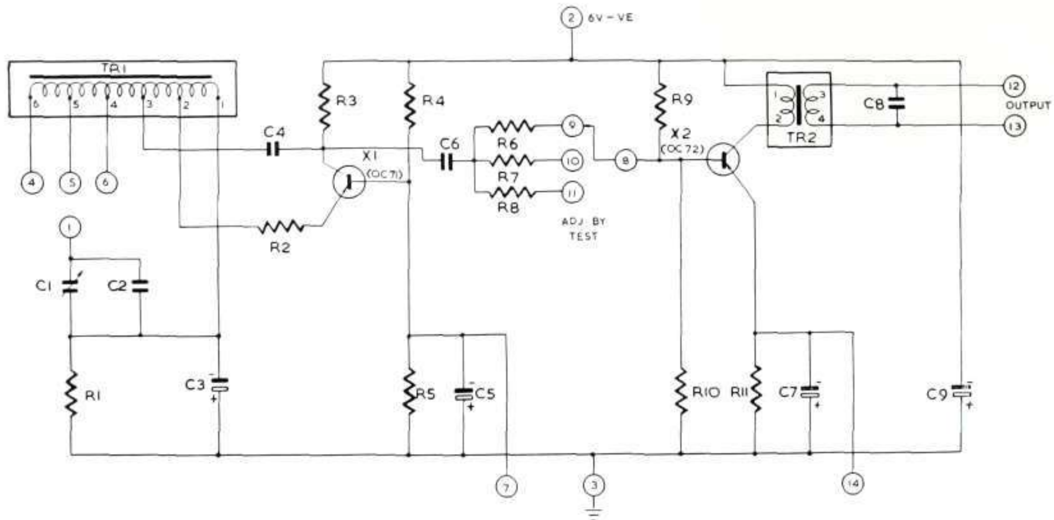


Fig. 5—Oscillator Unit Circuit

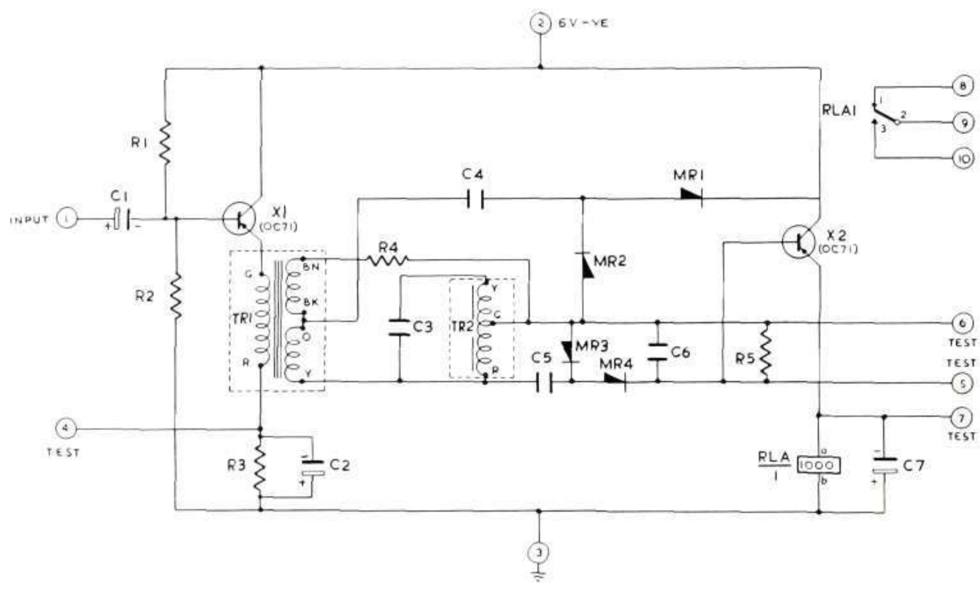


Fig. 6—Ringing Receiver Circuit

is amplified by the Voice Frequency Amplifier and applied to the Ringing Receiver. The first stage of the Ringing Receiver is an OC71 emitter follower which isolates the Voice Frequency Amplifier from the frequency-dependent impedance of the circuit which detects the 500 c/s ringing signal. The emitter follower output is applied to a bridge circuit connected to a system of rectifiers. The bridge is balanced when it receives a signal containing no frequency other than 500 c/s, and in consequence a d.c. signal is applied between the collector and base of the second OC71 in the Ringing Receiver. This transistor normally passes sufficient current to hold the relay in its emitter circuit operated, but the d.c. resulting from the rectification of the 500 c/s signal cuts off the current and so releases the relay. The relay contacts then cause 17 c/s ringing current to be connected to the local switchboard terminals. When speech signals are applied to the Ringing Receiver, the bridge is unbalanced ; the e.m.f. produced in the rectifier network by the 500 c/s component of the input signal is counteracted by an opposing e.m.f. resulting from the components at other frequencies, so that no d.c. signal is applied to the second transistor and the relay does not release.

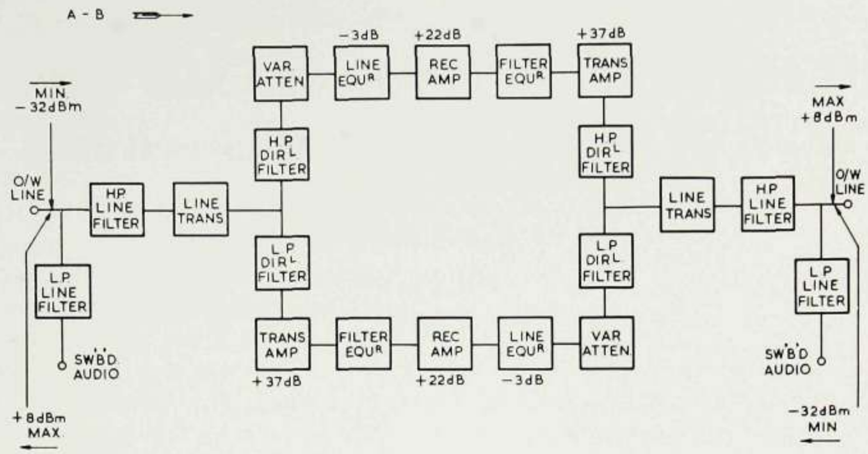


Fig. 7—Block Diagram of the Repeater Unit

RINGING GENERATOR

When no external source of 17 c/s ringing current is available, a Ringing Generator Unit is included in the terminal equipment. A 17 c/s multivibrator employing two OC71 transistors drives a class B output stage which in turn feeds the output transformer. The transformer modifies the waveform so as to simulate that produced by a magneto generator. The Ringing Generator is mounted on a 3″ x 2½″ printed wiring panel.

REPEATERS (FIG. 7)

As previously stated, operation is satisfactory over circuits with attenuation not exceeding 38 db at 8·7 k c/s. This represents open-wire line lengths of the following order:—

350 miles of 150 lb. copper

380 miles of 200 lb. copper

420 miles of 250 lb. copper

For longer lines, a repeater of similar construction to the terminal equipment has been designed for introduction at intermediate points. It has a maximum gain of 40 db and a maximum output of +8 dbm.

The same power supply arrangements are available for the repeater as for the terminal equipment, the requirements being of a similar order. Power consumption is approximately 30 mA at 6 volts.

Many of the units in the repeater are identical to those in the terminal equipment, and provision is made for line slope equalization adjustment to compensate for the additional attenuation slope introduced by the extra length of line.

MANUFACTURING CONSIDERATIONS

The use of transistors and printed wiring has made it possible to produce the ETL 14 equipment at a lower price than its predecessor, which employed thermionic valves and conventional construction methods. In the design of the circuits, attention has been given to manufacturing considerations as well as to securing the required performance with minimum power consumption and component costs. The use of printed wiring adds to reliability and reduces cost per unit. However, certain types of unit are not suitable for printed wiring, and the advantages of the technique are nullified if attempts are made to employ it in these cases. It is by attention to such considerations that the full benefits of new devices and methods of manufacture are realized, and the ETL 14 equipment demonstrates the improvements which can be obtained when new techniques are used to the best advantage.

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FLAMEPROOF TELEPHONES AND THE DEVELOPMENT OF A TABLE MODEL

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(Reprinted from The Post Office Electrical Engineers' Journal by kind permission of the Engineer-in-Chief of the British Post Office)

This article outlines the methods of ensuring that telephones used in situations where dangerous gases and vapours are present do not cause explosions, and refers to the arrangements for certification of the degree of safety provided by specific items of telephone apparatus. The article then refers briefly to existing Post Office flameproof telephones and continues with descriptions of two versions of a newly developed table model flameproof telephone.

Introduction

Although the telephone works at such low power that its safety in everyday use is never in question, there are circumstances in which great care must be taken to ensure that a spark at a contact or at an accidental disconnexion cannot cause an explosion if dangerous gases or vapours should be present.

Oil refineries and chemical plants are perhaps the two main places which spring to mind when considering where explosive gases might occur, and with the increasing consumption of both oil products and synthetic materials, and the consequent increase in the number and size of the industrial plants concerned, the safety of life and plant from the dangers of explosion is worthy of all the care and attention that is given to the design and manufacture, and the installation and maintenance of special equipment.

Telephone apparatus for use in mines, which is not fitted by the Post Office, is outside the scope of this article. The design, installation and maintenance of all telephone and signalling apparatus for use in mines is governed by the Mines and Quarries Act 1954, and the specific requirements are given in Statutory Rules and Orders No. 797 and No. 1407: 1938.

Methods of Providing Safety

Although alternative methods are occasionally used in heavier forms of electrical engineering, in telephone engineering the two principal methods of providing safety utilize either a circuit that is safe because it cannot cause a dangerous spark (intrinsic safety), or a mechanical construction that will withstand an internal explosion and will not transmit flame outwards to an external explosive atmosphere (flameproof construction).

These two methods, which are described in more detail in the following sections, are the subject of practical tests which are imposed on actual items of equipment by the Safety in Mines Research Establishment at Sheffield and Buxton. On the results of these tests, a Flameproof Certificate is issued by the Ministry of Power, or a Certificate of Intrinsic Safety is issued by H.M. Chief Inspector of Factories, Ministry of Labour and National Service, or the Ministry of Power, depending on whether the equipment is for use in industry or coal mines. The equipment is type tested, i.e. the item that is tested is regarded as fully representative of the manufacturer's normal production and the certificate covers this normal production. Any subsequent change to the drawing mentioned on the certificate requires further certification.

There are cases, however, where it is not practical to use either of these two methods, and in such cases safety can be ensured as far as possible by the method and standard of construction. The Factory Inspectorate of the Ministry of Labour and National Service again issue a certificate after consultation with the Safety in Mines Research Establishment. An example of this type of certification is described later when dealing with the development of the flameproof table telephone (1,000-ohm version).

It has not yet been practicable to make a telephone handset and cord flameproof according to the requirements of B.S.229 " Flameproof Enclosure of Electrical Apparatus ", and hence, although telephones are commonly described as flameproof, usually only certain parts have been certified as such. Consequently it should be realized that in these instances the term " flameproof " is not strictly correct as a description of the complete telephone, but it is used as a convenient indication of the type of installation for which the telephone is intended.

Intrinsic Safety

Protection by the method of intrinsic safety is achieved by using a safe source of supply, either primary cells whose open circuit voltage does not exceed 24V, or a special transformer of 15V r.m.s., or in the case of a magneto telephone, by using an approved generator. All these sources of supply have limited short-circuit currents, the limitation usually being obtained by using series resistors or in the case of the generator by the inherently high impedance of the windings in conjunction with a non-inductive shunt resistor. Furthermore, the supply must not be earthed. Together with the limiting of the source of supply, it is usual to fit protective devices in the form of non-inductive resistors or metal rectifiers across the inductive components of the circuit to by-pass the inductive energy that would normally appear as a spark at switching points during the operation of the circuit. By these means any sparks, which might appear at switching points or at any point of fault, are of such low intensity that they are incapable of igniting the gas or vapour which might be present. Intrinsic safety is the statutory method used for signalling and for telephones in coal mines (Mines and Quarries Act 1954). The main reason for this is the need for the telephone system to keep pace with the moving coal face without undue attention to the standard of cabling.

Flameproof Apparatus

With protection in the form of flameproof apparatus no steps are taken to prevent the sparking that would normally occur during operation of the circuit or which might occur under fault conditions. The protection is obtained by enclosing the components in a robust metal enclosure, defined in B.S.229 : 1957 as:—

" A flameproof enclosure for electrical apparatus is one that will withstand, without injury, any explosion of the prescribed flammable* gas that may occur within it under practical conditions of operation within the rating of the apparatus (and recognized overloads, if any, associated therewith), and will prevent the transmission of flame such as will ignite the prescribed flammable gas which may be present in the surrounding atmosphere ".

The design of such an enclosure is based on the following data. All joints in a flameproof enclosure must be either flanged joints, spigoted joints or screwed joints without the intervention of any loose or perishable packing. The width of these joints and the maximum permissible gap are related to the groups of gases and vapours listed in B.S.229. The flange width in general should be at least 1 in. with a maximum permissible gap of 0·016 in., although where the gap can be more accurately controlled, widths of $\frac{1}{2}$ in. are now acceptable. The maximum gap related to the $\frac{1}{2}$-in. flange is 0·006 in. for the gases encountered in the petroleum and chemical industries.

The tests to ensure that the maximum permissible gap is not exceeded are made by checking that each part of the mating surfaces of the flanges does not vary from a true plane by more than half the stated figure, i.e. for telephone equipment covered by this article, the maximum variation is not greater than 0·003 in.

Fig. 1—Telephone No. 149

* The term " flammable ", now used by the British Standards Institution, is synonymous with the more common term " inflammable ".

Where an operating rod or spindle passes through the wall of a flameproof enclosure, it must be of metal and the hole through which it passes must be such that the effective length of the flame-path is not less than 1 in., fitting as closely as operating conditions permit. In no case must the diametral clearances of the flame-path exceed 0·016 in. and 0·008 in. for gases in Groups II and III respectively.

For the purposes of flameproof certification, gases are divided into four groups as follows:

Group I. covers requirements for coal mines.

Group II. covers, in general, the petroleum, chemical and paint industries. Prior to 1957, this group was divided into five sub-groups *a*, *b*, *c*, *d* and *e* according to the types of gases met in particular classes of industry.

Group III, divided into two sub-groups, covers (*a*) the more sensitive vapours of the petroleum industry and (*b*) coal gas and coke oven gas.

Group IV. The gases (including hydrogen and acetylene) in this group demand a maximum permissible gap which is too small to be practicable to justify certification on the basis of type tests. It is possible to produce apparatus which will withstand a hydrogen test but it is doubtful whether the same standards of construction could reasonably be expected in commercial production. Approval for individual apparatus for use with gases in this group is usually given in the form of a Test Report issued by the Ministry of Power.

When apparatus is certified, the certificate quotes the groups of gases for which the apparatus is considered suitable. The apparatus should not be used in gases of other groups even though the test conditions appear to be the same. If the apparatus were suitable for use in other gases, quite naturally the manufacturer would ensure adequate certification to increase his sales.

The onus for prescribing the groups of gases which might be encountered in any telephone installation rests with the subscriber. Care should then be taken that any apparatus which is used is certified for those groups.

Existing Flameproof Apparatus

Because of the rigid mechanical requirements, flameproof apparatus has always tended to be strictly functional, and in general the lack of aesthetic appearance has not been questioned.

Fig. 2—Flameproof Table Telephone and Bell

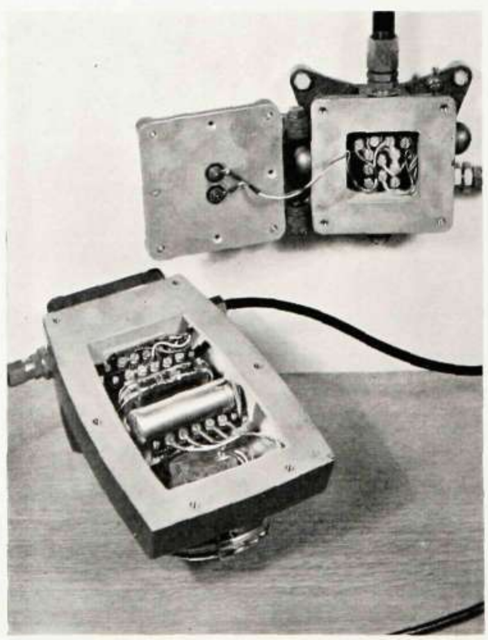

Fig. 3—Flameproof Table Telephone and Bell with Covers Removed

Fig. 1 shows the Post Office Telephone No. 149, which has been available for use on automatic and C.B. systems for many years. A similar instrument, the Telephone No. 153, has also been available for magneto working. These telephones will continue to be available for installations where the newly developed table telephone cannot be used. They are wall-mounted instruments and are weatherproof.

Certificates of flameproof construction which they carry (Groups II and III for the Telephone No. 149 and Groups I and II for the Telephone No. 153) relate only to the enclosure of the more dangerous elements of the circuit such as the dial and the switch-hook contacts.

Development of a Flameproof Table Telephone (600-ohm Version)

The remarkable developments by the oil industry in the production, refining and distribution techniques of petroleum products have created an increased demand for telephone equipment. It is now commonplace to have remote control rooms in which are housed metering and recording equipment together with the control desks. Telephones are essential features in these control rooms and, apart from their flameproof properties, it was considered desirable that they should be similar to the conventional table telephones if the appearance and function of the control rooms were to be maintained. Consequently the development of a table model was put in hand, and it was soon apparent that the design would have to be based on the following lines:—

(*a*) The bell should be housed in a separate enclosure due to the difficulty of finding a suitable arrangement for the bell gongs. The gongs could not be mounted on the outside of the telephone case if appearance were to be preserved, and they could not be mounted inside, for there they would not be heard.

(*b*) The line connexion to the instrument should be via a flexible cable to permit the telephone to be moved to suit the convenience of the user.

These two considerations led to the design of a unit in which is housed the bell and also the terminal block for the connexion of the rigid permanent line.

The bell coils are mounted inside the case and their cores are carried through the case to actuate the bell-hammers. The bell and terminal unit, which is shown in Fig. 2, can be fitted in a convenient place near the telephone, and connected to it by a tough rubber-sheathed cable, which is a permitted cable in areas when only an occasional hazard may exist. Being a separate unit, the bell and terminal unit can also be mounted as an extension bell if desired.

A range of glands has been developed to enable conduit or any of the accepted forms of permanent cabling for hazardous areas to be connected easily and safely to the bell and terminal unit.

The case of the telephone instrument, shown in Fig. 2 and 3, is constructed throughout in aluminium alloy LM6, the use of which not only permits a great saving in weight, but, more important, because of its low magnesium content, precludes the possibility of frictional sparking which might occur with other materials if the instrument were accidentally dropped.

The case consists of two compartments: (*a*) the main enclosure in which are housed the circuit components and (*b*) the terminal chamber. This segregation is normal practice with all flameproof electrical apparatus to ensure that the main enclosure is not disturbed when connexion or disconnexion of the line wires is required.

The cover of the main compartment serves as the base of the instrument and is fitted with four rubber feet. It is secured to the body by six triangular-headed screws, which are recessed to discourage unauthorized access. A warning notice is embossed on both covers to the effect that the circuit must be isolated elsewhere before either cover is removed.

