# THE ETELCO BULLETIN

No. 35
JULY, 1957

*Editor :* S. DENTON. *Tech. Adviser :* J. T. STRINGER, M.Sc.



## CONTENTS

Page 34 — The New Cordless Switchboard — *W. Sinclair and G. R. Gunson*

Page 44 — The New 'Type 1000' Telephone — *G. R. Gunson and D. Richardson, B.Sc.*

Page 53 — Electronic Automatic Telephone Exchanges

Page 54 — Flood Warning System for the New Zealand Railways — *J. R. H. Stevens*

Page 61 — Some Applications of the Add-on Counting Equipment — *G. Bishop*

*Published by*

Etelco LIMITED

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

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

UDC.621.395.26

# THE NEW CORDLESS SWITCHBOARD

W. Sinclair — Apparatus Development Department
G. R. Gunson — Circuit Development Department

*Cordless PBX switchboards of the c.b. and auto types are used by telephone administrations and business houses all over the world. High standards of reliability were established many years ago, and consequently designs have remained unchanged over a long period; this stability of design was founded on simplicity of circuit and construction. Whilst utilizing new materials and production techniques the new range of switchboards retains the basic simplicity and reliability of the older types.*

## General Design

ALL designs are controlled to some extent by materials and manufacturing methods. In the past timber has been employed for switchboard construction and this has imposed limitations on the shapes which could be used. The development of moulding materials and new forming processes has widened the scope of the designer in this respect, and the new materials can be coloured in many attractive shades. As can be seen from the coloured illustration, the new switchboards will harmonize with modern office settings. Design foibles which date the styling have been avoided and in accord with the long functional life provided it is expected that the appearance will prove pleasing for many years to come.

Fig. 1 shows a switchboard of the new type with the drop-on cover removed from the unit formed by the base and component mounting plates. Models with two exchange and four extension lines or three exchange and nine extension lines can be accommodated within the case illustrated, which is approximately 13″ long and 13″ wide with a maximum height of $8\frac{1}{2}$″. The key and indicator plate and the relay mounting plate pivot on the base (see Fig. 2) to give access to all components and wiring; this speeds production and simplifies maintenance. Spring washers on the plates act as brakes to prevent violent movement, and the plates are arranged to support each other so that there is no need for separate chassis members. Careful consideration has been given to the positioning of the four captive cover-fixing screws in order to ensure close seating on the key and indicator mounting plate (Fig. 3). Rubber feet are let into the base of the switchboard to prevent damage to the finish of the desk or shelf on which it stands.

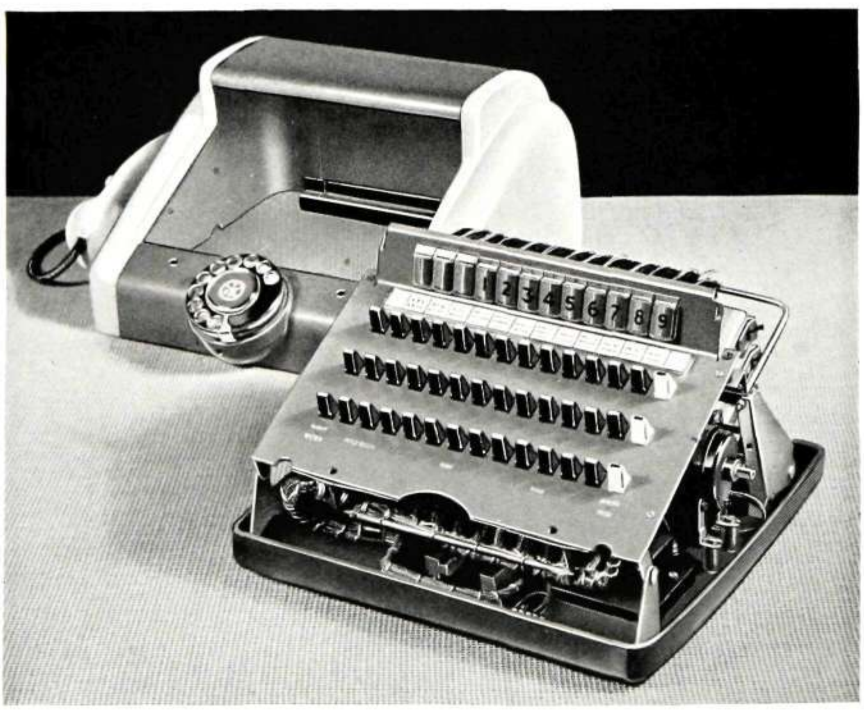
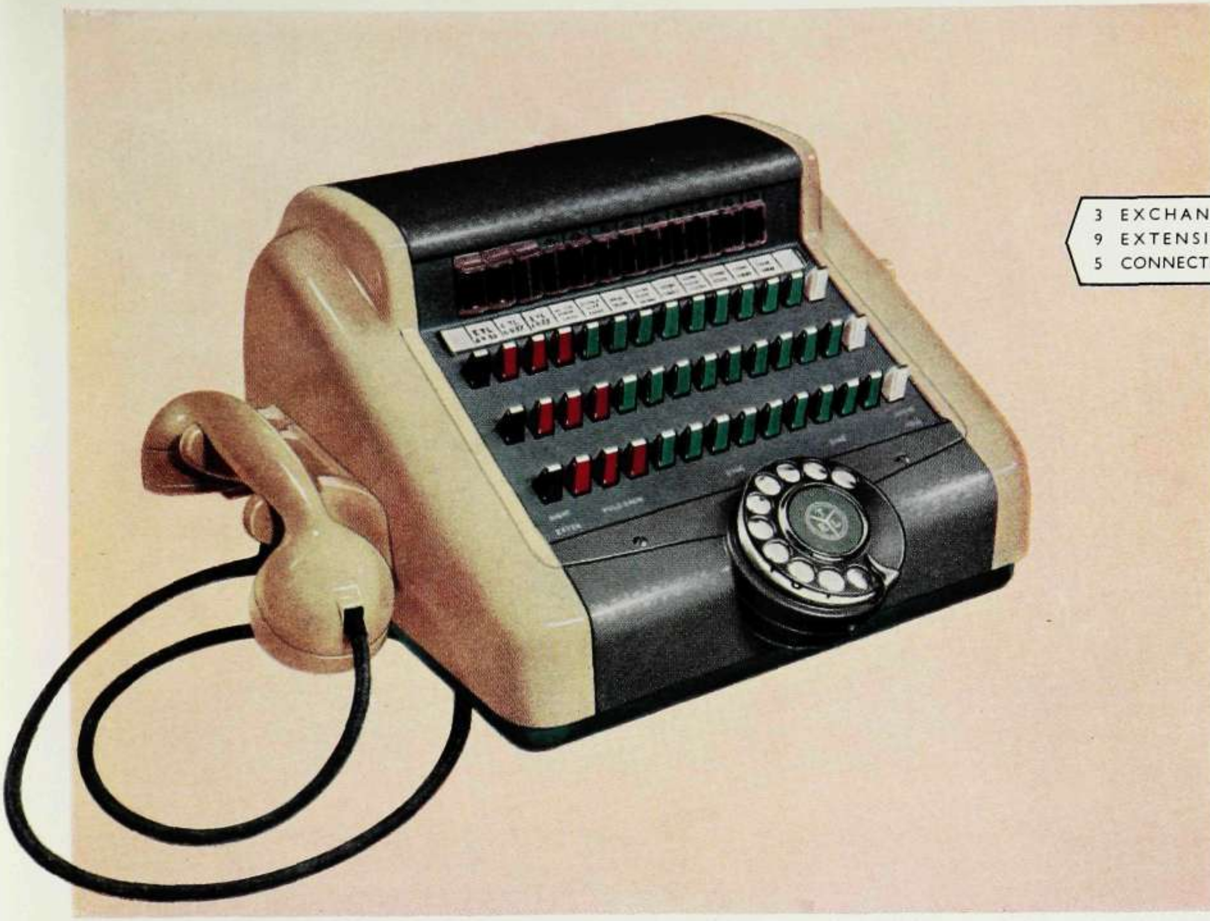



**Fig. 1—12-line Switchboard with Cover off**

The cover is assembled from several parts (see Fig. 4) and has considerable strength. The cover ends are moulded in a thermo-setting material with a durable finish and good resistance to surface abrasion. For the c.b. type the front and rear centre sections are formed from aluminium sheet and the fixing screws, captive in the front section, are covered by a push-on facia strip.



3 EXCHANGE LINES
9 EXTENSION LINES
5 CONNECTING CCTS

TYPE N112

## CORDLESS SWITCHBOARDS

TYPE N111

2 EXCHANGE LINES
4 EXTENSION LINES
3 CONNECTING CCTS

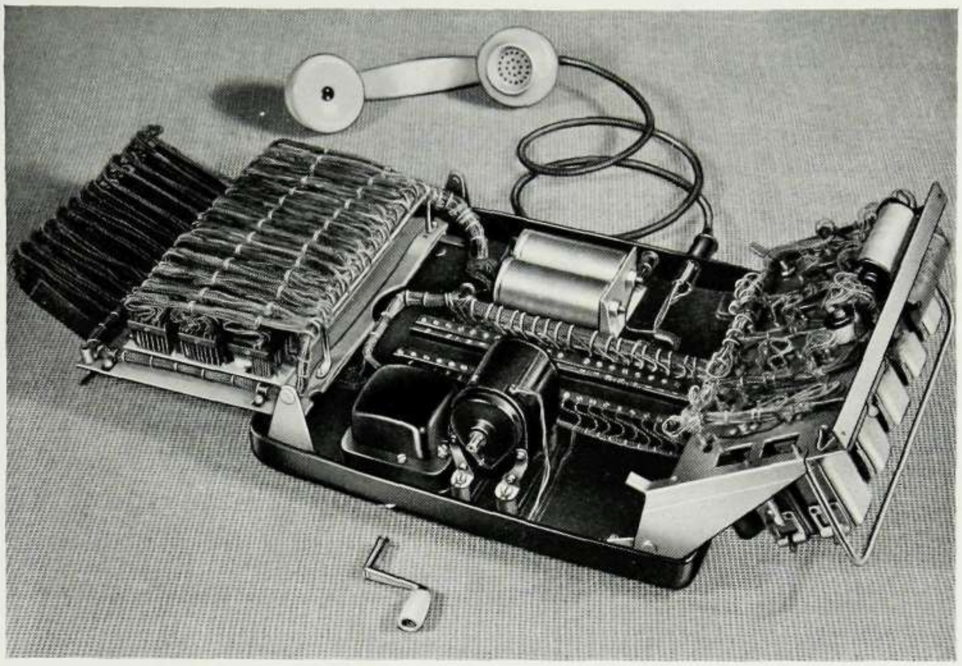


Fig. 2
Switchboard
Fully Opened

On auto types the front section is an aluminium alloy casting providing a dial mounting. The metal sections are finished in mottled enamel and two-tone colour schemes have been used for the complete assembly. Where c.b. type covers are supplied initially, subsequent conversion to auto is easily arranged by changing the front section and fitting a dial. Dial connections are made by a plug and do not obstruct removal of the cover.

The base is shell moulded from an aluminium alloy and shaped to form a rigid platform for the complete switchboard.