The dial is of the latest " trigger " type, and the mechanism can be detached from the instrument case by removing three screws located round the rim of the dial case. Owing to the extra friction due to the flame-path along the operating spindle, it is necessary to return the finger plate back to normal independently of the dial mechanism, so enabling the dial mechanism to operate unhindered. In this method of operation the finger plate flies back under the action of its own spring and is locked in the rest position until the dial mechanism has returned to rest. Otherwise the dial would be very prone to mis-operation. Provision is also incorporated in the dial to lock the mechanism for C.B. working.

The remaining elements of the circuit within the case are mounted on a chassis that can easily be removed for attention.

It was evident during the development of the table instrument that it would be difficult and impractical to make the handset and cord of flameproof construction. Hence it was decided to try to make the transmission circuit intrinsically safe by limiting the maximum short-circuit current at the microphone to be less than the minimum igniting current as ascertained from test conditions. Tests using pentane as the representative vapour were conducted by the testing staff of the Safety in Mines Research Establishment and were made with the standard 600-ohm circuit telephone connected to standard Strowger circuits. It was found that under loop conditions ignition could be obtained with zero line and with both a.c. ringing current and d.c. transmitter feed current causing a spark in the microphone circuit with the microphone short circuited. Such a condition could arise with a sticking F relay in the final selector at the exchange and, simultaneously, an instrument fault. The chances of such a condition are extremely remote, but when safety is concerned such are the conditions of test. It was found possible to reduce the intensity of the spark to a safe level under these conditions by inserting a 160-ohm resistor in the circuit as shown in Fig. 4. Although this resistor reduced transmission by about 2 db in each direction and reduced the line signalling limits by 160 ohms, the losses were regarded as unavoidable in the interests of safety.

Development of the Flameproof Table Telephone (1,000-ohm Version)

With the advent of the 1,000-ohm loop telephone circuit it was decided that any new flameproof telephone should take advantage of this latest development if it were to have a useful life without modification.

Further, while the tests on the 600-ohm version had proved the handset circuit to be safe under the conditions of test, no proof was available that the circuit would still be intrinsically safe if the instrument were to be connected to any of the many earlier and different systems used by the Post Office. A very involved testing program would have been necessary to check the safety of the circuit in practical tests in conjunction with all these circuits and circuit elements and, moreover, possible earth fault conditions were an additional point of doubt. The new table telephone (600-ohm version) was, however, an improvement on the existing instruments.

Because of all these points it was decided to utilize the 1,000-ohm loop circuit (Fig. 5), and in consultation with the Safety in Mines Research Establishment a different approach was made to the problem of the safety of the handset and cord.

As mentioned earlier, an accepted method of providing an adequate degree of safety under practical working conditions is by ensuring a suitable design and standard of construction.

The scheme adopted in this instance was:—

(*a*) To fill the free space where pockets of gas or vapour could possibly collect in the Handset No. 1,[1] which is used in conjunction with the 1,000-ohm circuit. This was done by fitting a moulded rubber insert at the back of the transmitter, and fitting rubber plugs into the ends of the hollow handle to seal the space around the wires. No filling was required for the receiver end of the handset because the presence of the lead weight was considered sufficient.

(*b*) To secure the receiver and mouthpiece caps to prevent unauthorized entry. The caps on the Handset No. 1 are both of the screw-on type and it was decided that the use of Allen screws to secure the caps would give adequate safeguard against indiscriminate removal.

(*c*) To provide some form of metallic braid to a robust tough-rubber sheathed flexible handset cord which should be firmly secured at each end. The type of cord which met the approval of the testing authority is " Stranded 55/·004 in., 4-core, V.I.R. 0·02-in. radial, neoprene sheathed 0·04 in. nominal, braided with 0·006-in. tinned copper wire and covered overall with nylon cordonet ".

This telephone with the 1,000-ohm circuit has now received its certificates as follows, the bell and terminal unit and telephone case remaining as for the 600-ohm version.

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[1] Spencer, H. J. C., and Wilson, F. A. The New, 700-Type Telephone. *P.O.E.E.J.*, Vol. 49, p. 69, July 1956.

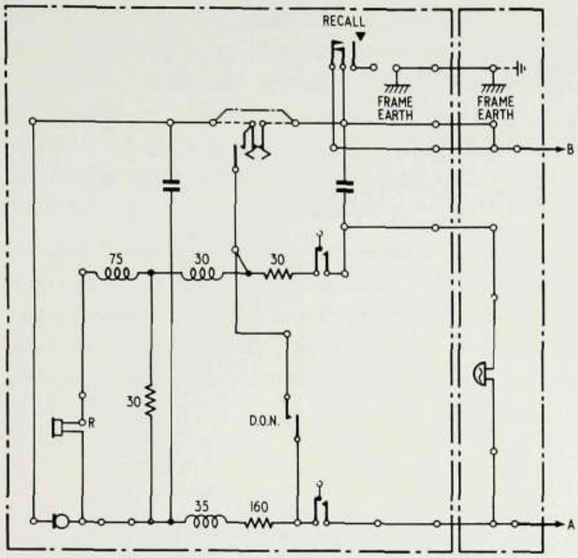


Fig. 4—Circuit of the 600-ohm Flameproof Table Telephone

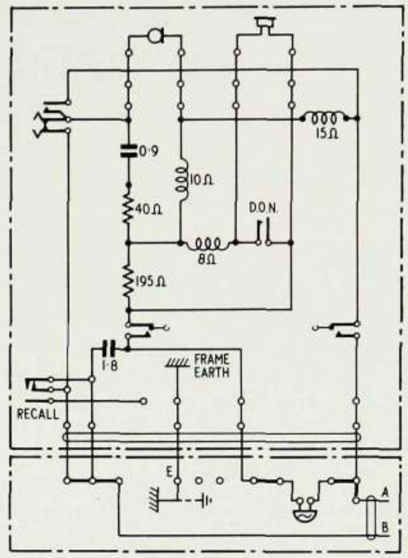


Fig. 5—Circuit of the 1,000-ohm Flameproof Table Telephone

Complete Telephone ..	Factory Inspectorate Certificate No. 202.
Telephone Case ..	Flameproof Certificate No. F.L.P. 3651.
Bell and Terminal Unit	Flameproof Certificate No. F.L.P. 3652.

These certificates were based on B.S. 229 : 1946 and cover groups II(*a*) and II(*b*).

Installation and Maintenance

With all the care and attention taken in the design and certification of these special telephones, it is obvious that they should be installed carefully and maintained in good condition. The precaution of disconnecting a circuit at a point outside the area of risk or at a certified switching point should always be taken before opening flameproof apparatus in an area of risk. When covers are replaced, the flanges should always be wiped clean to ensure that the joint gap is not widened by any trapped dirt or foreign objects. Any repairs or replacements must be in conformity with the drawings specified on the safety certificates, and, because of this, only minor replacements are permitted in the field. The ultimate success of the standard of safety provided by the apparatus depends on the standards of installation and maintenance.

Conclusion

The foregoing is but an outline of the certification of telephones for use in locations where there might be an occasional danger from explosive gases or vapours. Present-day knowledge of the behaviour of explosive mixtures is the result of years of research and the statistical evaluation of very many practical tests, and its application to telephones is only part of the work of the Safety in Mines Research Establishment, where all types of industrial equipment are dealt with.

In addition to gases and vapours, there are many dusts which ignite easily and explode with considerable force. These dusts, many of which are of such common materials as cocoa, flour and sawdust, demand precautions which are, if anything more exacting than the flameproof construction that has been described. In addition to the flameproof construction, it is necessary to make the equipment completely dustproof. The use of flameproof equipment for protection in dusty atmospheres is not therefore justified and the publication of a British Standard on this subject is awaited with interest.

Acknowledgments

The authors wish to express their appreciation of the co-operation that they received in the testing and certifying of the new telephones from the Safety in Mines Research Establishment and the Inspectorate of Factories. They also wish to record that the request for a flameproof table telephone came from the Oil Companies Materials Committee.

UDC.621.395.6 : 614.83

A FLAMEPROOF DISTRIBUTION BOX FOR TELEPHONE LINES

E. Woodward — Development Engineering Department

The presence of inflammable substances in the atmospheres of oil refineries and chemical plants gives rise to special problems in the distribution of telephone lines. With the equipment hitherto available it was necessary either to use more cable than would be required in a normal installation or to adopt a system in which maintenance work on any line involved taking a whole section of the network out of service. The flameproof distribution box described below gives greater freedom in the arrangement of the cabling and provides facilities for isolating single lines safely.

THE distribution of telephone lines in oil refineries and chemical plants has always presented difficulties because of the fire and explosion risks and the limitations of safe distribution equipment. In the past, two methods of cabling have been used. The more usual arrangement was to distribute the individual lines to the telephones from a point outside the hazardous area; the lines were made flameproof by enclosing them in conduit or by employing single wire armoured or mineral insulated cable. This system was expensive because many long runs of flameproof line were necessary. The other method was to terminate a multi-pair cable at a flameproof junction box, situated within the area of risk, from which the lines to the telephones were distributed. The only flameproof junction box available was designed primarily for power and lighting circuits, and it was necessary to open the main terminal chamber if maintenance was required on any single line. This could only be done safely if all lines passing through the box were first disconnected at a point outside the hazardous area, and consequently maintenance work on any line involved putting a whole section of the telephone system out of service.

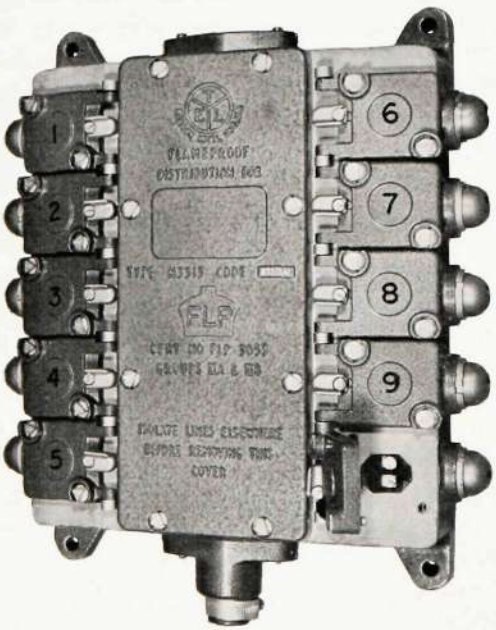


Fig. 1—The Distribution Box with one line terminal chamber open

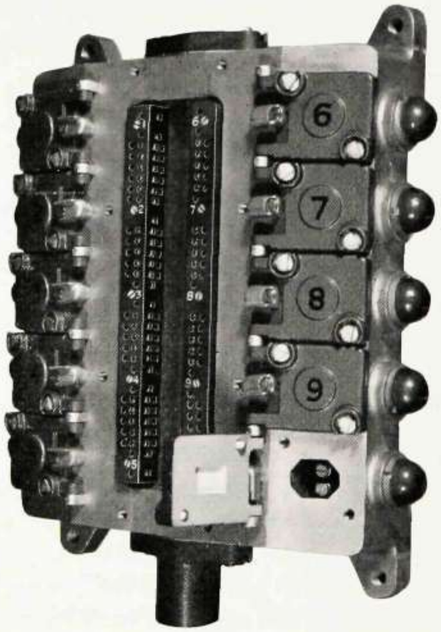
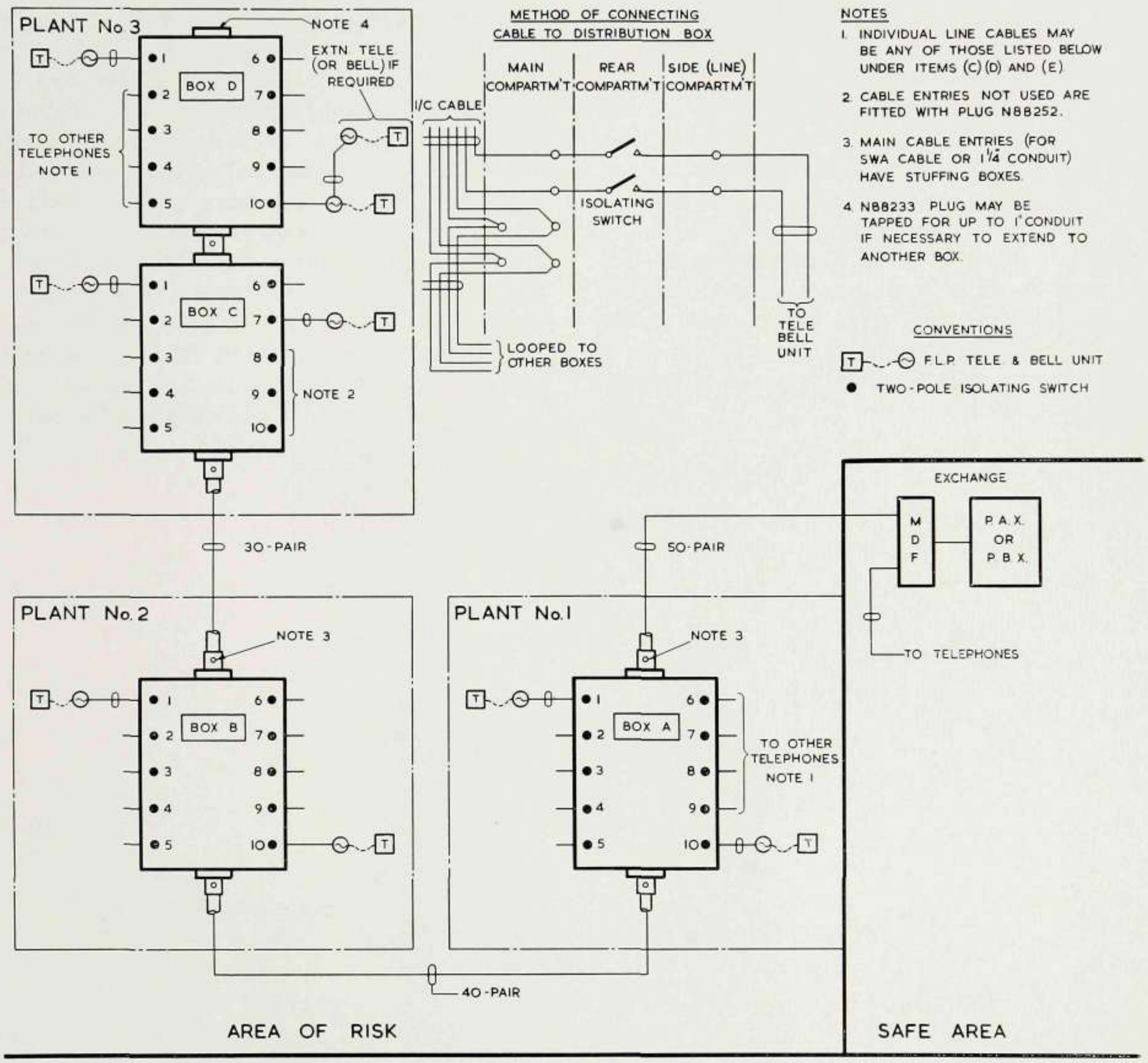


Fig. 2—Front view with main cover off

The distribution box shown in Fig. 1, which was developed in collaboration with the Oil Companies Materials Committee, overcomes these difficulties and permits the isolation of any single line at the box. It conforms to the Ministry of Power requirements for flameproof equipment as set out in BSS. 229, 1946, and is approved for use in gases and vapours of groups IIa and IIb. The LM6 alloy used in its construction has a low magnesium content and is not subject to thermal reaction on impact.

In the main chamber of the box a fifty-pair cable from the exchange can be terminated on the two terminal blocks shown in Fig. 2. Ten separate chambers at the sides contain the local line terminals, and ten of the multi-pair cable terminations may be connected to these, the remainder being looped to other distribution boxes as required. A typical



LIST OF F.L.P. APPARATUS

TABLE TELEPHONES
(COMPRISES TEL. & BELL UNIT CONNECTED TOGETHER. PLUGS N88252 ARE SUPPLIED FOR 2 OF THE 3 CABLE ENTRIES. ORDER GLAND (C), (D) OR (E) FOR THIRD ENTRY.)
N1018A AUTO TELE. W/OUT PUSH BUTTON
N1019A " " WITH " "
N1377A C.B. " W/OUT " "
N1378A " " WITH " "
NOTE:- IRONCLAD F.L.P. WALL TELES N1087 (AUTO) OR N1470 (C.B.) ARE ALSO AVAILABLE.

EXTENSION BELL
N3131A3
(INCLUDES 3 PLUGS N88252. ORDER GLAND (C) (D) OR (E) FOR THE REMAINING ENTRY.)

DISTRIBUTION BOX & GLANDS
DISTN. BOX N3313A (INCL. 1 OF ITEM (F) & 10 ITEM (G))
(A) N89261A MAIN GLAND FOR 1¼" CONDUIT } FOR DIST. BOX
(B) N89262A " " " SWA CABLE }
(C) N89234A SIDE GLAND FOR SWA CABLE } FOR DIST. BOX OR BELL UNIT
(D) N89240A " " " PYROTENAX
" " " " " TRS CABLE
" " " " " P.V.C.S. CABLE
(E) N89247A " " " 3/4" CONDUIT }
(F) N88233 PLUG FOR MAIN ENTRY OF DIST. BOX
(G) N88252 " " SIDE " " " "

Fig. 3—Typical Telephone Network using Flameproof Distribution Boxes

installation is shown schematically in Fig. 3. It will be seen that Plant No. 3 in this figure is served by two boxes coupled together so that twenty telephones can be connected. Wide variations in the numbers of local lines and the grouping of the telephones can be accommodated.

The local lines can be isolated singly by robust double-pole switches housed in a compartment at the rear of the distribution box, as shown in Fig. 4. Insulated pillars connect the terminals in the ten local line chambers to the fixed contacts of the switches, and the local circuit terminations in the main chambers to the moving springs. The switches are operated by cam-actuated plungers from levers positioned near the line terminal chamber covers; these levers can be seen in Fig. 1. A mechanical interlock prevents any cover being opened unless the corresponding switch is off, and a locking screw retains the levers in the "on" position to prevent accidental isolation.

All covers of the flame-proof distribution box are secured by triangular-headed screws so that they cannot be removed without using a special tool.

The glands associated with the main chamber will accept single wire armoured cable or 1 inch to 1½ inch diameter conduit. To meet the requirements of the testing authority a stuffing box which must be filled with a sealing compound to make a gas-tight joint is included in the 1½" conduit gland. For the local line outlets, glands can be provided to accommodate conduit, single wire armoured cable, copper sheathed cable or mineral insulated cable. These are of the running coupler type so that the conduit or cable does not rotate when the gland is screwed in. Blanking plugs are supplied for unused outlets. Cross sections of the glands are shown in Fig. 4, and it can be seen that the armoured cable glands have a clamp for securing the armour wire and a conical compression sleeve which is driven into the gland bush to make a gas-tight seal over the inner sheath of the cable when the glands are in place.