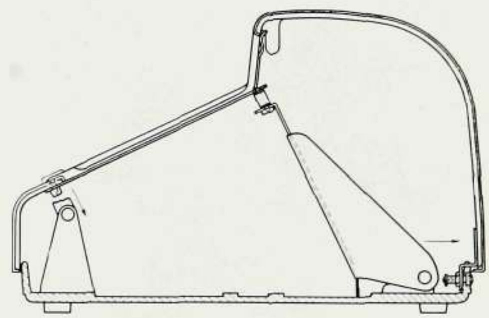


Fig. 3—Positions of Cover Fixing Screws

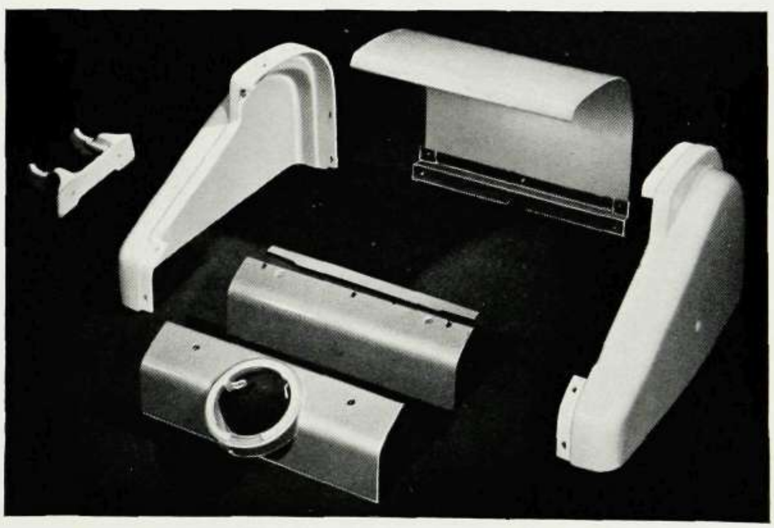


Fig. 4
Cover Construction
The alternative auto and C.B. front sections are shown

To reduce the size of the switchboard new designs for some components have been introduced ; major contributions in this respect are made by the new keys and indicators.

KEYS

The keys are assembled in units (Fig. 5), the component parts of the two or three keys in each vertical row being fitted on a common mounting which is secured to the key panel by two nuts. As shown in Fig. 6, access to the contact springs for cleaning or adjustment can easily be obtained. Careful choice of materials and of the shapes of springs and frames has enabled a considerable reduction in size compared with the previous type of lever key to be made, yet large contact clearances with adequate spring travel and spacing are maintained, whilst contact pressures are more precisely controlled than in previous designs.

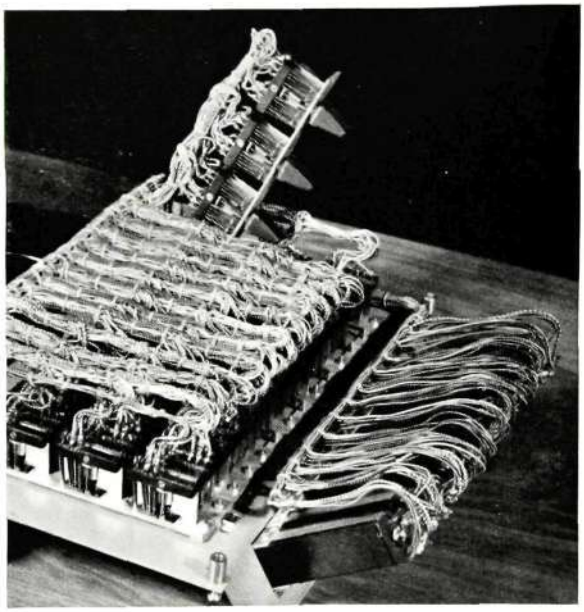


**Fig. 6—A Key Unit Removed to Expose Contact Springs**

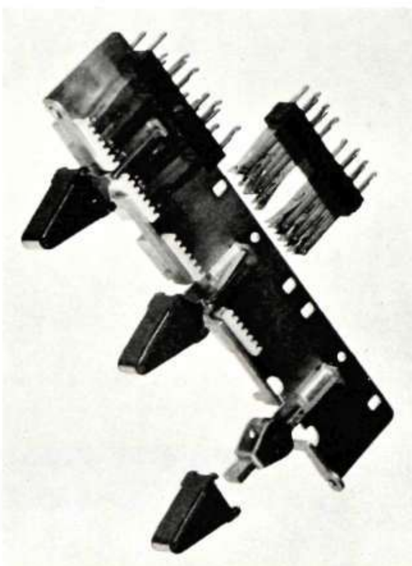


**Fig. 5—Partially Assembled Key Unit**

The key unit frame is formed from steel sheet in a shape that ensures complete rigidity. The contact springs are mounted between moulded insulating blocks and secured on either side of the frame. Twin contacts are fitted and the length of the springs is the minimum necessary to withstand the operating stresses for an extended period of use without fatigue or loss of contact pressure. The cam operates the springs by means of a moulded comb lifting plate and has two pivot pins which centralize it in the unoperated position, thus preventing contacts operating on overthrow when restoring to normal. The twin pivots limit the arc of movement and establish a relationship between pivot and cam lifting faces which virtually eliminates wear of the moulded comb.

Locking is achieved by a toggle action with a compression spring housed in a central bush holding against the load of the contact springs. For keys which are non-locking on one side a special toggle plate is used to change the direction of the forces so that the cam returns to normal on release. Where a completely non-locking key is required there is no need for the toggle action and the cam is centralized by a small compression spring fitted between cam and frame. Fig. 7 shows the various types of action.