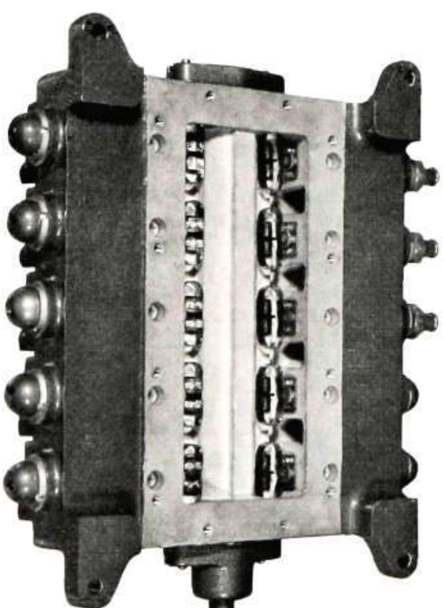
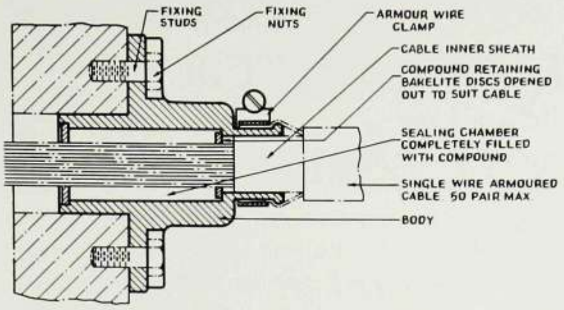
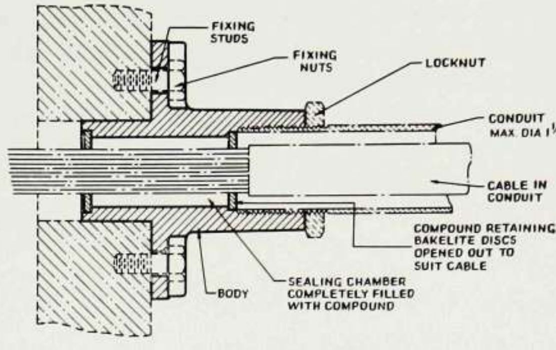


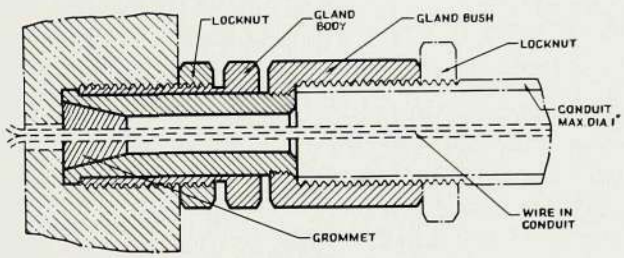
Fig. 4—Showing DP switches at rear of box



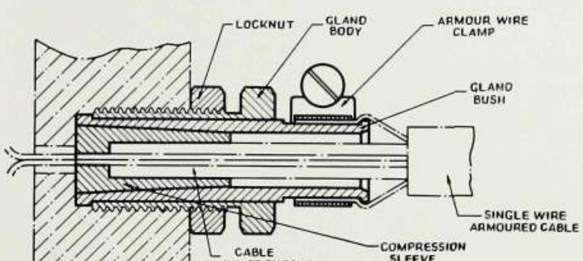
Main gland for SWA cable



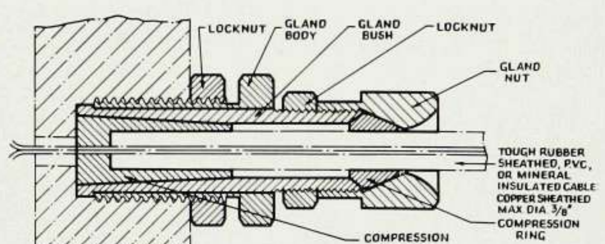
Main gland for wires in conduit



Side gland for wires in conduit



Side gland for SWA cable



Side gland for mineral or copper-sheathed cable

Fig. 5—Cross-sections of Cable Glands

UDC.621.385.12

A NEW COLD-CATHODE TRIGGER TUBE
Type GTR120W
FOR ECONOMIC APPLICATION IN COMPUTERS AND DATA PROCESSING

A. TURNER, B.Sc., A.Inst.P. — Valve Research Laboratory

The reliability, long life and low power consumption of cold-cathode trigger tubes make them suitable for computing and data-processing applications, provided that the highest operating speeds are not required. It is usual for a very large number of tubes to be necessary in an installation of this kind, so that cost is of first importance. The price of cold-cathode tubes available hitherto has been such as to make their use uneconomic in applications for which they were otherwise well suited, and the GTR120W *has been developed to overcome this difficulty. By careful choice of materials, development of simple processing methods, and adaptation to automatic manufacturing techniques, the cost of the tube has been reduced many times below that of any other now available ; at the same time the characteristics necessary for efficient functioning have been retained. As a result, the* GTR120W *can be advantageously employed in many situations where a large array of trigger tubes is appropriate.*

COLD-CATHODE tubes have advantages over thermionic valves in many applications, particularly where large numbers of tubes are used, since the problems of supply and dissipation of heater energy do not arise. Because of their inherent long life in the standby condition, when no current flows, cold-cathode tubes are especially useful in low duty cycle applications such as are encountered in computers. Since they are slower in operation than valves with heated cathodes, they are not suitable for all such applications; for example, in complex computers where many operations are carried out in succession, speed is essential and other devices are required. However, in smaller machines designed for more specialized purposes, where the number of consecutive operations is limited, speed becomes less important than long life and low cost.

The GTR120W trigger tube (Fig. 1) was developed for a particular application where low price was essential and very close control of tube characteristics not important. It is however suitable for many situations in the computing and data-handling field. The cost of the tube has a bearing on its range of application, since it is often possible to overcome limitations imposed by the operating speed or the slightly increased characteristic tolerances which the low price necessitates by using tubes in larger numbers than would be permissible with a more expensive device. For example, in digital apparatus the parallel mode of working uses more tubes but gives a much higher effective operating rate than the serial mode.

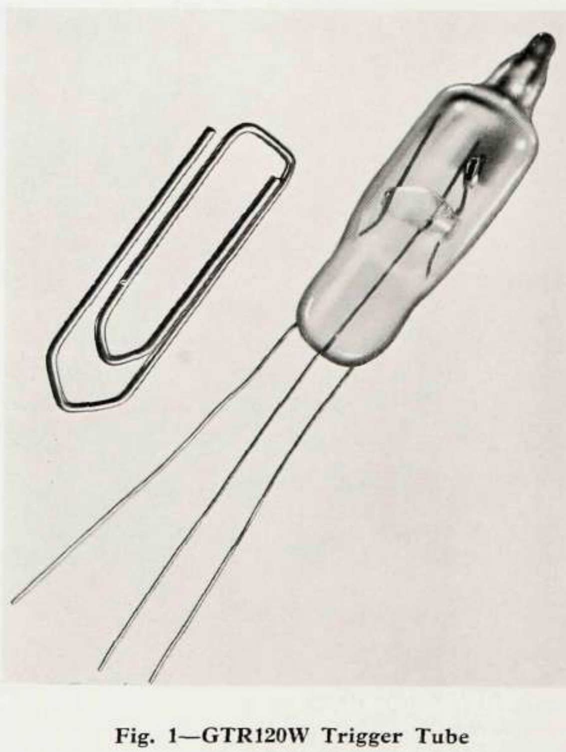


Fig. 1—GTR120W Trigger Tube

PRINCIPLES OF OPERATION

A discharge can take place between an anode and a cathode in a gas at a pressure of a few millimetres of mercury when the potential applied between the electrodes reaches a certain value V_s known as the striking voltage. Initially electrons are produced at the cathode by photo-emission; these electrons are accelerated in the field towards the anode and if the anode-cathode potential is sufficiently high they acquire enough energy to ionize the gas molecules into positive ions and electrons. The electrons are swept to the anode and the positive ions are accelerated to the cathode, where secondary electrons are produced by bombardment. When the processes of ionization and positive ion bombardment give rise to more than one secondary electron for each electron initially emitted by the cathode, the discharge current increases until it is limited only by resistance in the external circuit. The time required for the establishment of the discharge after the onset of ionization is called the formative delay of the gap; it depends on the amount of initial ionization and on the anode-cathode potential. The voltage V_m between anode and cathode when the discharge is established is called the maintaining voltage, and its value depends on the nature of the cathode surface and on the pressure and the gas used.

A cold-cathode trigger tube is a device in which there are three electrodes, an anode, a triggger and a cathode, forming essentially two diodes with a common cathode. The anode-cathode gap is the wider and has a relatively high striking voltage V_{sa}, while the trigger-cathode gap is closely spaced and has a lower breakdown voltage V_{st}. If a voltage V_a, which is slightly lower than V_{sa}, is applied to the anode, the cathode being earthed, while the trigger voltage V_t is less than V_{st}, no current will flow. When V_t is increased to a value in excess of V_{st} the trigger-cathode gap breaks down and provided that the resulting current I_t is large enough, the anode ' takes over ', that is, the anode-cathode gap breaks down and passes current.

The processes involved are as follows. On application of a trigger voltage in excess of V_{st}, the trigger-cathode discharge is established after the elapse of the formative delay. Some of the electrons emitted from the cathode are accelerated to the anode, which is at a more positive potential than the trigger, and these act as the initiating electrons in the anode-cathode gap. The anode current increases during the anode formative delay period, until the main discharge between anode and cathode is established. The sum of the anode and trigger formative delays is termed *the ionization time of the tube; it is an* important characteristic since it determines the speed with which the tube reacts to a trigger impulse. The anode formative delay, which is usually the longer, is dependent firstly on the trigger current, which in turn depends on the voltage applied to the trigger and the circuit impedance, and secondly on the anode voltage.

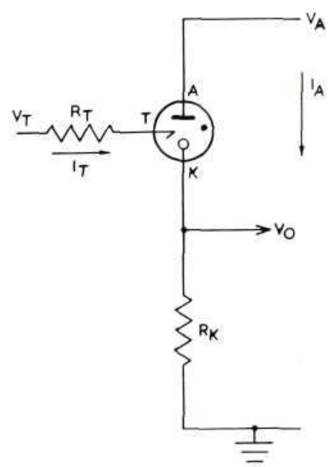


Fig. 2—Trigger Tube in Circuit

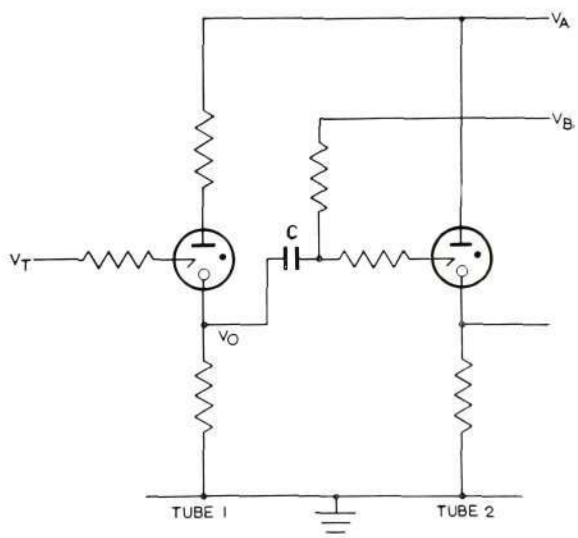


Fig. 3—Capacitor-coupled Trigger Tube Circuit

The discharge in a cold-cathode tube can be extinguished only by reducing the anode-cathode and trigger-cathode voltages below the maintaining voltages. When this is done the emission from the cathode and the ionization produced in the gas are insufficient to maintain the discharge, and the residual ionization decays by recombination of the ions and electrons on surfaces within the tube. The period which must elapse before the voltages may be restored to their pre-discharge values without causing the gaps to strike again is called the de-ionization time of the tube. It is approximately proportional to the discharge current before extinction and it increases with the value of the re-applied anode voltage. The sum of the ionization and de-ionization times determines the maximum repetition frequency at which the tube can be used.

Characteristics Required

Some of the properties desirable in a cold-cathode trigger tube can be deduced from a brief examination of a few typical circuits. If a tube is connected as shown in Fig. 2, the trigger-cathode current when the trigger gap only is conducting is given by

$$I_t = \frac{V_t - V_{mt}}{R_t + R_k}$$

This must be large enough for the anode to take over and for the ionization time to be acceptably short. It is desirable that V_t, the voltage applied to the trigger, should be as small as possible, and as circuit considerations usually necessitate a large value for R_t, it is important that V_{mt} should be small.

Fig. 3 shows an arrangement often used to couple two tubes so that the establishment of a discharge in the first will cause the second to strike. The trigger of tube 2 is connected via a resistor to a bias voltage V_b which is less than the minimum value of V_{st} by say 10 volts. When tube 1 strikes, a pulse of amplitude V_o is applied through capacitor C to the trigger of tube 2, and the condition that the trigger-cathode gap of this second tube strikes is

$$V_b + V_o > V_{st\,max.}$$

Now $V_b = V_{st\,min} - 10$ and $V_o = V_a - V_{ma}$ so that substitution of these values in the relation above gives

$$V_{st\,min} - 10 + V_a - V_{ma} > V_{st\,max.}$$

whence $V_{st\,max} - V_{st\,min} < V_a - V_{ma} - 10$

The permissible variation of the trigger striking voltage during the life of the tube, and the acceptable manufacturing tolerance on this voltage, thus depend on the magnitude of the difference $V_a - V_{ma}$ which can be obtained in practice. A low value of V_{ma} is desirable so that V_a can be made economically low after allowing for the variation in V_{st} caused by manufacturing tolerances and drift during life. A low value of V_{ma} is also helpful to the circuit designer since the change in output voltage resulting from the striking of a tube increases with the value of $V_a - V_{ma}$.

It can thus be seen that low values for the trigger and anode maintaining voltages and a high value for the anode striking voltage are among the desirable characteristics of a trigger tube.

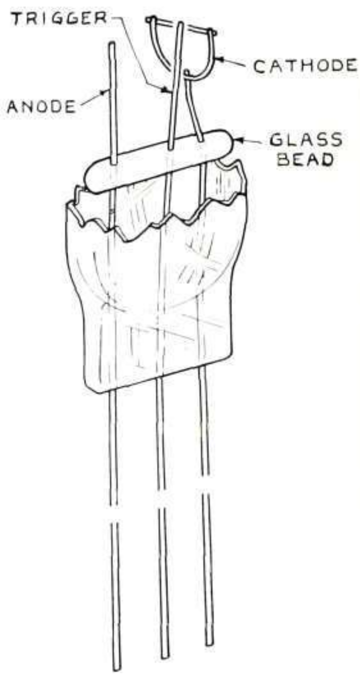


Fig. 4—Internal Construction

Design

To keep the cost of the GTR120W low, it was necessary to use cheap materials, simple construction, and to design the tube so that the processing and pumping could be carried out automatically so far as possible.

The maintaining voltages obtained with cathodes of readily available pure metals are high; oxide coated cathodes give low maintaining voltages but normally are expensive to produce. However, in 1954 a method of making such cathodes which involves only easily obtainable materials and elementary processing was devised here. When a barium getter is fired in an inert gas, barium is deposited over the getter frame, where it combines with the residual oxygen in the tube so that a thin film of barium oxide is formed. The oxide film in conjunction with a suitable gas filling gives an initial maintaining voltage of about 105. With an appropriate electrode spacing, an anode striking voltage of over 300 can be obtained, so that the difference $V_a - V_{ma}$ can have a large value, which was shown above to be a desirable feature.

A barium oxide cathode made in this way is used in the GTR120W. The internal structure of the tube is shown in Fig. 4. The three electrodes are composite wires of nickel and borated copper, and the getter is welded to the end of the cathode support wire so that all are of the same length. A glass bead secures the electrodes and prevents relative movement when the assembly is sealed into the glass bulb after adjustment of the spacings. The borated copper leads give vacuum-tight seals through the glass.

Since sputtering caused by positive ion bombardment reduces the life of the cathode, the nature and pressure of the gas used in the tube have to be chosen to keep sputtering to a minimum. A gas of low atomic weight is needed, since less sputtering is caused by light ions than by heavy ones. The anode striking voltage is proportional to the gas pressure, but an increase in pressure raises the maintaining voltage and causes a deterioration of the take-over characteristic; hence the pressure used in practice represents a compromise between conflicting requirements. The quantity of gas used materially affects the cost of such a low-priced tube as the GTR120W, and for this reason a low pressure is to be preferred. Since a small amount of residual oxygen is necessary in each tube for formation of the cathode surface, the pumping requirements are not very exacting, and it is possible to use an automatic pumping system.

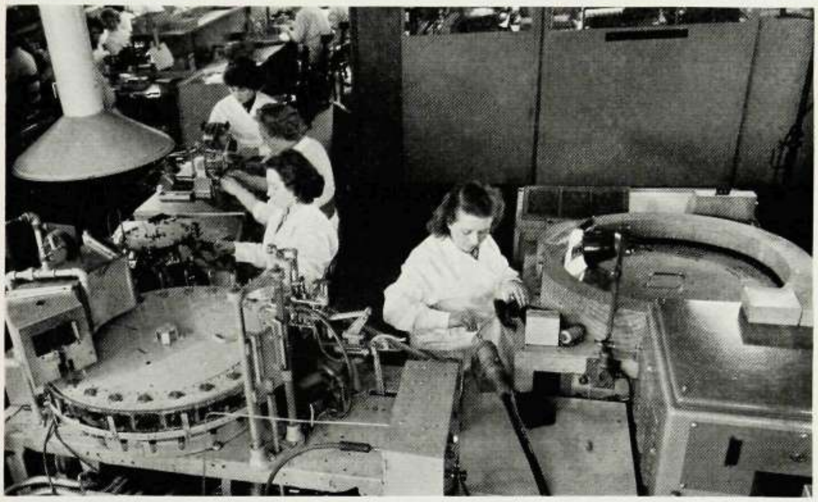


Fig. 5—GTR120W Production Unit

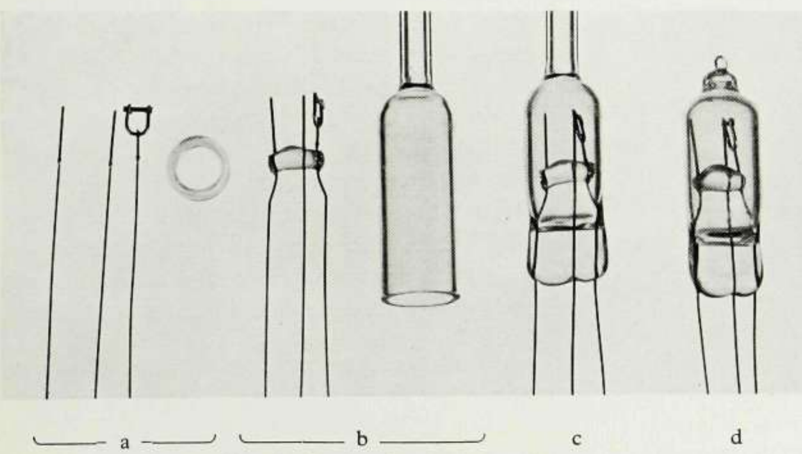


Fig. 6—Stages during Manufacture

Cold-cathode tubes undergo large initial changes in characteristics when current is passed through them immediately after manufacture. The characteristics are stabilized before testing by an ageing procedure which consists of passing through the tubes a current which is higher than the normal operating current. The ageing schedule necessary for the GTR120W is sufficiently short to allow it to be carried out automatically on a rotary machine.