The keys have moulded push-on handles giving a large area for the finger. The shape of the cam and the resilience of the handle material together ensure security of fixing even when handles have been removed and replaced many times.

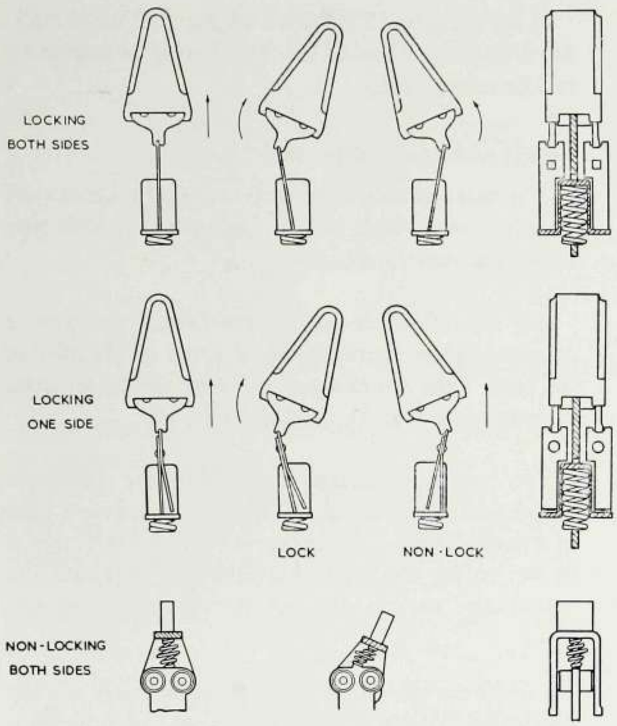



**Fig. 7—Key Operation**

At the apex of the handle there is an insert of a contrasting colour which serves to show clearly whether or not the key is operated. The small angular movement of the handle permits keys to be mounted at the close vertical spacing of 1½″, and the horizontal separation may be as little as 5/8″.

Keys are lubricated initially with a high viscosity grease containing molybdenum disulphide.

INDICATORS

Indicators for exchange and extension lines, shown in Fig. 8, are again of a new design which saves space. As far as possible standardized parts are used for both types, and the size of the mechanism has been kept to the minimum to leave room for a large coil, in order to obtain maximum sensitivity.

The two iron shutters (Fig. 9A) are pivoted within a U-shaped iron frame and held in the unoperated position by a leaf spring ; the spring tension is adjusted by a screw on the underside of the indicator (Fig. 9B). A centre polepiece on which the coil is wound projects between the shutters and when the coil is energized the magnetic forces open the shutters horizontally so that a curved white plate occupying the whole frontal area of the indicator is exposed behind the push-on plastic window. The Exchange line indicator (Fig. 9C) locks in the fully operated position and is released by pressing the front cover downwards ; a moulded projection is provided for this purpose. The return spring adjustment together with the inertia and wide angle of movement of the shutters ensure discrimination between ringing current and dial pulses. The indicator will operate and lock on receipt of ringing current over a 1,000 ohm line, but will not lock during dialling, even with maximum exchange battery voltage and a low resistance line.

On both types of indicator a contact is provided which makes in the operated condition and can be used to complete an audible alarm circuit. The contacts can be seen without removing the indicators from the mounting plate.

(1) *Operated Exchange Line Indicator. Release is effected by pressing down projection above window.*