Manufacture

In order to reduce the cost it was necessary to mechanize as many processes as possible,

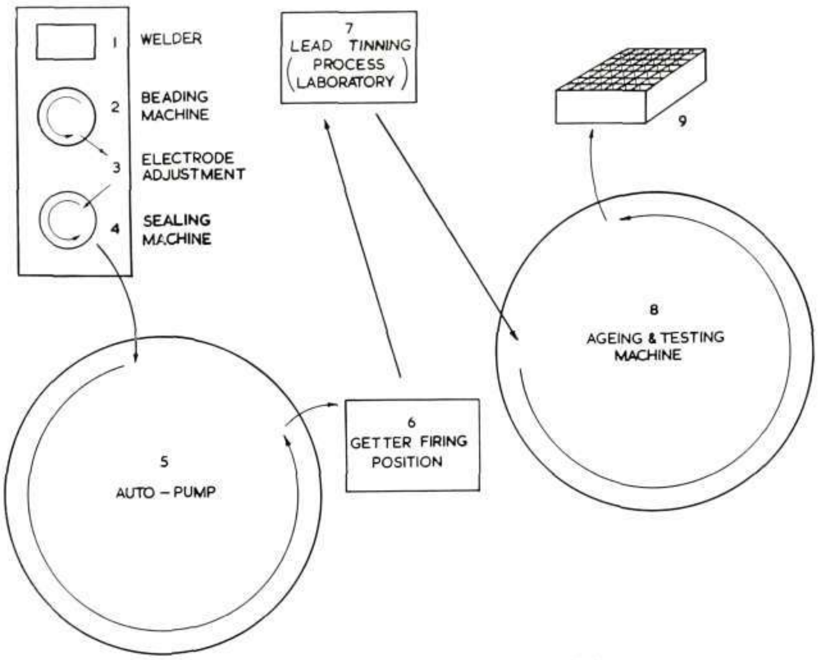


Fig. 7—Layout of Production Unit

and several pieces of equipment have been specifically designed for the manufacture of this tube. A production unit is shown in Fig. 5.

Fig. 6 shows the stages in assembly of the tube, and Fig. 7 gives a diagrammatic layout of the production unit showing the flow of materials. In position 1 the getter is welded to the cathode support wire and this assembly, with the anode and trigger wires (Fig. 6a), is placed into a jig in the beading machine (position 2 of Fig. 7) which holds them in approximately their correct positions. The glass bead is positioned round them and, as the machine indexes, gas flames melt the ring into a bead on the wires (Fig. 6b). In position 3 of the production unit the beaded assembly is inspected and the trigger-cathode separation is adjusted.

The assembly is then fed into the sealing machine (position 4), the tubulated bulb placed over it, and as the machine indexes the assembly is sealed into the bulb (Fig. 6c). The tube is inspected for glass defects before being placed into one of the positions on the auto-pump (position 5) on which the various stages of pumping and gas-filling are carried out. Firstly the tube is evacuated and checked for leaks, which may be caused by a poor seal or a crack in the glass. If a leak is detected a vacuum valve is operated automatically, isolating the tube from the pumps to prevent deterioration of the pumping system. If there are no leaks, the tube passes through an oven to bake out gas from the glass envelope, and, after being allowed to cool, a further leak check is made before it is filled with inert gas. In the next position the tube is automatically sealed off (Fig. 6d) and is dropped down a chute to the getter-firing position (position 6) where the cathode surface is prepared by eddy-current heating of the getter.

So that good connections may be made, it is convenient at this stage to clean and tin the borated copper leads, which have become oxidized by the previous heat treatment. The tube is then secured to terminals on the ageing and testing machine, and in the first series of positions through which it passes the ageing takes place. After being allowed to cool for several minutes, the tube passes to a series of test positions. On failure to pass any test, it is automatically released and drops into a particular partition of a rejection box, which may be inspected periodically for an assessment of the causes of failure. Tubes which pass all tests are removed from the machine, visually inspected for mechanical and glass defects, and put into a box for despatch.

Components and finished tubes are under continual scrutiny by the Technical Control Section and sample tubes taken at random are subjected to life tests to ensure that the quality of the tube is maintained.

UDC.621.3.083.7

A REMOTE SIGNALLING SYSTEM FOR SHIP REFUELLING

N. S. BONSER — Circuit Development Department

Oil-burning ships are refuelled at Aden by means of submarine pipelines extending from storage tanks on the shore to oil berths in the harbour. Pumping operations are controlled from the shore in accordance with signals sent by the ships, and for efficient use of the refuelling service a rapid and reliable signalling system is required. Since ships of many nationalities call at Aden, systems which depend on verbal instructions are not satisfactory, and a lamp signalling system which meets the necessary conditions has been devised.

A REFUELLING service for ships visiting Aden is operated by B.P. (Aden) Limited, a subsidiary of the British Petroleum Company Limited. Oil from the Persian Gulf is refined at Little Aden and pumped about nineteen miles to the storage tanks of the BP bunkering installation at the port. Since the harbour is not deep enough to allow any but the smallest ships to navigate alongside jetties, oil buoys moored 350 or more yards from the shore are used. There are eight buoys connected to the storage tanks by submarine pipelines, and when refuelling is in progress oil is conveyed from the buoys to the ships by floating pipelines with flexible hose terminations. Fig. 1 shows a general view of Aden with ships bunkering at oil berths in the inner harbour. A nearer view of an oil buoy connected to a vessel is shown in Fig. 2. The oil supply to the buoys is controlled from two shore stations, therefore ship-to-shore communication is required. Telephone communication is not entirely satisfactory since ships of many nations use the service, and a lamp signalling system has been devised to overcome this difficulty and speed up the refuelling operation.

One of the two shore stations controls the oil supply to six buoys, the other to two buoys. The signalling installation comprises a control console at each shore station and portable units which are taken aboard the ships; the portable units are

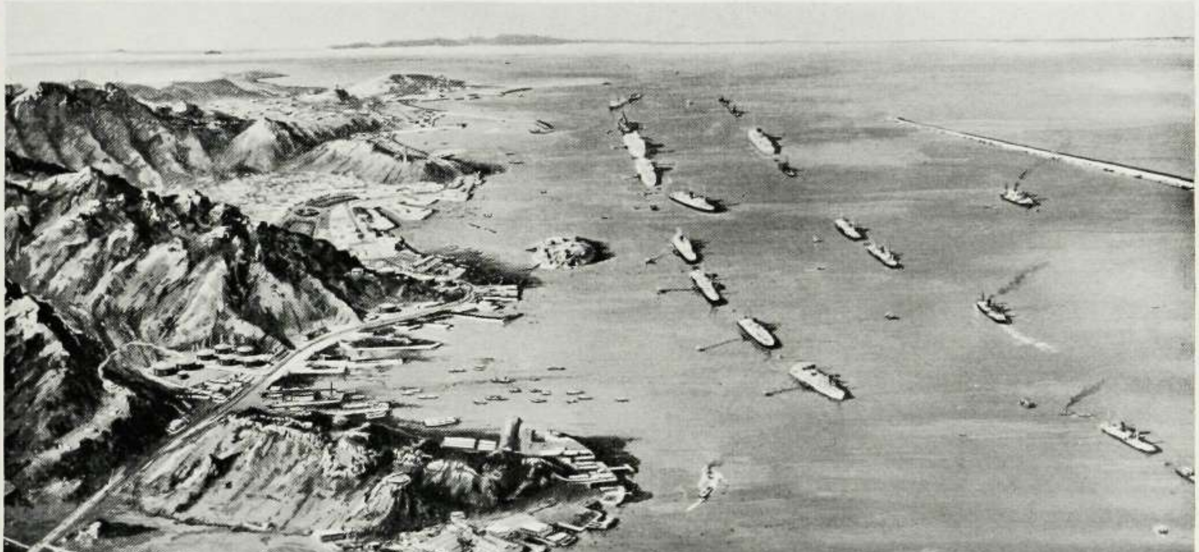


Fig. 1—Bunkering Facilities at Aden. Little Aden is on the horizon

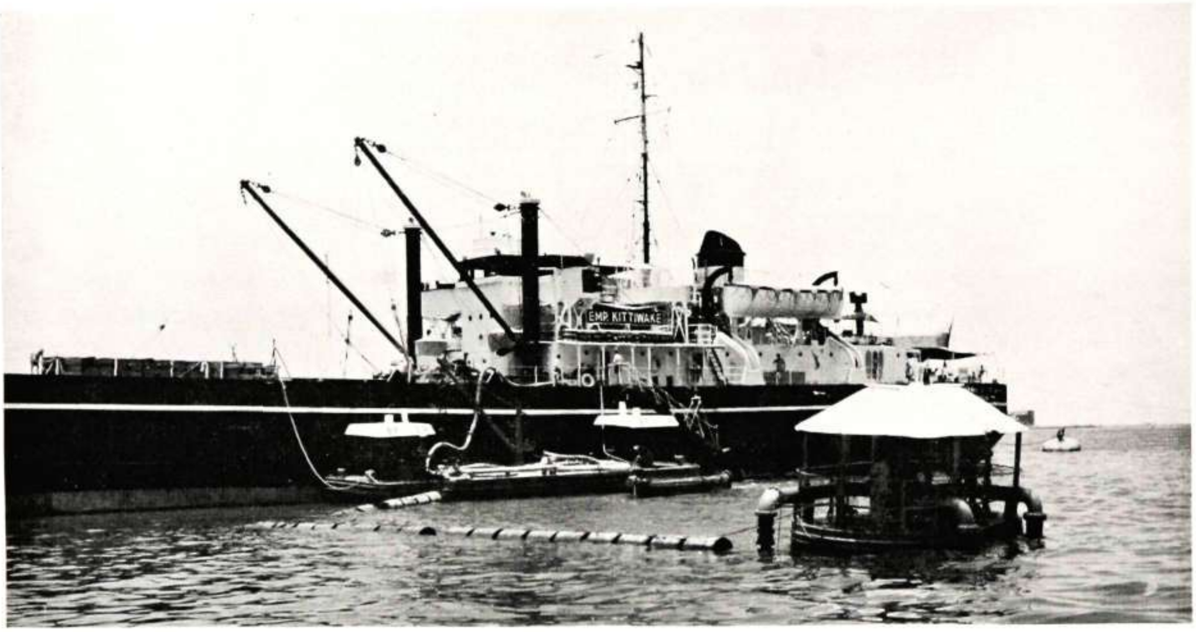


Fig. 2—Bunkering in Progress

connected to the consoles by flexible submarine and land cables. Signals from these units operate lamps on the consoles and, where the oil control valves are situated some distance from the consoles, are extended to mains-energized lamps mounted near the control valves. In addition to the signalling circuits, each portable unit and each oil buoy has a telephone line to the console. The connections between a ship and a shore station are shown diagrammatically in Fig. 3.

PORTABLE UNIT

A portable unit is shown in Fig. 4. It is enclosed in a hardwood case suitably treated and finished to withstand tropical conditions, and operating instructions in English, French, German and Italian are engraved inside the lid. The cable to the console is connected by an eight-way plug and socket at the rear of the unit. The on-off switch, signalling keys and indicators are mounted on a panel faced with green Warerite. When the unit is plugged in and switched on, an 'Equipment Ready' indicator operates to show that signals may be sent.

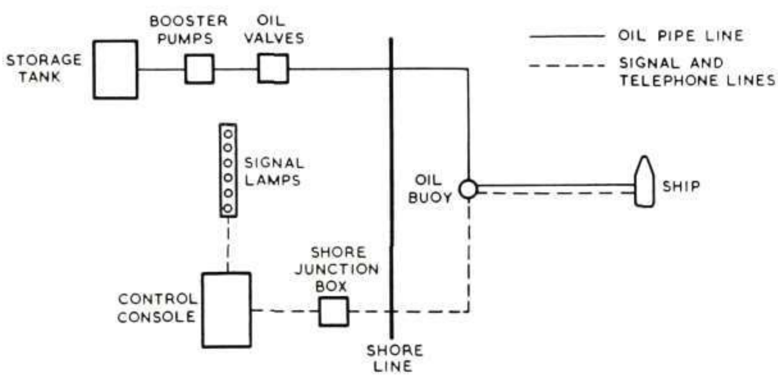


Fig. 3—Ship-to-Shore Connections

There are five signalling keys, distinguished by being differently coloured, and a correspondingly coloured indicator is associated with each. The signals which can be made are Pump Slow (amber key and indicator), Pump Fast (green), Gravitate (white), Stop Pumping (red) and Bunkering Finished (blue). To send any of these signals the appropriate key is depressed for about two seconds. The corresponding indicator on the unit is energized while the key is operated, and when the console operator acknowledges the signal the indicator is energized again and remains held to show which operation is proceeding. If it is necessary to send a further signal, a black Release key on the panel must first be depressed to clear the existing signalling condition at the console. When refuelling is completed the Bunkering Finished key is operated; on acknowledgment of this signal the release key must be depressed and the portable unit may then be switched off and disconnected.

At any time during the operation of the portable unit the telephone may be used. The console operator is called by lifting the handset included in the unit.

CONSOLE

A control console is illustrated in Fig. 5. It is constructed of hardwood, treated and finished in the same way as the portable unit case, and has a green Warerite shelf and front panel. On the left-hand side of the panel is a switchboard for thirteen C.B. extensions and three exchange lines. One of the extensions is used as a test line for the portable units, the remaining twelve being employed for communication with the oil buoys and portable units. Heat coil and fuse alarm lamps together with an audible alarm cut-off key are mounted above the switchboard keys. The C.B. circuits and the remote signalling system operate from a 24 volts d.c. power supply.

The right-hand side of the console panel carries the lamps and keys associated with the remote signalling system. It can be seen from the figure that there are seven similar columns of lamps; each of the first six columns receives signals from one of the portable units and the seventh is used for testing. Each column has a Signal Acknowledged key below and a Forced Release key above it. The lowest lamp of a column lights when the corresponding Signal Acknowledged key is operated; the next five lamps above this are coloured in the same way as the signal indicators on the portable units and each lamp lights when the corresponding indicator is energized; the next two lamps in each column are cable and lamp failure alarms, and the uppermost lamp gives the Signal Change indication. When one of the signalling keys on a portable unit is pressed, relays in the unit and the console operate and cause an intermittent audible alarm to be given to the console operator, at the same time lighting the Signal Change lamp in the column appropriate to the portable unit from which the signal was sent. The relay operations also cause the appropriate lamp at the oil control valves to be illuminated. The console operator then depresses the Signal Acknowledged key at the foot of the column containing the glowing Signal Change lamp ; this stops the alarm, extinguishes the glowing lamp and lights the Signal Acknowledged lamp and also the lamp showing which operation is in progress. The console operator can clear any signalling condition independently of the portable unit operator by depressing the appropriate Forced Release key.

If the cable between a portable unit and the console is severed or if the battery or earth leads in the cable are broken, the Equipment Ready indicator in the portable unit is released and the Cable Fail lamp in the appropriate column lights on the console. Similarly, the relevant Lamp Failure lamp will glow if any of the lamps mounted at the six oil control valves fail. The separate Fuse Alarm and Heat Coil Alarm lamps glow, respectively, if a fuse blows in the console signalling circuit or if the heat coil which protects the battery feeds to the portable units is fused. In each of the four eventualities described above, the console operator receives a continuous audible alarm in addition to the lamp indication of equipment failure.

Fig. 4—Signalling Unit used on board ship when refuelling

MAINS ENERGIZED LAMPS

Fig. 6 shows the oil control valves with the associated signal lamps mounted vertically behind them. The relays which apply mains power to these lamps in accordance with the signals extended from the console are housed in a wooden cabinet. (Fig. 7). The cabinet has lockable front and rear doors which give access to the relays and wiring. Interlocks are provided so that the mains are switched off when the doors are opened. The fuses, being mounted above the front door, can be replaced with the door closed.

CIRCUIT

A portable unit circuit and the corresponding console signalling circuit are shown in skeleton form in Fig. 8. The contacts of the portable unit signalling keys are connected in such a way that when a key is pressed the corresponding indicator is energized by the operation of the appropriate combination of relays A, B and CD. Relays A, B and CD in the console circuit operate at the same time as the corresponding relays in the portable unit, and as a result a signal relay D, E, F, G or H operates, depending on which signal was sent (only relay E is shown in the figure). Operation of one of these signal relays energizes a relief relay DR, ER, FR, GR or HR, and the contacts of the relief relay complete circuits for the audible alarm and the console lamps, and cause signals to be extended to the mains-energized lamps at the oil control valves. For example, when the Pump Slow key is depressed the B and CD relays in the portable unit and the console operate. The indicator in the portable unit is energized via contacts A1, B2 and CD3, and in the console earth is extended to operate relay S via CD1 and B3. Contact S1 operates relay X, and S2 completes the circuit for relay E. Contact E1 then energizes relay ER, and E2 short-circuits the high resistance winding of E, so preventing the operation of D, F, G or H should another signalling key be pressed before the release key is operated. Contact ER1 extends earth to operate a mains switching relay which applies power to the appropriate lamp at the oil control valves; ER2 lights the Signal Change lamp on the console, ER3 locks relay E by completing a circuit to earth at Z1 (relay Z being energized when the portable unit is connected and switched on) and ER4 lights the Pump Slow lamp on the console. Contact ER7 completes the circuit for the pulsing relays PA and PB and as a result an audible alarm is sounded. When the portable unit signal key is released the B and CD relays release and the indicator in the unit is restored to normal.

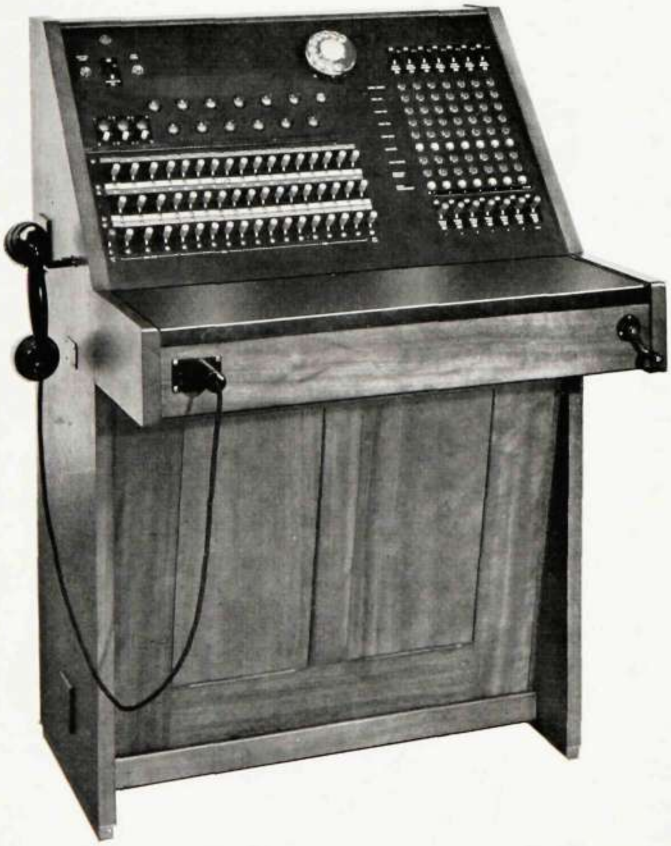


Fig. 5—Control Console

When the console operator presses the Signal Acknowledged key, relay SA operates and locks. Contacts SA1 and SA5 extend earth from ER6 and ER5 to leads 2 and 3, so that relays B and CD in the portable unit re-operate and the indicator is energized again and remains operated. Contact SA2 extinguishes the Signal Change and lights the Signal Acknowledged lamp, and a further contact of SA stops the audible alarm by disconnecting the earth at ER7 from the PA and PB relays.

If a signal is cancelled by the operation of the Release Key on the portable unit, the short circuit across resistor R1 is removed and relay Z releases. Relays E, ER (or the corresponding relays for other signals) and SA in the console release but X remains in the operated condition until the Bunkering Finished signal is sent, when it is released by the

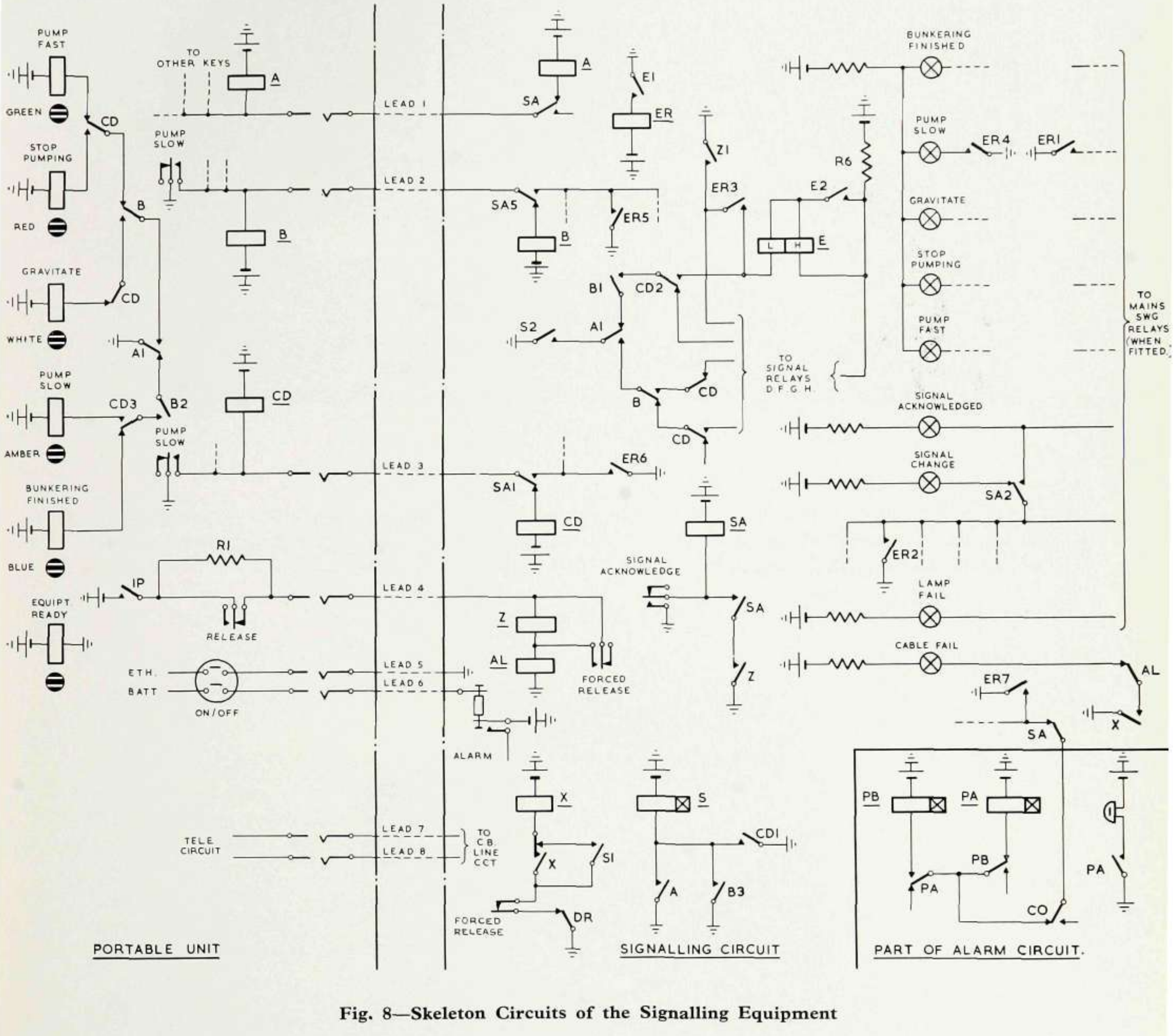


Fig. 8—Skeleton Circuits of the Signalling Equipment

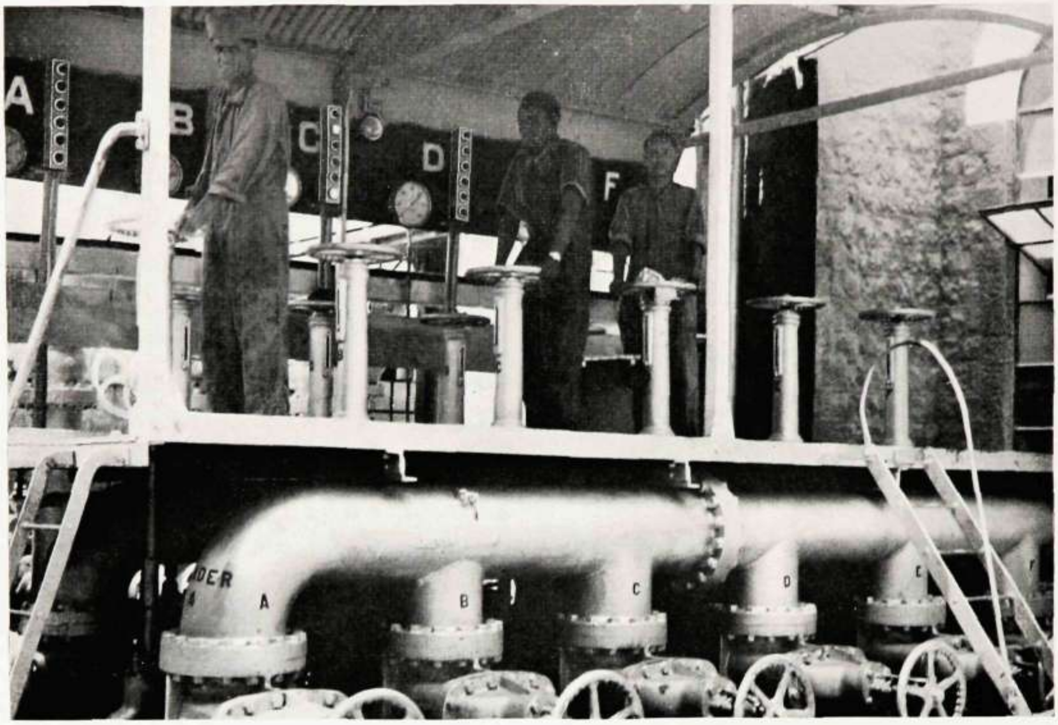


Fig. 6—Oil Control Valves

operation of a DR contact. Operation of the Forced Release key on the console short-circuits relay Z and so clears the signalling condition. If the battery or earth leads to the portable unit are broken, the Equipment Ready indicator is released. This disconnects the battery from lead 4 and causes relay

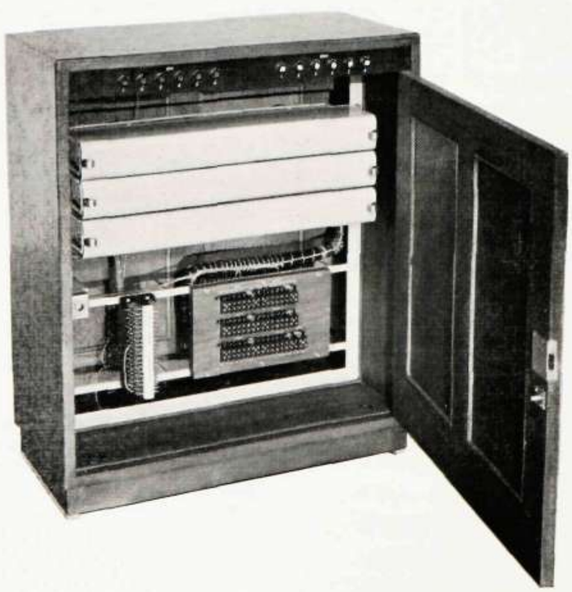


Fig. 7—Mains Switching Relays for Lamp Units

AL to release. Contacts of this relay then light the Cable Fail lamp and give an audible alarm.

Although designed to meet the requirements of the BP bunkering service at Aden, this signalling system could readily be adapted for use in other situations where similar conditions prevail. It was developed by us with the collaboration of Mr. W. J. E. Brown and Mr. D. R. Bushell, telecommunications engineers of BP Trading Limited, London.

This article is published by kind permission of BP Trading Limited, to whom we are indebted for photographs Figs. 1, 2 *and* 6.

THE "RURAX" AUTOMATIC TELEPHONE SYSTEM AND ITS EXPANDING FIELD OF APPLICATION

THE " Rurax " system described and illustrated in our Bulletin No. 28, January, 1954, has achieved considerable success throughout the world and many thousands of lines are now in service, in addition to those in process of manufacture.

In Bulletin No. 28 we gave a broad outline of the " Rurax " Automatic system, its operation and some of its applications when used as a private system in a factory or office, as a rural exchange with facilities similar to the B.P.O. Unit Auto's Nos. 12, 13 or 14, and as a trombone satellite exchange in a multi-office area.

The flexibility of Rurax has enabled us to extend the field of application so that the equipment can now be used as a P.A.B.X., as a discriminating satellite exchange, or as a main office with or without manual board.

Rurax also meets the requirements of nation-wide subscriber dialling and periodic metering. The Company has recently installed a complete network in Grenada, B.W.I., embodying many of the features referred to above. The Grenada network is described in this issue of the Bulletin and is a typical example of the adaptability of Rurax to meet the special needs of overseas customers.

No fundamental changes have been made to the basic switching principles, which remain substantially as described in the introductory article, but constant effort is directed towards improvements so as to ensure that trouble-free service is given. To enable more equipment to be accommodated and to give better access to apparatus for maintenance purposes, the layout of the units has been modified.

The present trend throughout the world is the introduction of colour into the home or office, as witness the new range of coloured telephones illustrated in our Bulletin No. 35, 1957.

The Company was of the opinion that Rurax equipment deserved attention in this respect and the conventional drab grey finish has been superseded by " Opaline " Green exterior finish with cream interior and cream P.V.C. sheathed external cables, thus giving Rurax a distinctive finish.

In our Editorial in Bulletin No. 28 we said:—

" Intensive research is being prosecuted in the telephone world today in an effort to develop new automatic switching systems having greater reliability and longer life than those hitherto evolved. Systems using new electro-mechanical and electronic devices are receiving full attention and the Company has a large team of engineers continuously employed on work in this field. It is, however, fully realised that there always will be a need for exploitation of " *well-known and long established techniques* for certain classes of automatic switching systems, and our Rurax . . . is a typical example ".

The success of Rurax fully justifies our confidence in " well-known and long established techniques ".

In the short space of a few years, 18,300 lines have been supplied to more than twenty different P & T Administrations throughout the world. The number of repeat orders is a testimony to the excellent qualities of Rurax.

U.D.C.621.395.331./621.395.441./621.395.772

AUTOMATIC TELEPHONE NETWORK FOR GRENADA—BRITISH WEST INDIES

A. Foster — Circuit Development Department
W. B. Knight — Equipment Engineering Department

The problem of providing efficient automatic telephone service in remote areas where capable technicians are scarce is one with which many administrations are faced. In Grenada the difficulty has recently been overcome by installing 'Rurax' type equipment in six outlying districts and a new main exchange at St. Georges, to provide a straight-forward and relatively simple system giving automatic telephone service throughout the Island.

THE small island of Grenada set in the Caribbean Sea, was the location for the production of a film now in circulation entitled "Island in the Sun". Grenada could not be more aptly described. It is the southernmost of the Windward Islands, some 120 miles from the mainland of South America and 12° north of the Equator. It is approximately 21 miles in length and 12 miles in breadth and at the time of its discovery by Columbus, in 1498, was given the name *Conception.*

Volcanic mountains rising in places above 2,700 feet occupy the centre of the island, and foothills, intersected by picturesque valleys and luxuriantly clothed with tropical vegetation, stretch on all sides right to the water's edge. Consequently the centres of population are situated around the coast and particularly in the lower lying regions in the north-east and the extreme south. It is not surprising in view of the topography of the island that adjacent centres have little community of interest. Therefore, communications are directed towards the capital and port of St. Georges, which has a population of some 20,000; approximately a fifth of the island's total.

Planning the Network

Until the recent installation, the telephone communications on the island consisted of an old Ericsson three-position C.B.S. manual switchboard at St. Georges serving about 300 subscribers and linked by indifferent open wire lines to a number of magneto switchboards. Most of these were old and some were locally made. Consequently there was a need for a new and up-to-date telephone system. On the advice of various commissions set up by the Government of the Islands, Cable and Wireless Ltd. were asked to make a survey and submit recommendations.

From the point of view of efficiency and staff economy an automatic system would have obvious advantages, and owing to the lack of skilled labour and technicians for maintenance it was essential to make simplicity the keynote. It was decided that the requirements in the St. Georges area could best be met by a conventional step-by-step system employing two-motion switches of the SE 50 type. These combine the best features of the standard British Post Office 2000 and pre-2000 switches.

For the outlying exchanges, which would be unattended and without air conditioning, the ruling considerations were ease of maintenance and low fault liability under adverse climatic conditions. For many of their exchanges in the Persian Gulf, the Seychelles Islands and elsewhere, Cable and Wireless have employed Rurax equipment with very satisfactory results. As the climatic conditions in these locations are even more adverse than in Grenada it was evident that for the application in mind Rurax was ideally suited.

The original scheme envisaged six terminal exchanges located at St. Pauls, St. Davids, Morne Rouge, Grenville, Sauteurs and Victoria, with a tandem or transit switching centre at Gouyave. However, in the interests of simplicity and since most of the junction traffic is into and out of St. Georges, it was decided to connect the Victoria and Gouyave subscribers to one exchange at Gouyave and provide direct junctions between each of the six exchanges and St. Georges. This simplified the area numbering scheme and avoided complicated junction circuits and pulse regenerating equipment which tandem switching would have necessitated. The final plans resulted in the straight-forward junction network shown in Fig. 1.

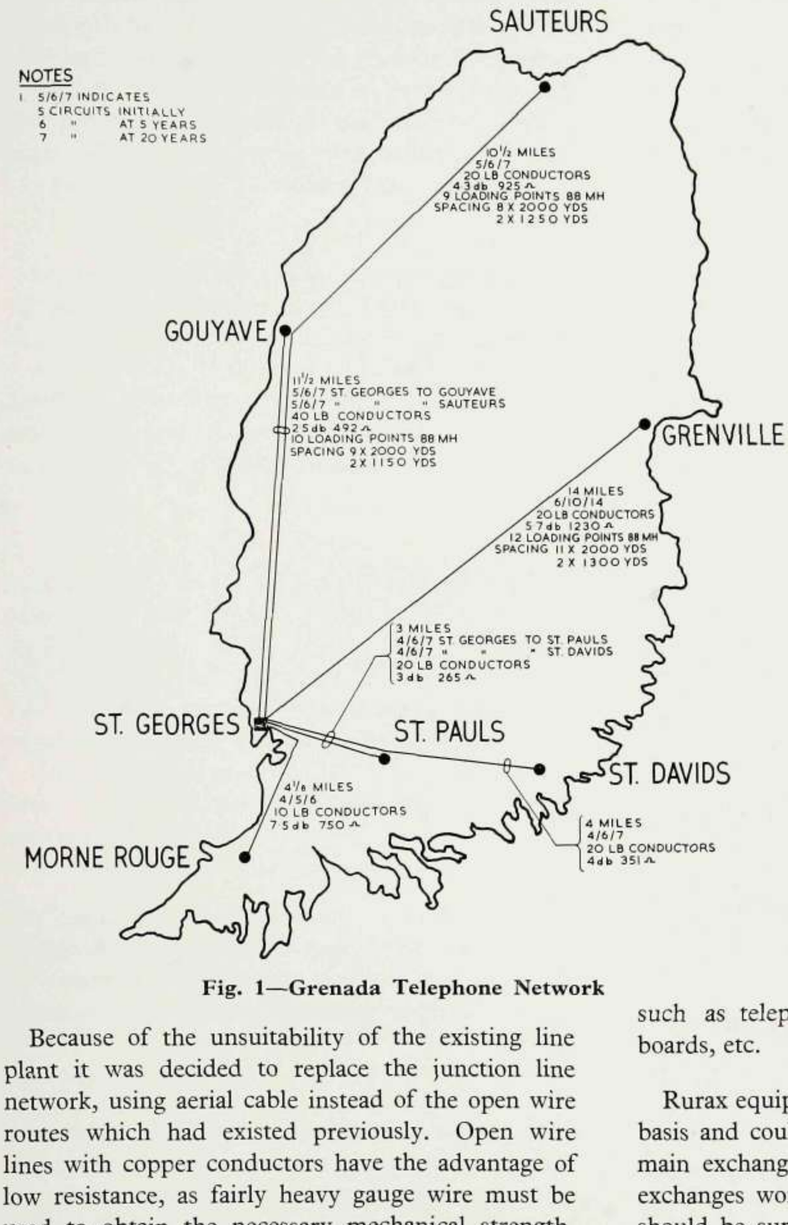


Fig. 1—Grenada Telephone Network

Because of the unsuitability of the existing line plant it was decided to replace the junction line network, using aerial cable instead of the open wire routes which had existed previously. Open wire lines with copper conductors have the advantage of low resistance, as fairly heavy gauge wire must be used to obtain the necessary mechanical strength. Moreover, the spacing of the conductors gives low capacitance between lines. Unfortunately such lines are vulnerable to storms and easily develop low resistance leakages due to persistent humid conditions, contact with overhanging foliage or, on coastal routes, formation of salty deposits on insulators. The open wire routes in Grenada were exposed to all these hazards and because of the thick vegetation the lines had more or less followed the winding roads. With the introduction of suspended cable, short cuts could be taken across bends to reduce line length.

Aerial cable is as likely to be brought down in a storm as open wire but the chances are that the insulation will be unimpaired and the service can still be maintained. Loop resistances on aerial cable routes are, of course, higher on account of the smaller gauge of wire normally used, and because of the proximity of the wires precautions have to be taken to avoid overhearing and interference between lines. To prevent distortion and minimize attenuation, the longer junction cables are loaded by the addition of inductance coils. The cables chosen in this case are plastic covered quad and, as will be seen in Fig. 1, 88 MH inductance coils are inserted at 2,000-yard intervals.

Cable and Wireless Ltd. was entrusted by the Grenada Government with the reconstruction of the island's telephone system and the administration of it on completion. The Company, under contract from Cable and Wireless Ltd., was to provide and install the telephone exchange equipments and supply the subscribers' station apparatus such as telephones, P.A.B.X. and P.B.X. switchboards, etc.

Rurax equipment is to some extent kept on a stock basis and could be provided more quickly than the main exchange. It was therefore decided that the exchanges working over the shorter junction routes should be supplied in early 1956, with terminating equipment to allow junction working between these exchanges and the existing manual exchange at St. Georges. The remaining equipment was to be delivered by September, 1956. However, before delivery of the equipment was due, an unforeseen event threw all plans into disorder.