(2) *Extension Line Indicator with window and cover removed.*

(3) *Complete Extension Line Indicator, which is of non-locking type.*

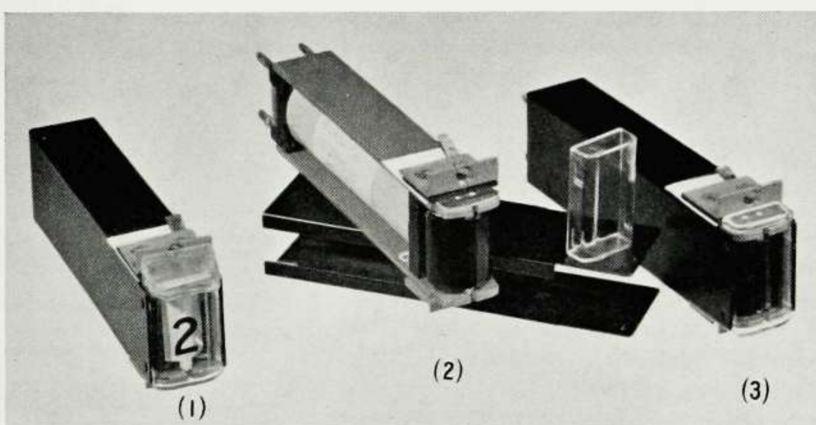



**Fig. 8—The New Indicators**

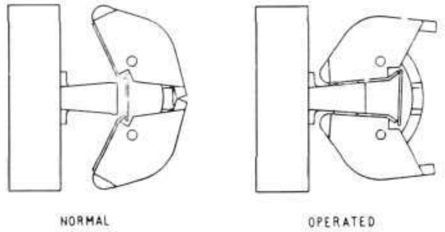



**Fig. 9A—Plan View showing form of Indicator**

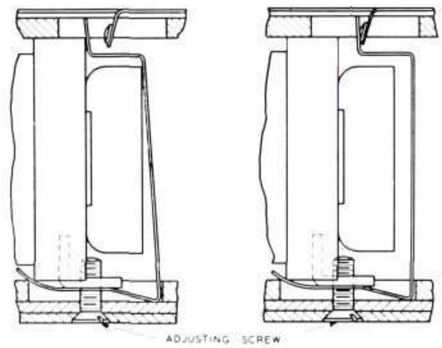



**Fig. 9B—Extension Line Indicator Contact and Return Springs**

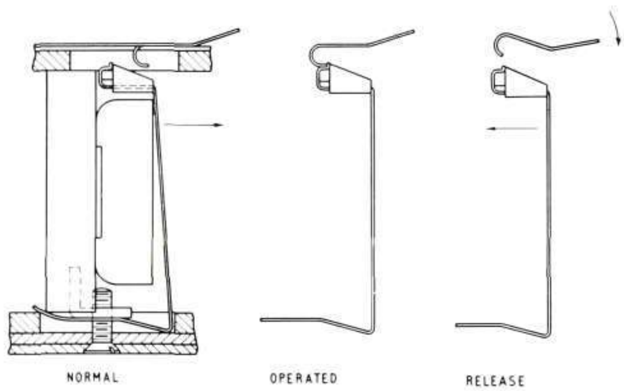



**Fig. 9C—Exchange Line Indicator Contact and Locking Device**

### Dial and Operator's Telephone

The operator's handset (B.P.O. type No. 1) is connected to the switchboard by a miniature plug, B.P.O. type 420 MK1, and jack B.P.O. type 84A MK1. The circuit is similar to that of the new type 1000 telephone described elsewhere in this Bulletin and provides for high grade transmission over lines of up to 1000 ohms loop resistance.

A B.P.O. type 12 standard trigger dial is normally fitted but non-standard dial numbering or impulsing can be catered for.

### Miscellaneous Components

The hand-generator is of the rotating magnet type described in Bulletin No. 34, and standard 3000 type relays and retards are used.

An inter-Services sealed fuseholder carrying a miniature glass cartridge fuse is fitted on the side of the base of the switchboard. A fuse can be replaced without removing the switchboard cover.

The paper designation strip below the indicators is protected by a moulded transparent window held in a metal frame. As shown in Fig. 10, the frame is in two halves which can be separated to release the spring clips securing the designation strip to the key plate.

P.V.C. covered wire, with its advantages of high insulation, small bulk and bright identification colours, is used for the connections.

### Facilities and Operation

The switchboard provides the usual facilities for connecting and supervising calls between local extensions and between exchange lines and local extensions. Each line is equipped with keys arranged in vertical rows beneath the associated call indicator, and the key handles can be moved up or down, each position operating in effect a separate key. With the key units mounted side by side the key handles also form horizontal rows. To connect two lines together a key for each line on the same horizontal row is operated in the same direction.

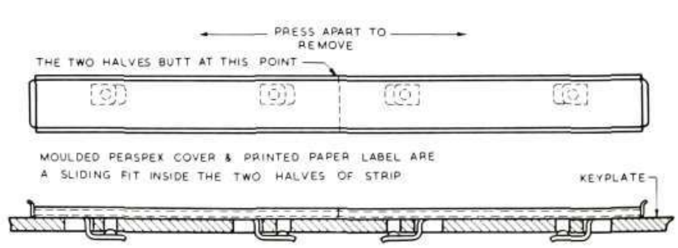



**Fig. 10—Fixing of Designation Strip**

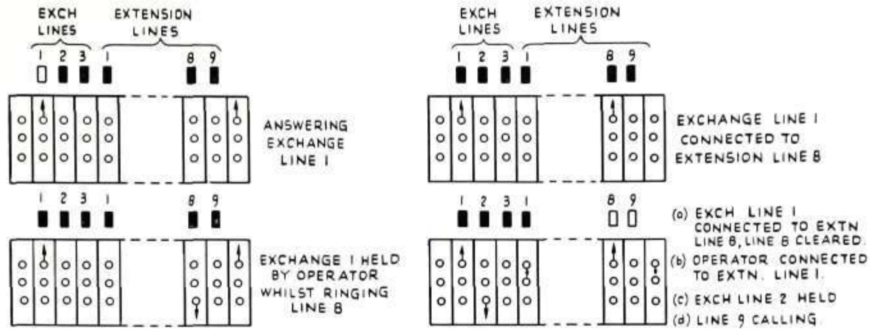



**Fig. 11—Operation of Keys and Indicators under four typical conditions**

The keys at the extreme right are associated with the operator's telephone circuit and have no indicator above them. By moving one of these keys and a line key on the same horizontal row in the same direction the operator is enabled to speak on the line.

The vertical row on the extreme left contains the night extension keys. These are used to connect an exchange line to an extension when the switchboard is unattended, for example at night. Through connection without supervision at the switchboard is obtained when the night extension keys are operated together with the exchange and selected extension keys in the same horizontal row.

The downward position of the bottom horizontal row of line keys has a different function. In the case of the exchange lines it enables the line to be held while the operator connects or speaks to the required extension. On the extension lines the lowest key position is for ringing the extension. The keys are self-restoring from this position.

Different coloured handles are used to indicate the various functions of the vertical rows of keys. Fig. 11 shows typical operating conditions. A calling line is identified by the indicator showing white. Exchange line indicators are operated by incoming ringing current, while extension indicators operate over the extension telephone loop when the handset is lifted. Extension indicators also provide clearing signals when the extension handset is replaced. Contacts on all indicators are connected via the night service keys to a buzzer for audible signalling of incoming calls.

Fig. 12 is a schematic circuit diagram of the new switchboard. During extension-to-extension calls the retard R provides battery current via relay S to both parties in parallel. The connecting keys when operated change the indicators from the line to a local circuit depending on the S relay contacts. During conversation relay S is operated by the microphone current of the two extensions, and it releases at the end of the call when both handsets have been replaced. S contacts then apply earth to operate both extension indicators via the connector keys and so give a clearing signal, on receipt of which the operator restores the connector keys.