On the 22nd of September, 1955, Grenada was struck by a tropical hurricane of great intensity and although casualties were happily not heavy, much damage was caused. Most of the existing line network was destroyed and the old exchanges were put out of action. A large amount of line stores material was lost and of the remainder much was pressed into emergency service. For example, large quantities of poles were taken from stock for the construction of temporary bridges. To make matters worse, the deep water pier at St. Georges was demolished and all telephone plant had to be landed in lighters. Since the available labour force was occupied for a time in erecting temporary trunk lines, it can be appreciated that the task of building the new permanent network was severely hampered. As a result of delay caused by the hurricane, the earlier programme whereby the first installed automatic exchanges were to operate into some of the old manual areas during their reconstruction period was abandoned. Installation of the automatic equipment was also retarded by several months, eventually beginning early in 1957.

Fig. 2

30 ft. pole on the Grand Etang Road between St. Georges and Grenville being hoisted by winch and sheerlegs of a three-ton truck

Fig. 3 indicates the area routing scheme and shows the initial and ultimate number of lines at each exchange. A Rurax subscriber dials digit '9' to reach the automatic equipment at St. Georges; he may then dial a subscriber's number or a further routing digit to any other Rurax exchange. The subscribers at St. Georges need only dial a single routing digit to reach any of the Rurax dependent exchanges. Circuits are arranged so that digit 'O' dialled anywhere on the island connects the caller to the manual board at St. Georges. Coin box lines have access only to numbers on the same exchange or to the operator.

A very simple scale of charges has been adopted. Calling subscribers' meters register a single fee for each completed local call in the usual way. Such calls are not timed. On a call over a junction to any other exchange, two meter fees are registered immediately the call is answered, and this charge is repeated at 3-minute intervals for the duration of the call.

Although initially the junctions are operated bothway, it may be more economical with the ultimate number of junctions to operate some of them unidirectionally. Consequently the junction circuits have been designed with separate incoming and outgoing relay sets, initially tied for bothway operation.

The St. Georges Exchange

There would be little point in describing the equipment at St. Georges in detail, since it is largely of conventional type mounted on 8 ft. 6 in. racks. A few of the more interesting features are explained below.

To give some degree of standardization and to ease the maintenance and spares problem, the main exchange at St. Georges, like Rurax, employs a linefinder scheme with P.G. lock-out facilities. The linefinders are of the 50-point single-motion type. To economize on first selectors, a 25-point selector hunter is associated with each linefinder and the first selectors are graded from outlets of these hunters. Each 50-line group has 8 linefinder-hunter circuits.

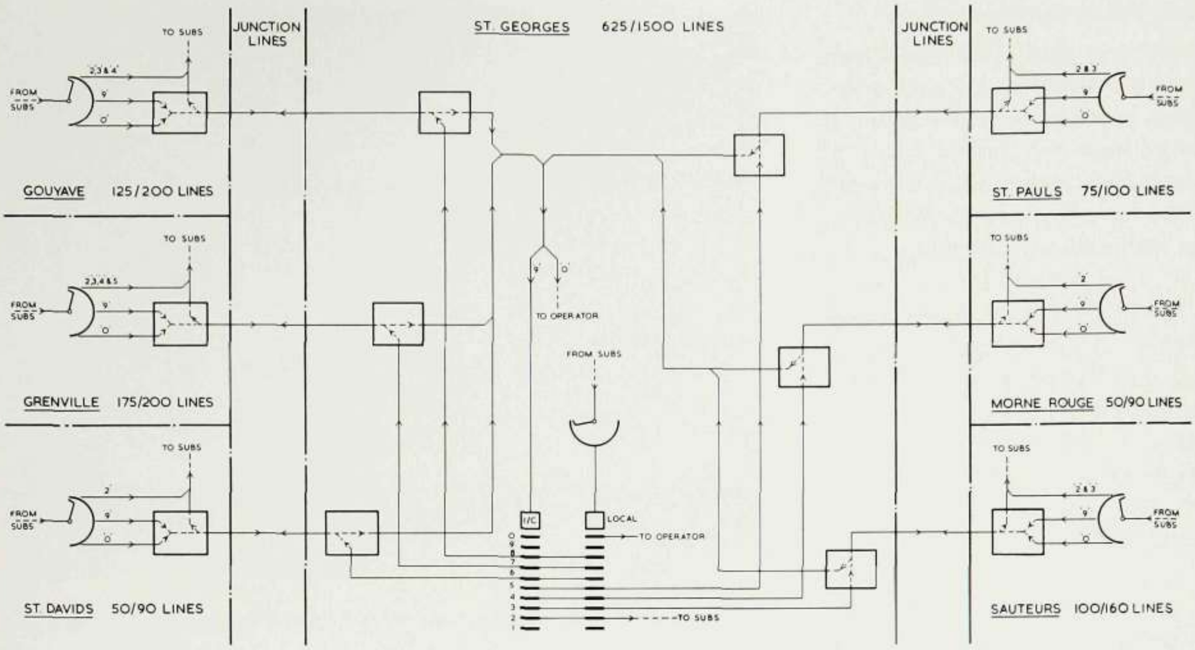


Fig. 3—Area Routing Scheme showing initial and ultimate line requirements

Coin box lines, of which there are 25, are in a separate group. As only 6 linefinders are required to cater for this group, selector hunters are not necessary and these linefinders are connected direct to first selectors.

Group selectors and final selectors are both 100-outlet SE 50 type two-motion switches. All group selectors employ battery testing, the coin box and local first selectors having P.G. lock-out.

Each group of final selectors is provided with 15 banks, and initially 13 selectors per 100-line group are equipped. The coin box lines are arranged to fall within the numbering of P.B.X. 2/10 lines although other multiple numbers can be used, if desired, by jumpering to other groups. The advantages of this scheme are that as coin box lines normally originate more calls than they receive, and P.B.X. lines often receive more calls than they originate, a combination of the two under one group tends to equalize the traffic to and from this group. Moreover, in the event of the unexpected growth of a P.B.X. group it may become necessary to alter subscribers' numbers, and as coin box lines are often ex-directory they may be changed without inconvenience.

The two-position manual board is of the sleeve control type, the enquiry circuits having combined access from coin box and regular subscribers with separate calling lamp. The operator gains access to the dependent exchanges via manual board selectors. The complications resulting from junction circuits having combined operator and selector access are thus avoided. Because of the inter-dialling between all exchanges, the main function of the manual switchboard is to assist in extending coin box calls between exchanges and to establish connection to radio links for overseas calls. As all such calls via the manual board are timed, four cord circuits on each position are equipped with standard chargeable time clocks. These clocks are stepped by a 6-second pulse derived from an electrically driven master clock. The pulses providing the 3-minute warning signal follow immediately after the appropriate 6-second pulses and use a separate set of contacts. Usually three such warning pulses are used but in order to obtain from the same contacts the 2-fee meter pulses required on all dialled junction calls, the master clock has been modified in this instance to give only two pulses. The need for a master clock at each of the dependent exchanges has been avoided by distributing the 6-second pulse and the two meter control pulses over spare junction wires.

THE RURAX EXCHANGES

As it is now some three years since a description of Rurax equipment appeared in our Bulletin, it is perhaps not out of place to summarize the features which make the system particularly suitable for an application of this kind.

A special feature is the adaptability which enables equipment installed initially to serve 50 lines or less, on an extremely economical basis, to be extended easily by stages to serve a normal maximum of 350 lines, or more than this number if necessary.

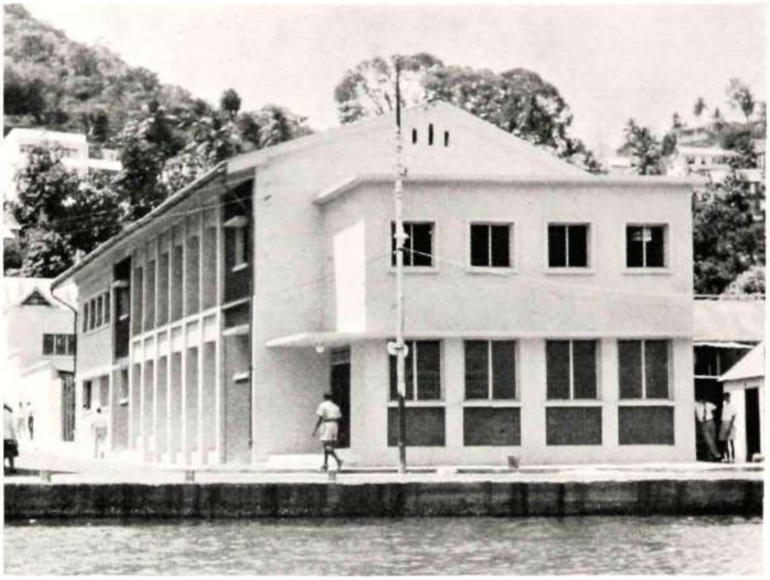


Fig. 4—The main exchange on the waterfront at St. Georges

For simplicity the step-by-step principle is employed, 50-point linefinders being used to connect the caller to the switching equipment, which consists only of uniselectors and relays. The use of two-motion selectors, registers, by-paths or common equipment for the selecting stages has been avoided to simplify fault locating and maintenance. The equipment can quite easily be adapted for connection to any type of system or network and is fully tropicalized. Construction is on the self-contained unit principle, the basic equipment being a 50-line unit. All units are enclosed in metal cabinets, sealed against dust, and all wiring is insulated with p.v.c., which is highly resistant to insect attack and will not promote fungoid growth.

These features together ensure the low fault liability which is particularly sought after for locations such as Grenada, where only periodic visits of maintenance staff are possible.

The construction of Rurax equipment and the use of enclosed batteries has allowed all the plant to be housed in one room at each exchange. A typical Rurax building and a floor plan of the Sauteurs exchange are shown in Figs. 5 and 6, respectively.

With the exception of the junction circuits which are arranged to include the repeat metering facility, standard Rurax circuit arrangements are employed, these being as follows:—

The 50-line exchanges at Morne Rouge and St. Davids have the linefinders tied directly to the connectors (final selectors), but when the exchanges are extended, group selectors mounted in separate units are interposed between these two ranks of switches. The connectors are arranged to absorb the first digit when a local subscriber's number is dialled, and to switch the call to junction hunter switches if the first digit dialled indicates that a junction or special service is required. This arrangement allows these exchanges to have a 3-digit numbering scheme initially so that on extension beyond 50 lines, when group selectors are introduced, it will not be necessary to change the existing subscribers' numbers.

With group selectors fitted as at Grenville, Gouyave, Sauteurs and St. Pauls, the facility for absorbing the first digit of a local subscriber's number is strapped out on the connector, and as the junctions and special services can be reached from the required levels of the group selectors, the junction hunter switches are not required.

Ringing and tones are supplied from two jack-in relay mountings, one of these housing the supply apparatus and the other carrying the interrupter relays. A vibrator supplies the ringing current and the tones are produced electronically. Although

Fig. 5

Typical Grenadine vegetation surrounding one of the Rurax exchange buildings

one such set of equipment will suffice for a 200-line exchange, on the larger exchanges, (i.e. those over 50 lines) duplicate equipment with auto/manual changeover facilities is provided.

The outgoing junctions from the Rurax exchanges employ combined '9' and 'O'-level working. This arrangement allows a Rurax subscriber to be connected to the automatic equipment at St. Georges by dialling '9', or directly to the operator by dialling 'O'. If '9' is dialled from a coin box, N.U. tone is returned to the caller and forced release conditions are applied. The circuit includes a repeat meter switch which is brought into use when a call to a distant auto subscriber is answered. The 6-second pulse and the two meter control pulses derived from the clock at St. Georges are fed to the junction circuit via distribution and alarm equipment. The 6-second pulse steps the repeat meter switch and the two meter control pulses operate the calling subscriber's meter when the switch is on outlet 1, whilst the two warning pips of tone are given from outlet 28, i.e. 12 seconds before the termination of the 3-minute period.

The standard alarm test circuit, reached by dialling '1', gives a tone signal if an alarm condition exists at the exchange. Distinctive tones are employed to indicate ring fail alarm, fuse alarm, supply fail alarm and clock pulse fail alarm. In addition, an alarm extension circuit is associated with one junction on each route and makes use of the tone signals employed for the alarm test circuit. Should a

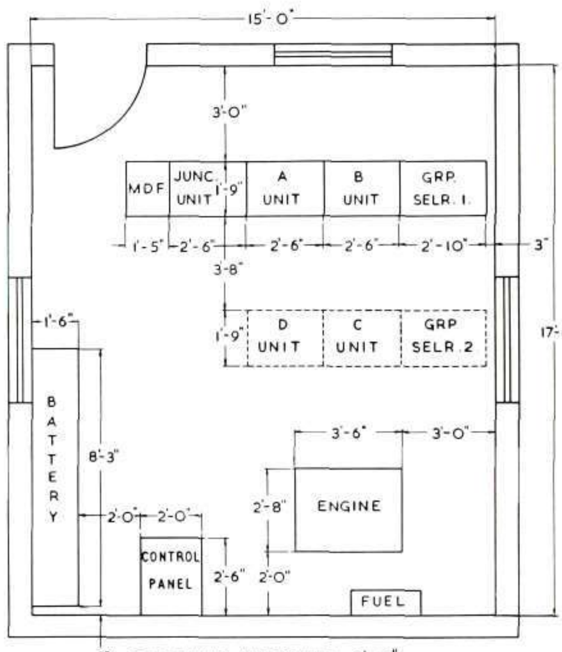


Fig. 6—Layout of equipment at Sauteurs

fault occur, the alarm extension circuit originates a call to the operator, who upon answering receives the tone signal indicating the type of alarm. Removal of the operator's plug frees the junction and prepares the alarm extension circuit so that when the fault has been cleared another call is originated to the operator, who then receives the "all clear" tone signal. Arrangements are made to ensure that the junction line is not seized by the alarm extension circuit whilst a call is in progress.

Power Supplies

The nominal operating voltage for all exchanges is 50 volts d.c., but to produce this potential three types of plant are used. At Morne Rouge, St. Pauls, St. Davids and Grenville, mains supplies are available and the single-battery float scheme is employed. This simple type of plant uses one charging unit having an output equal to the ultimate load of the exchange, and a battery able to provide service for approximately 24 hours in the event of mains failure, no switching being necessary to maintain the voltage during such failure.

At Gouyave and Sauteurs there are no mains supplies and each station has its own diesel generator which is preset to run during the busy period for approximately 8 hours. This period of operation is chosen to suit local conditions. The plant operates on the semi-automatic float principle. While running, the generator supplies energy to the exchange and in addition, during the lighter load periods, replaces the energy taken from the battery during the idle periods of the generator. This system can operate automatically or under manual supervision.

In both the above schemes a boost charge is required to replace battery energy and stir up the electrolyte. This boost is given once each month at Gouyave and Sauteurs but only once every three months at the other exchanges. Because of the more frequent high voltages imparted with the semi-automatic float system, contactor switching is provided at the diesel generator stations to maintain the exchange potential within acceptable limits.

The main exchange at St. Georges employs a duplicate battery float plant. This consists of two 24-cell batteries normally floated in parallel across the outputs of one or two of the float charging units. The control panel switching arrangements permit battery isolation for boosting with either of the charging units every few months to counteract the slight loss of battery capacity incurred whilst floating. The exchange employs a positive battery for metering, and a 30-volt supply for P.B.X.'s in the area is obtained by means of 7 C.E.M.F. cells connected in opposition to the main battery. The ringer panel is equipped with apparatus to control ringing and tones and effect automatic changeover from the normal to the standby machine should the ringing supply fail.

The main advantage of all these full float power plants is that, apart from supervision during boost charging, they may be left unattended, and although at Gouyave and Sauteurs a daily visit is necessary to reset the time switch and start the set, this causes very little inconvenience.

As a precautionary measure, a portable diesel generator has been provided. This is mounted on a two-wheeled trailer unit complete with steel canopy and a power plug and socket. Its output is 50 volts d.c. and it can function as a standby in the event of failure of the mains or charging equipment at any station, or even be used to supplement the 24-hour battery reserve.

This precaution ensures that a breakdown of power at any of the exchanges can be remedied very quickly.

In the normal course of events, the provision made for automatically charging the batteries, and the reliability of the Rurax equipment—so amply demonstrated in other parts of the world—can be expected to preclude the necessity for maintenance at any of the outlying exchanges, except at infrequent intervals. Even then, routine maintenance and the clearance of any faults that could conceivably develop would require the minimum expenditure of the technician's time, because of the relatively simple nature of Rurax apparatus and circuits.

The exchanges at St. Georges, St. Pauls and Morne Rouge were brought into service on the same day, and the others in quick succession, the final cut-over being effected soon after Christmas 1957.

It is reported that the cut-overs were virtually fault free and that public reaction to the new system is very favourable.

This article is published by permission of Cable and Wireless Limited, to whom we are also indebted for the use of the photograph, Fig. 2.

UDC.621.395.61

A CONVERTIBLE TELEPHONE

Type N2186A

G. R. Gunson — Circuit Development Department

The N2186A Telephone is designed to provide easy conversion from one system of working to another. The conversion from Local Battery to C.B. or Auto working is effected by changing strap connections on the instrument terminal block and, for automatic working, by adding a dial. No wiring changes are necessary and the simplicity of the changeover obviates any need to remove the instrument from the subscribers' premises and does not involve undue interruption of the service.

FOR telephone systems in areas remote from other networks, the magneto method of working is initially often the most suitable. As development of the area proceeds, a change to central battery or automatic working may be desirable. In these circumstances it is advantageous if the trouble and expense of replacing all the subscribers' and extension instruments can be avoided by having a convertible telephone which can be simply and quickly adapted to any system of working. In the past the requirement has been partially met by providing telephones assembled in auto type cases with dial dummies, fitted with generators where necessary and having additional wires in the form to allow for circuit changes. For local battery working each instrument was equipped with the appropriate induction coil, and to carry out the conversion this had to be removed and replaced by a C.B. coil, making use of the additional wires in the form. The change also involved the capacitor connections, and a number of joints had to be unsoldered and re-made. It can be appreciated that this method of conversion was more troublesome than a straightforward replacement of instruments; it was only justified when the cost of the change-over had to be kept to the minimum.

The necessity for changing the induction coil is obviated in the telephone illustrated in Fig. 1. It is fitted with a C.B. type coil, and the circuit incorporates a separate inductor for the local battery feed to the microphone, so that operation is satisfactory on either local or central battery systems. A hand generator, a 0.5 μFd. capacitor and the capacitors for the anti-sidetone network are also included in the circuit. The arrangement of the components is seen in the interior view of the instrument, Fig. 2.

Fig. 1—Convertible Telephone. Type N2186A

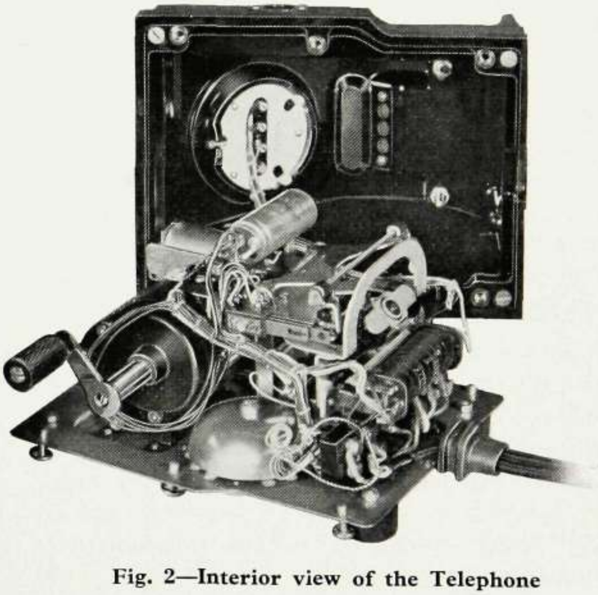


Fig. 2—Interior view of the Telephone

The most usual requirement is for a magneto telephone capable of easy conversion to automatic working, but other conversions are sometimes necessary and a total of eleven systems of operation are covered by the provision made for circuit adaptation. Most of the adaptations are effected by merely altering terminal strappings, although for earth clearing systems (which are obsolete and seldom encountered nowadays) the series connection of the bell coils must be changed to a parallel connection.