On exchange-to-extension calls retard R is disconnected and the battery feed to the extension is supplied by the exchange, again via relay S in the connecting circuit. This relay is slugged so that it holds during dialling. The exchange indicator, which is connected across the line in series with a capacitor, does not fully respond to dial impulses but is operated by the ringing current. On restoration of the extension handset relay S releases and its contact operates the extension indicator. In this type of connection only one indicator operates as a clearing signal, the exchange line indicator remaining connected across the line to function as a follow-on call signal. Thus if an exchange call is received after an extension has cleared but before the operator has restored the keys to normal, the ringing current will operate the exchange indicator. Ringing current also passes through the connecting circuit to ring the bell at the extension, so that if the operator is absent the call can be answered at the extension. If the operator is present when a follow-on call is signalled, the connector keys should be restored to normal and the call answered in the usual way.

The new switchboards are operated from a nominal 24 volts supply, and typical busy-hour loads are 0.4A for the 2+4 size and 0.6A for the 3+9.

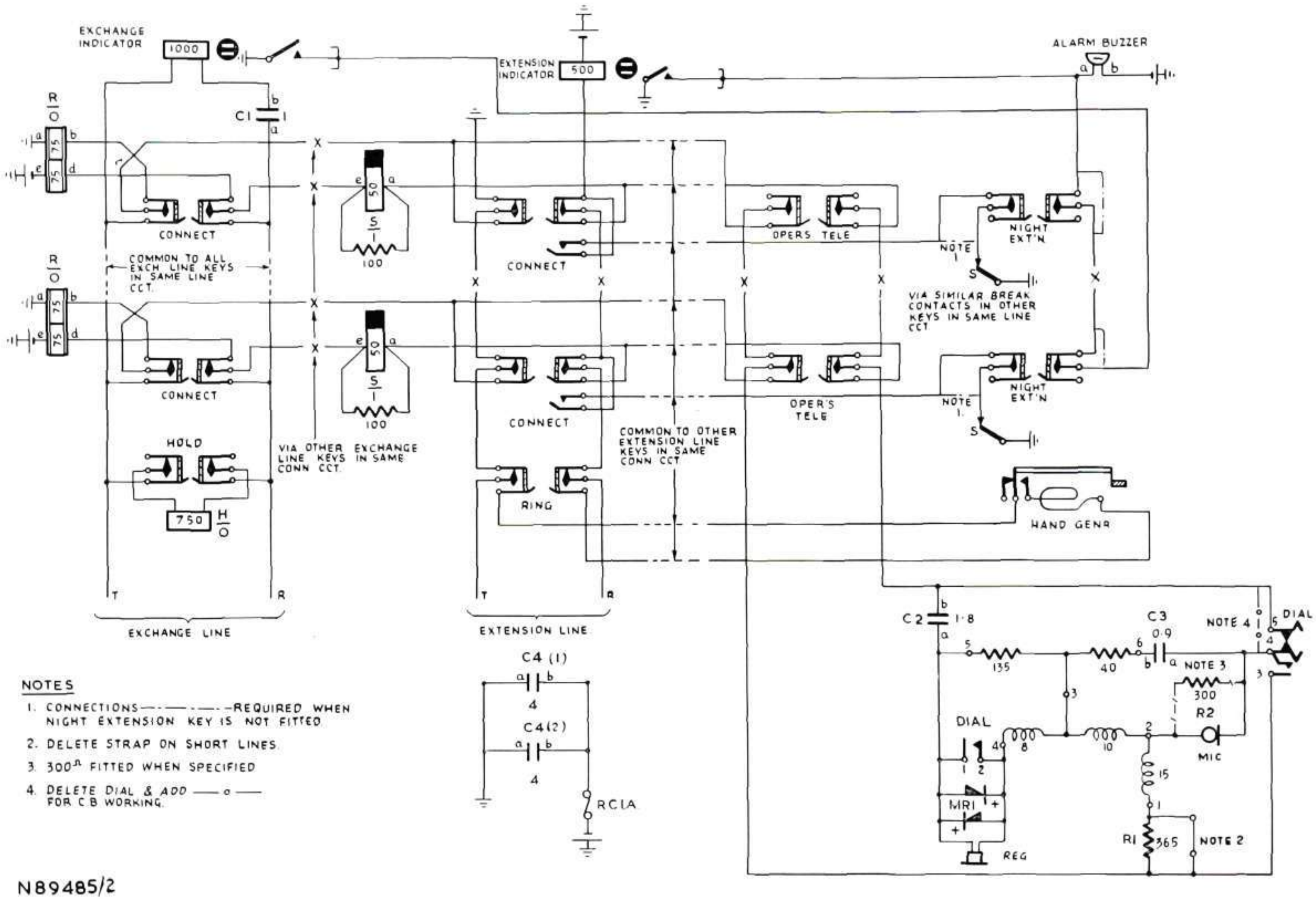



**Fig. 12—The Switchboard Circuits**


**Fig. 13—Switchboard Connected for Functional Testing**

The line loop resistance between the main exchange and the most distant extension should not exceed 1000 ohms if the extension telephones are of the new 1000 type, or 600 ohms if older instruments are used. If the exchange-to-switchboard line has less than about 360 ohms loop resistance it may be necessary to remove the strap to which Note 2 in Fig. 12 refers. The extension lines may have loop resistance up to about 500 ohms. If the loop resistances of the extensions vary widely, it may be advisable to pad the short lines to avoid the possibility of a short line shunting too much current from a long line to which it is connected, since a common feed is employed for both extensions engaged in a call. In normal installations this problem does not arise as extension lines are usually of less than 200 ohms resistance.