When the change from magneto to automatic working is to be carried out, the dial may be fitted and connected without removing the local battery. In this condition the instrument will continue to work on the old system. The conversion is completed by making the strapping changes required to adapt the circuit for automatic working and disconnecting the local battery. The generator may be left in place if desired, the handle being removed and replaced by a cover plate; this can if necessary be deferred until after the changeover to the new system. The conversion is thus effected without removing the instrument from the subscriber's premises, whereas the older type of telephone had to be returned to the workshop for alteration when the system of working was changed. Conversion from C.B.S. No. 2 to automatic working is similarly simple and convenient.

The systems for which the convertible telephone can be adapted are listed below, and since the instrument has to accommodate all the components needed for any of these systems, a type N.1002 automatic telephone case is used with a plinth base to afford space for the generator. A curved handset with a rocking armature inset receiver is provided and is connected by a close-braided nylon cord to the instrument terminal block. The induction coil is of the closed-iron-circuit type as used on the Type 1000 telephone. A rotary magnet generator of standard output is fitted and is particularly easy to operate. The telephone is suitable for use in temperate and all types of tropical climates. The circuit is shown in Fig. 3.

The transmission efficiency on C.B. or automatic systems is the same as that of the Type 1000 telephone described in Bulletin No. 35, whilst on local battery systems the efficiency is higher than that obtained with the previous standard circuit. In all cases the anti-sidetone properties are satisfactory and in local battery working the sidetone suppression is better than before.

The maximum loop resistance for satisfactory operation is 1000 ohms when working to automatic exchanges having 50-volt batteries and 200/200-ohm feeds or 65/65-ohm feeds with barretters. Operation over lines of higher resistance is possible on local battery systems, the maximum length of line depending upon local conditions.

The systems to which the convertible telephone can be adapted are as follows:—

Magneto	Long line Auto
Magneto, loop clear	Extn on Intermediate C B.
Magneto, earth clear	Extn on Intermediate Auto
C.B.S. No. 1.	C.B.
C.B.S. No. 2	Auto
Long line C.B.	

Diagrams indicating the changes necessary for each conversion are shown in Fig. 4. The ease with which these changes can be made will be appreciated by administrations responsible for such conversions, and clearly demonstrate the advantages of the Type N2186A telephone over its predecessors, not only because of the saving of time and cost when changing from one system to another, but also because of the higher all-round efficiency of the new instrument.

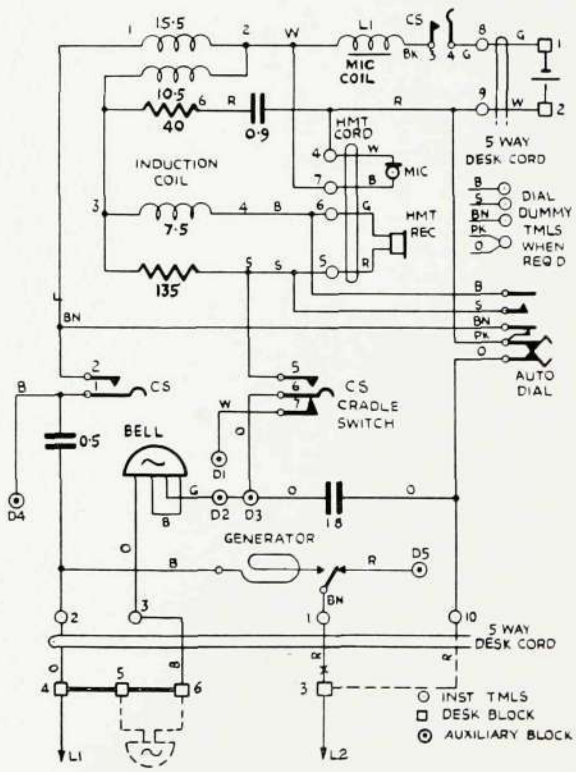


Fig. 3—Circuit Schematic

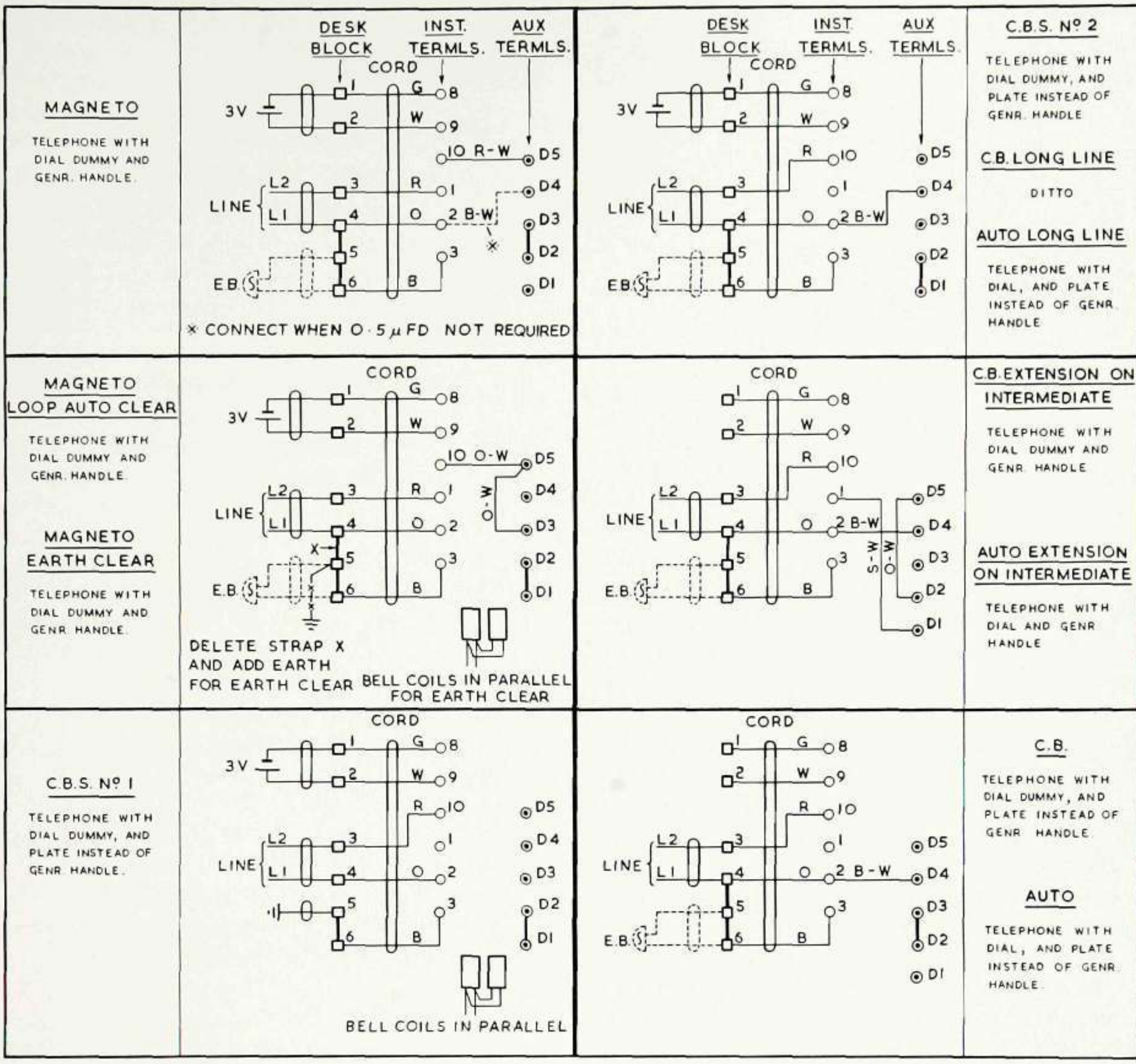


Fig. 4—Terminal Strappings for the Various Conversions

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A NEW LINE CONNECTOR

J. P. Harvey — Circuit Development Department

The practice of providing a separate pair of wires from a telephone exchange to every subscriber's instrument becomes uneconomic when a substantial proportion of the lines carry very light traffic, since the total time for which a lightly-loaded line is used amounts to only a small fraction of each day. As telephone networks develop, there is a tendency for service to be required by increasing numbers of residential subscribers, who are usually situated at some distance from an exchange and have low calling rates. In these circumstances, some means of offering normal facilities without installing a direct exchange line to every telephone is desirable.

The line connector is a device enabling a relatively small number of exchange lines to be shared among a group of low calling rate subscribers without impairing the service. The connector with which this article is concerned provides for the use of four exchange lines by up to 22 subscribers. It is designed for easy maintenance, and incorporates a very reliable battery which is charged from the exchange over the speaking pairs when they are disengaged.

MANY residential subscribers make telephone calls at the rate of one a day or even less frequently. Although it is uneconomic to provide a line to the exchange for the exclusive use of a subscriber whose calling rate is very low, all subscribers expect to have available the full facilities of the service. The line connector, or line concentrator as it is sometimes called, is a means of giving normal facilities to low calling rate subscribers without providing a separate exchange line to each telephone. In a typical case the traffic due to twenty subscribers in the same district may be such that it can be adequately carried by four lines. By installing a line connector at some convenient point, as close as possible to all the subscribers' premises, some sixteen pairs of wires can be saved.

Each subscriber has an individual line to the connector, which has four lines to the exchange. (The exchange lines are usually referred to as links). The function of the connector is to join any of the subscribers' lines to a free link when a call is either made or received, and at the end of the call to disconnect the subscriber's line and leave the link free for the use of other subscribers served by the same connector. Provided that the connector is situated some distance from the exchange, the cost is less than that of the additional exchange lines which would be needed in its absence, so that an economy results from its use. In addition to the saving in line plant a similar economy in the provision of exchange calling equipment is possible in many cases where connector working is adopted.

Interest in the scheme has increased with the tendency of towns to spread into the surrounding countryside, since it is with groups of residential subscribers situated at a considerable distance from the exchange that economies in line plant become most desirable. Some existing types of connector use special mechanical devices which give rise to maintenance problems, whilst others do not provide for the subscriber trunk dialling facilities which many administrations are now introducing. The line connector to be described has been designed with such considerations as these in mind, and it fulfils the needs of present-day telephone networks.

Considerations of Design

A line connector should not affect the facilities offered to the subscriber and must be suitable for mounting in a roadside cabinet or other unattended enclosure. Installation and maintenance should be simple; in general this means that switches and other components should be of standard type. Since the connection of a power supply at sites remote from the exchange introduces difficulties, it is advantageous if power can be obtained from the exchange. However, designs which require power lines in addition to the speaking pairs are undesirable, since such connections reduce the saving in the line plant and make the functioning of the apparatus dependent on the serviceability of one pair of wires.

Traffic statistics enable the number of links required by connectors of various capacities to be determined, and taking traffic considerations only into account it would appear that the greatest economies are obtained with a connector serving about fifty subscribers; in this case about eight links are necessary. However, the number of subscribers in an area suitable for service via a connector is often less than twenty, so that if a fifty-line connector were adopted as standard, much of its capacity would frequently be wasted. Moreover, the use of two small connectors instead of a single large one to serve an exceptionally large group may have advantages. The connectors can usually be located closer to the subscriber's premises, so that a greater saving in line plant is obtained; also, the probability of calls between two subscribers served by the same connector tends to decrease as the capacity of the connector is reduced. It is desirable that the number of such calls should be small, because they are completed via the exchange and so engage two links. The complication of the connector which would be necessary to switch calls of this nature independently of the exchange is not economically justifiable, and it would be difficult to arrange for the completion of calls via the connector only, without some variation of the normal dialling procedure.

For these reasons it was decided that the new Line Connector should have a capacity of about twenty subscribers' lines. Because of the need for easy maintenance, standard 25-point uniselectors mounted in jack-in units were chosen to effect the switching. The jack-in arrangement limits the number of terminations available for subscribers to twenty-two. Four links are needed to carry the traffic to be expected with a normal residential group of this size. A local battery is provided for the remote equipment and is kept in a charged condition over the speech pairs when they are not in use, so that no additional power lines are required.

THE EQUIPMENT

Fig. 1 shows the subscribers' unit of the connector mounted with the battery and a vertical of cross-connection terminals in a standard British Post Office type roadside cabinet. The relay sets are enclosed in an aluminium container which, when its cover is in place, is impervious to moisture, so that the cabinet can be opened in bad weather without the risk of impairing insulation or causing contact trouble. There is space within the inner container for silica gel desiccators which absorb any moisture admitted when the container has been opened. The desiccators can be seen below the relay sets in Fig. 2. As all the lines are brought out to external connectors, opening of the inner container is usually only necessary to obtain access to the relay sets.

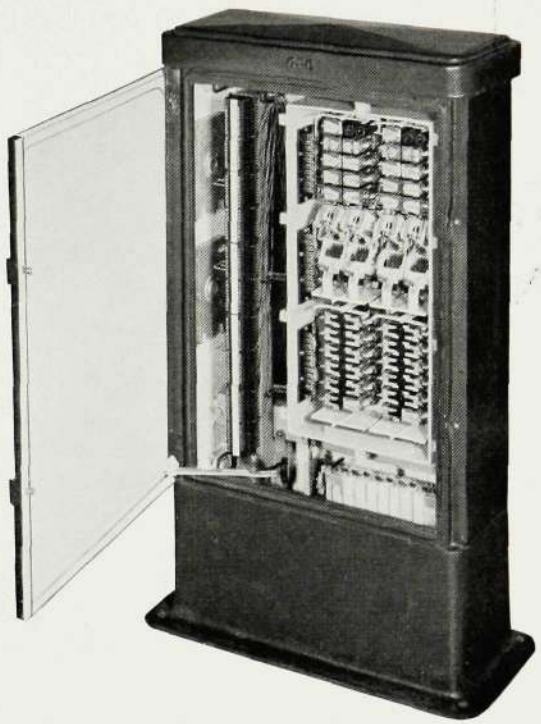


Fig. 1—The Subscribers' Unit in a standard B.P.O. type roadside cabinet with cover of inner container removed

The external connections are arranged for easy jumpering to the vertical of cross connection terminations so as to give complete flexibility in the choice of exchange and subscriber's lines. The jumpering field is visible in Fig. 1 and the screw type terminations can be seen on the side of the inner container in Fig. 2.

Each of the two upper relay sets in the container carries the uniselectors and control relays for two link circuits. The two lower relay sets each accommodate the line and cut-off relays for 11 subscribers. The jack-in construction reduces to a minimum the maintenance work required to be carried out on site, since any of the relay sets can be removed to the exchange for servicing and testing.

The exchange equipment has a test position into which relay sets from the subscribers' unit may be jacked. Keys are provided to enable calls to be simulated so that the operation of the exchange equipment and the relay set under test can be studied simultaneously.

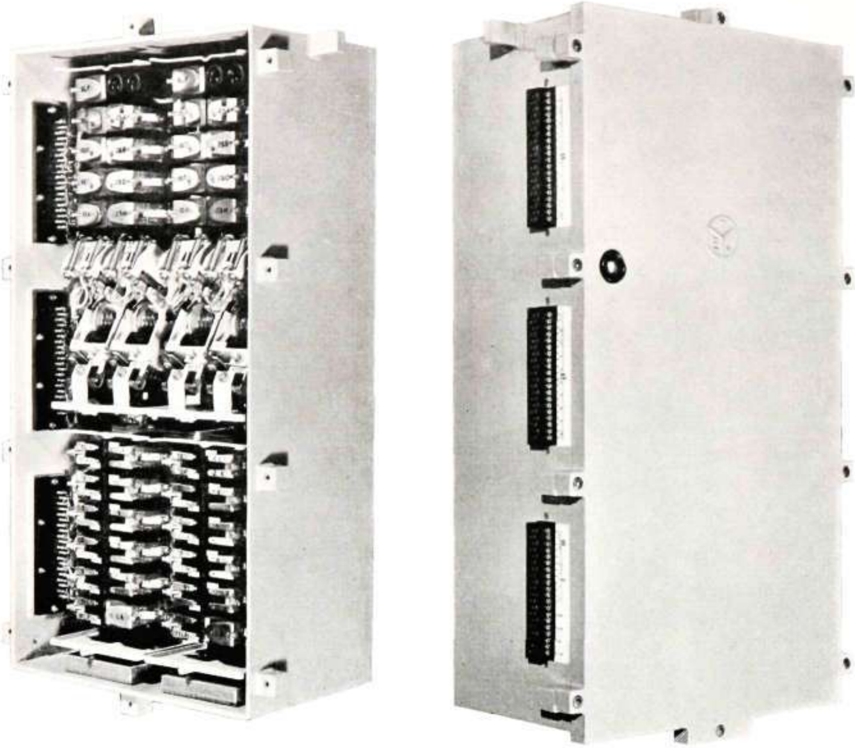


Fig. 2—Two views of the inner container of the Subscribers' Unit

It is not essential to jack in a spare relay set at the subscribers' unit whilst one is removed for servicing, since calls can still be connected by the two remaining links even though a reduced grade of service is given.

The test position is at the left of the upper relay set in Fig. 3. The rack on which the exchange equipment is mounted in this figure can be used when a line connector is installed as a temporary measure in an emergency or for such purposes as the provision of lines for an agricultural show.

CIRCUIT DETAILS AND OPERATION

The principle of a simple line connector giving service to a number of subscribers over one link is shown diagrammatically in Fig. 4A. Each end of the link is connected to the wipers of a uniselector, and the bank contacts of the uniselector at the subscribers' end are connected to the subscribers' lines, whilst at the exchange end the bank contacts are connected to exchange line circuits and the associated final selector multiple positions. Calls involving any one of the subscribers can be connected by stepping the two uniselectors in unison until the appropriate contacts are reached. Since only one link is provided, only one subscriber at a time can use the telephone, so it is not really necessary to provide more than one line circuit at the exchange. Fig. 4B shows how the elementary arrangement of Fig. 4A can be modified to arrange for this.

By multipling the subscriber's lines over four links similar to that shown in Fig. 4B, provision can be made for four simultaneous calls, and calls between two subscribers served by the same connector can be made (by taking two links into use) without departing from normal dialling procedure.

To enable a remote subscriber to be connected to the exchange the connector must be seized, a free link selected and the two uniselectors associated with the link stepped to the correct outlets. Fig. 4C shows the circuit elements involved in the initiation of such a call.