## Manufacture and Inspection

The new cordless switchboard is manufactured under product group conditions and assembly and wiring are completed on a line assembly unit. Components such as lever keys, indicators and relays are tested before reaching the line, but inspectors are situated at suitable points to check equipment details, quality of joints and position of wires. The final position in the line is used for the application of bridging, meggering and full functional tests. The functional tests cover all conditions, including incoming and outgoing calls on main exchange lines, connection of each extension to each exchange line, and interconnection of all extension lines. The equipment (Fig. 13) used for these tests applies each condition automatically by means of a sequence switch and enables the inspector to complete all tests in from five to eight minutes, depending on the size of the board concerned, in spite of the large number of manual operations necessary to check the correct functioning of all the switchboard lever keys. The transmission of the speaking bridges is checked by means of a power level meter.

While retaining the features of simplicity and reliability inherent in earlier designs, the new switchboard, in comparison, occupies less space and is improved in appearance and efficiency. The experience of many years, supported by stringent laboratory tests, has been applied to the design of components and the selection of materials and finishes which ensure long life and reliable working under all climatic conditions.

**A lamp signalling version of this switchboard is in process of development.**

UDC.621.395.61.

# THE NEW 'TYPE 1000' TELEPHONE

G. R. GUNSON — Circuit Development Department
D. RICHARDSON, B.Sc. — Audio Research Laboratory

*The E.T.L. 1000 type telephone, available in table or wall patterns, incorporates an improved handset with rocking armature receiver and associated induction coil circuit to provide better transmission efficiency coupled with enhanced appearance. It enables improved performance to be obtained under existing line conditions or alternatively the present standards of transmission can be maintained using lines of greater length or lighter gauge.*

THE 'export' table telephone, introduced in Bulletin No. 27 (January 1953), represents a step forward in design from the N.1002 shape which was our standard for many years. The 'export' case has proved very satisfactory and this shape is used with little modification for the 1000 type. The handset, however, is new, being more curved than previous models, with the microphone set at an angle which gives better acoustic performance. This permits the cup-shaped mouthpiece of the earlier type to be replaced by a more hygienic one. The curved handset matches the flowing lines of the case so that the two combine to form a telephone which is functionally efficient and pleasing in appearance.

A departure from previous practice has been made in providing two cup-shaped metal inserts in the telephone case, one on either side, which serve both as ventilation grilles and convenient lifting holds. The holes of the grille are screened with fine gauze.

In order to suit modern interior decoration schemes in homes and places of business, the new telephone is made in ten different colour assemblies. Seven of these are single-colour, and three dual-colour, the latter having the body in one shade and the handset and ventilation cups in another.

The dial fingerplate on black and ivory sets is stainless steel, while the others have a plastic fingerplate coloured to match the handset unless stainless steel is specified.

Careful study of the colour schemes has enabled the choice of colours for desk and handset cords to be restricted to four, so assisting stocking and maintenance.

Both table and wall versions of the Type 1000 telephone have been designed and are being produced in the same range of colours. A colour plate showing the complete range of table telephones is included in this Bulletin.

Following is a summary of the colours available.

SINGLE-COLOUR TELEPHONES

| Telephone | Cord(s) |
|---|---|
| Black | Black |
| Ivory | Maroon |
| Imperial red | Maroon |
| Colonial blue | Silver grey |
| Topaz yellow | Green |
| Silver sage | Silver grey |
| Forest green | Green |

DUAL-COLOUR TELEPHONES

| Body | Handset, etc. | Cord(s) |
|---|---|---|
| Aircraft grey-green | Forest green | Green |
| French grey | Elephant grey | Silver grey |
| Blush Ivory | Maroon | Maroon |

The desk terminal block with each table telephone is coloured to match the body of the instrument and is of conventional design—a moulded rectangular loose-lidded box containing screw terminals.

Like the table telephone, the wall set illustrated in Fig. 1 is characterized by its flowing contours. It has the same type of handset and a case of the form described in Bulletin No. 31 (January 1955).

Table and wall telephones with either standard or tropical finish are available. Fig. 2 shows a table set of tropical type. The dial mechanism is protected by a dust cover of transparent plastic material, and external terminals are provided to enable the dial cord to be disconnected without removing the cover. The dial can be detached from the case after removing a single screw, and is protected against the ingress of dust from the front by a felt washer. Other features of tropical versions include shrouding and dust proofing of the cradle switch operating plungers, gauze covering of the ringer holes in the base to

**Fig. 1—Wall Telephone (Type N1036A)**

prevent insects entering the case, varnish dipping of the cradleswitch springs to prevent surface leakage, and varnish impregnation of the induction and ringer coils.

The case of the table telephone is easily detached, after slackening captive screws underneath, to reveal the components mounted on an aluminium alloy pressed sheet base. Rubber feet are inserted to avoid marking polished surfaces.

The backplate of the wall telephone is die cast—not pressed—aluminium alloy and is similarly fitted with rubber feet. The case hooks on the top of the plate, to which it is secured by one screw at the bottom. When this is released, the case complete with automatic dial and cradle-switch plungers can be unhooked from the backplate and swung down on a webbing suspension which prevents the dial cord being strained.

The automatic dial is normally B.P.O. No. 12 trigger type with standard numbering and a $66\frac{2}{3}$ : $33\frac{1}{3}$ break-to-make ratio.

The components are connected as shown in Fig. 3. The induction coil is of the closed magnetic path type specially designed for use with the rocking armature receiver and is more efficient than the open-ended wire-cored type previously used. Fig. 4 illustrates examples of old and new coils. In the table set the capacitors are held in rubber mountings one of which is a push fit in the base, the other being fixed on top of the dial cord terminal strip. The cradle switch is operated by a simple friction-free mechanism in which rollers attached to the plungers in the case move over a pivoted plate.