When the remote subscriber lifts his receiver his loop operates the LR relay in the remote line circuit. The LR relay operates the LA relay which disconnects the charging circuit of the local battery. A relay, CH, is associated with each link at the exchange and is held operated by the charging current to the remote battery so that when the charging circuit is disconnected, the CH relays in all

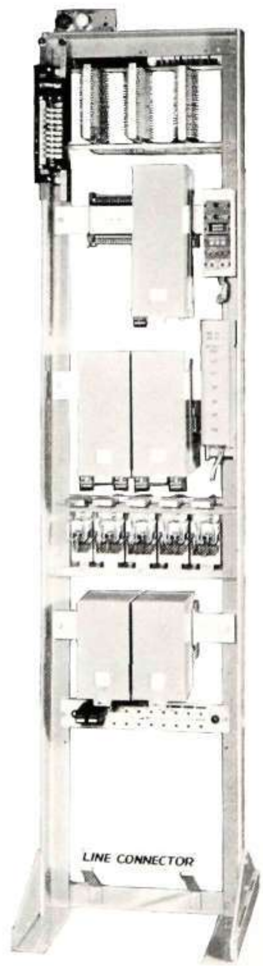


Fig. 3—Demonstration Exchange Unit

Fig. 4A—A simple Line Connector using one line circuit in the Exchange per Subscriber

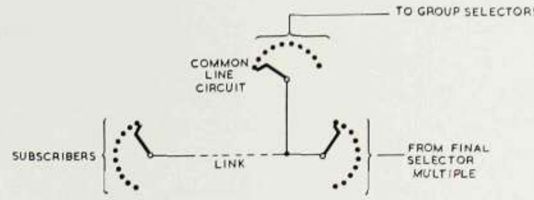


Fig. 4B—Line Connector using a common line circuit in the Exchange

free links release. This initiates the seizure of a free link.

When a call is made to the connector subscriber, the final selector tests into the RA relay, which takes the place of the K relay in a normal line circuit. A contact of the RA relay initiates the seizure of a free link. The functions of the control circuit are exactly the same, regardless of the direction of the call initiating the seizure. It is therefore impossible for any misoperation to occur due to calls in opposite directions being initiated at the same instant.

Seizure of the remote equipment is brought about by a reversal of the battery charging potential on the link to be used for the call. The elements of the circuits involved in the selection and seizure of links are shown in Fig. 4D. A common relay set at the exchange employs a control switch which is normally positioned on a free link and seizes the link by operating its KA relay. When this relay operates, it switches the exchange end of the selected link to the control relay set and in so doing reverses the potential on the link. As a result, the PA relay in the control relay set and the SA relay at the subscribers' end are operated in series; contacts of these relays operate the associated PB and SB relays.

A contact of a self-pulsing relay P is included in the circuit of the PA and SA relays, and pulsing is started shortly after the seizure of the link. With the PA and SA relays released, short circuits are applied to the PB and SB relays, rendering them slow to release ; these relays therefore remain operated during the pulsing of the PA and SA relays. The first release of PA and SA, with PB and SB operated, causes relays PC and SC to operate, and they remain energized until pulsing is completed.

Contacts of the SC relay disconnect the rectifier in series with the SA relay, whilst contacts of the PC relay reverse the potential on the pulsing loop. If for any reason the SC relay should fail to operate, the back resistance of the rectifier will prevent the PA relay from re-operating when the pulsing contact makes again. However, if seizure of the remote equipment proceeds normally, the pulsing of the PA and SA relay steps the J and S uniselectors, the circuits for the driving magnets of these switches being completed by the PC and SC relays. The switch wipers move at approximately 13 steps per second and the last outlet is normally reached within two seconds. As arrangements are made for the exchange line circuit to be seized immediately the link is seized, dial tone is normally received before the subscriber is ready to dial.

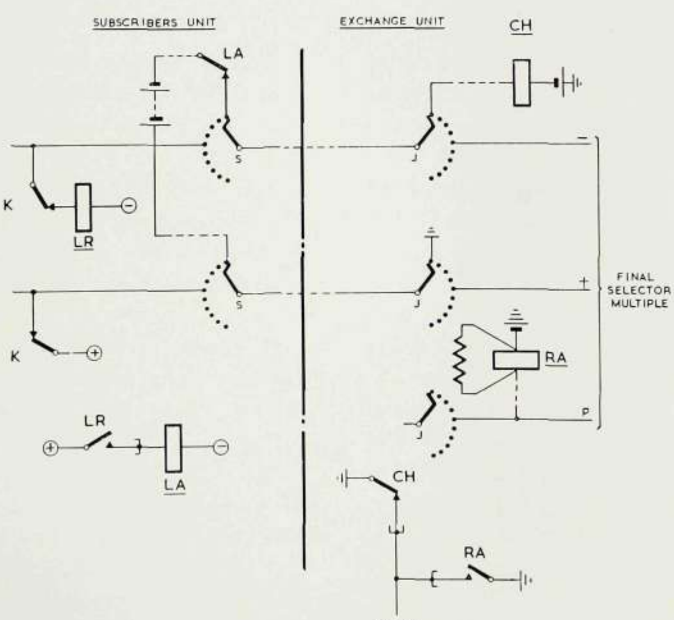


Fig. 4C—Initiation of a call to or from a remote Subscriber

Fig. 4E shows the circuit for the detection of the calling or called subscriber and the arresting of the J and S switches on the appropriate outlets.

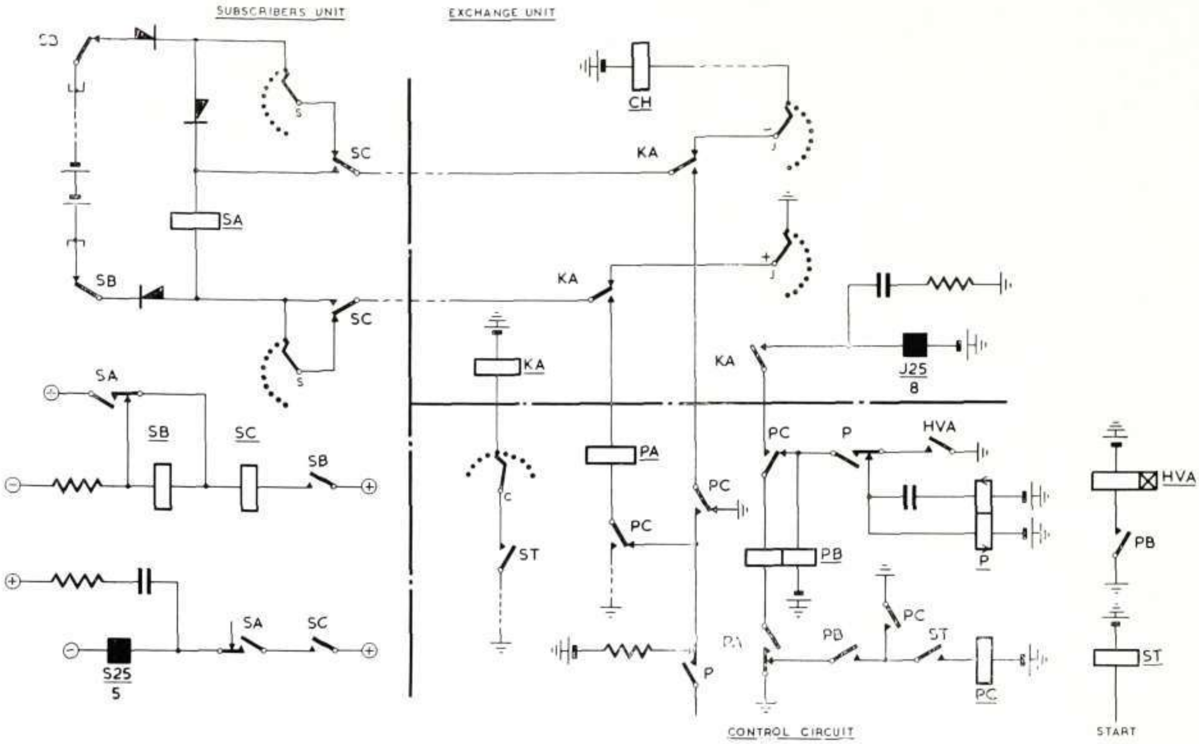


Fig. 4D—Seizing the remote equipment, checking the seizure, and stepping the J and S switches in unison

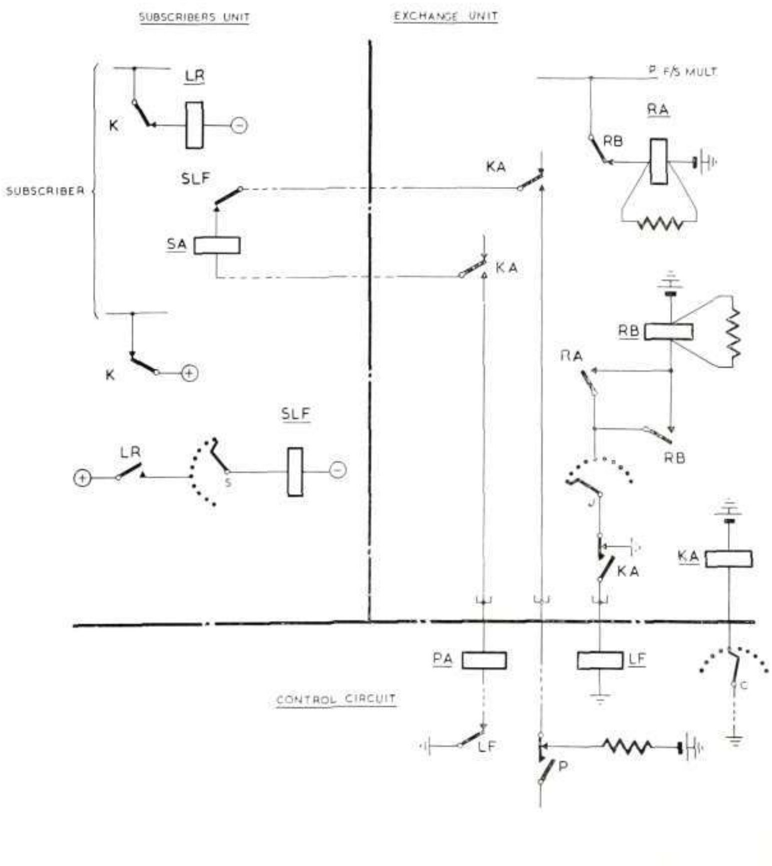


Fig. 4E—Cutting the pulsing loop to arrest both uniselectors on a marked outlet, regardless of the direction of the call

The SLF relay in the subscribers' link circuit operates when the S uniselector steps on to the contacts of a calling line. Similarly, the LF relay in the control relay set operates when the J switch steps on to the contacts of a called line; in either case the pulsing loop is broken by a contact of the SLF or the LF relay. With the pulsing loop broken, the PA and SA relays fail to re-operate when the pulsing contact of the P relay re-makes, and in consequence the PB and SB relays release. The release of the SB relay in the remote unit results in the release of the SC relay, and the subscriber is connected to the link via the wipers of the S switch.

The release of the PB relay in the control relay set causes the exchange link circuit KA relay to release, and the link is connected to the subscriber's final selector outlet via the wipers of the J switch. The control uniselector immediately steps to the next free link.

As indicated in Fig. 4F, when the subscriber's line is connected to a link the subscriber has, in effect, a direct exchange line for the duration of the call. To avoid unnecessary release and re-seizure operations on follow-up calls, especially when the connector subscriber, having received a call, is the last party to release and wishes to make another call at once, it is arranged that the link is not released until both parties have replaced their handsets.

The link is held by a relay connected to the exchange private wire, and the release of the connection is initiated by the release of this relay. In some exchanges this part of the circuit is modified because the exchange line circuit does not return earth potential on the private, and release has to be initiated by the connection of a battery condition to the private at the end of the call.

Fig. 4G shows the method of releasing the remote equipment. The neon diode, which contains tritium to ensure that striking is independent of illumination, is non-conducting when the line is at normal potential and so isolates the SH relay. The application of a low-power negative pulse of 150 volts amplitude to the line strikes the diode and energizes the SH relay. Operation of this relay causes the S switch to self-drive to the home contact.

With both the J and S switches on the home contact a circuit is completed for charging the remote battery; the charging rate is controlled by a potentiometer made up of the link line resistance and compensating resistors at both ends as shown in Fig. 4H. The potentiometer ensures that the battery is neither over nor under-charged and also holds the CH relays operated when there is no current via the battery in a fully charged state.

Power Supply

It has been stated that a local power supply in the form of a small battery is provided for the remote equipment to avoid having a power supply line from the exchange. The presence of a stable potential at the remote equipment simplifies the circuits and eliminates the possibility of a faulty power line putting the connector out of service.

The battery, developed by the Nife Battery Co., is of robust and reliable design; it is of the nickel-cadmium type and each cell is enclosed in a moulded polythene container. Topping-up and servicing are required only two or three times a year and should a prolonged fault completely discharge the battery, it can be recharged from a dry battery of small capacity without removal from its mounting or interrupting telephone service.

Field Trials

The British Post Office is at present carrying out field trials with a number of these connectors. One of the objects of the trial is to determine to what extent the inner container of the remote equipment should be sealed, since complete sealing increases the cost and makes removal of the lid more difficult. It is of course realized that in many countries complete sealing is essential.

Although the field trials have not proceeded long enough to give reliable findings on such problems as sealing, some useful information concerning the calling rate of residential subscribers has emerged. Meters have been installed to measure the traffic of individual subscriber's lines, and it has been observed that in many cases lines carried no traffic for periods of several days. Occasions when all links have been in use have been very infrequent and of such short duration as to make it unlikely that any calls were delayed.

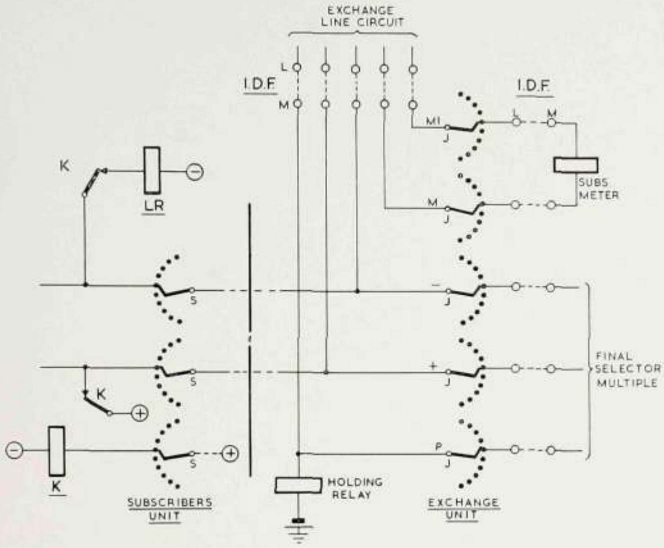


Fig. 4F—The connection is identical to that of an Exchange line when a call is set up in either direction

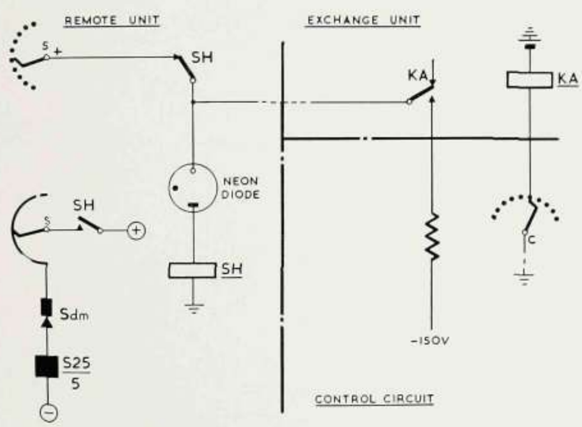


Fig. 4G—The use of a low power 150 volt connection to release the remote equipment

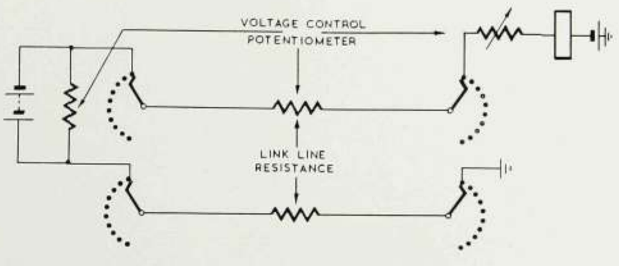


Fig.4H—Charging the remote battery via free links

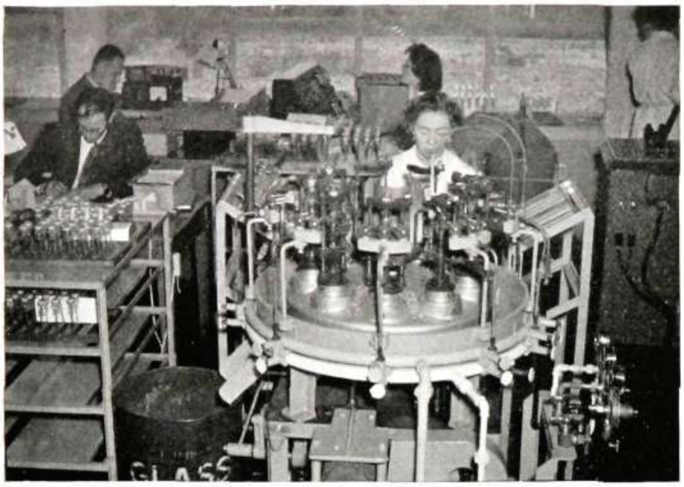
FUTURE TRENDS

It is possible, by additions to the link circuits, to provide for shared service subscribers, and this use of the connector may be justified where the subscribers' spurs are costly because of exceptional length.

Although, as stated earlier, the present requirements tend to be for service to rather small groups of subscribers, larger groups of subscribers may have to be catered for at a later stage. It may prove advantageous, especially with the advent of electronic switching, to situate large sections of the exchanges remotely to save line plant and avoid providing exchange equipment that is not fully utilized. It seems unlikely that development will reach this stage in the near future, but it would appear that there may be a demand for a connector capable of serving groups of up to perhaps 200 subscribers situated on the outskirts of large towns where there is little community interest.

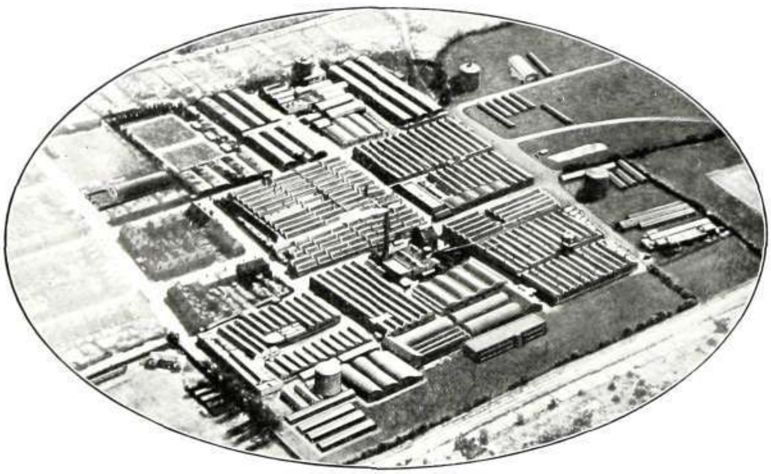
ACKNOWLEDGMENTS

The author acknowledges the help given by British Post Office staff in the Engineer-in-Chief's office in developing the connector, and also thanks the staffs at Nottingham and in the South-West Region for their assistance and information regarding the field-trial.



In the Valve Factory at Beeston

One of the high-speed automatic machines employed for sealing the glass envelope.



The Main Works at Beeston, Nottingham, England

Another view in the Valve Factory

Pumping units used in the valve exhausting process.