The blocks upon which the desk and handset cords terminate include a number of terminals wired to various points of the circuits so that modifications, such as for parallel working without bell tinkle, can readily be made. The internal wiring is in 25 s.w.g. with p.v.c. insulation, and the cord conductors also have p.v.c. insulation with nylon braiding over all.

**Fig. 2—Interior View of Table Telephone (Type N1025A)**

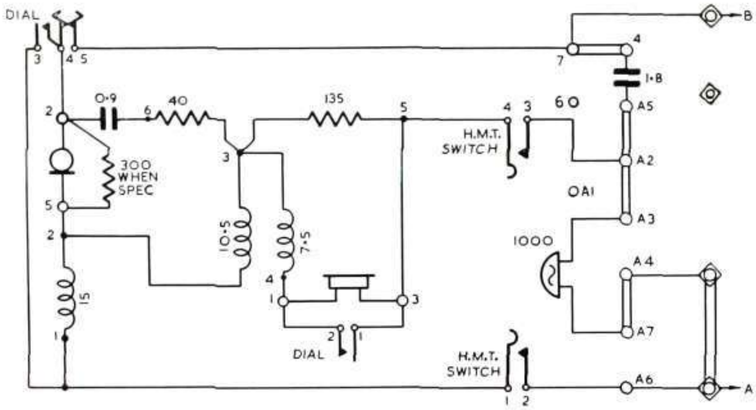



**Fig. 3—The Telephone Circuit**

The instruments can be arranged to accommodate auxiliary key circuits for various extension schemes, the maximum number of keys being three as on earlier types of telephones used for such schemes.

### Transmitter

The re-designed handset employs the B.P.O. No. 13 transmitter of the immersed-electrode carbon-granule type which has been in use for a number of years. In the new handset the transmitter is positioned nearer to the mouth, and under conditions of normal use is held at the angle of maximum sensitivity, that is, with the plane of the transmitter diaphragm at an angle of about 40° to the vertical. This results in an increase of from 2 to 3 db compared with the output obtained with the diaphragm vertical. It is sometimes found desirable to place a resistive shunt across the transmitter to reduce arcing between the granules. A resistor for connection to the appropriate terminals is available when required.

### Receiver

The magnetic-diaphragm 2P type receiver previously employed is replaced by the rocking-armature receiver which contributes most to the enhanced performance of the new telephone. In this receiver (Fig. 5) magnetic and acoustic functions are separated, the diaphragm being designed for optimum acoustic performance and driven by a small rod connected to the armature. The armature is fixed rigidly at each end of the frame and two thin torsion arms allow movement of the central portion. The two edges of the central portion are alternately attracted to their adjacent pole-pieces and hence impart a reciprocating motion to the diaphragm via the rod connected to the edge of the armature. The permanent magnet is a small rectangular block of anisotropic material. Its high reluctance is excluded from the alternating flux path by employing a balanced bridge type of magnetic circuit, so that the magnetic sensitivity is improved. The volume efficiency of the receiver is about 7 db better than that of the 2P receiver, and the frequency response curve is flatter as can be seen from Fig. 6.

**Fig. 4—Induction Coils, old (front) and new (rear)**

### Induction Coil

Since the new telephone will have to be used in conjunction with earlier sets for some time, maximum improvement will be obtained if sending and receiving performances are raised by about the same amount. For this reason the induction coil has been designed to utilize part of the receiver's increased efficiency in improving the sending performance of the circuit. The new induction coil shown in Fig. 4 employs laminations of grain-orientated silicon iron which gives low core-loss and increased permeability. This enables the required transformation efficiency to be obtained with fewer turns, thereby reducing copper losses.

### Circuit

Increased efficiency of the transmitter or receiver in a telephone set is accompanied by an equal increase in side-tone (the reproduction of the talker's voice in his own receiver) unless the side-tone balance network is improved. Fig. 7 shows the basic transmission circuit of the telephone. Transmitter speech currents $i_1$ and $i_2$ flow in the line and balance network circuits. A voltage $i_2Z$ therefore appears across the impedance Z of the balance network. At the same time an e.m.f. e is induced across winding 3, which, in series with the balance network, is connected

(4)

(3)

(2)

(1)

(1) Frame with magnet and coil assembly
(2) Diaphragm added
(3) Terminals added and coil wires attached
(4) Complete

**Fig. 5A—*Stages of Receiver Construction***

across the receiver. Hence if $i_2Z=e$ and the two voltages are in opposition there will be no current through the receiver and therefore no side-tone. When receiving, the signal from the line is divided between the receiver and the transmitter.

Absolute balance is not obtainable in practice since this would require perfect matching between the line and the balance network at all frequencies. Moreover, it is not desirable since it would make the telephone sound "dead" when spoken into. A suitable circuit can, however, give good side-tone suppression over the range of line conditions encountered in a normal telephone system. The balance network shown in the circuit diagrams (Figs. 3 and 7) consists of two resistors and two capacitors and enables the side-tone suppression of the new telephone to be maintained at the same general level as in telephones of lower efficiency. In order to make convenient use of the balance network components in the dial spark quench circuit, the common terminal for transmitter and receiver has been omitted; hence a 4-way handset cord is used. This also enables the handset connections to be made directly to the transmitter and receiver terminals, no internal connecting lead being necessary.

### Line Current

The current drawn by a telephone from the exchange battery depends largely on the distance between the telephone and exchange and on the gauge of wire connecting them, decreasing as the resistance of the circuit increases. The resistance of the carbon-granule transmitter increases with decrease of current, and therefore further reduces line current on long lines. This effect is small, however; a change of line resistance from 0 to 1000 ohms results in a change of only about 30 ohms in transmitter resistance.

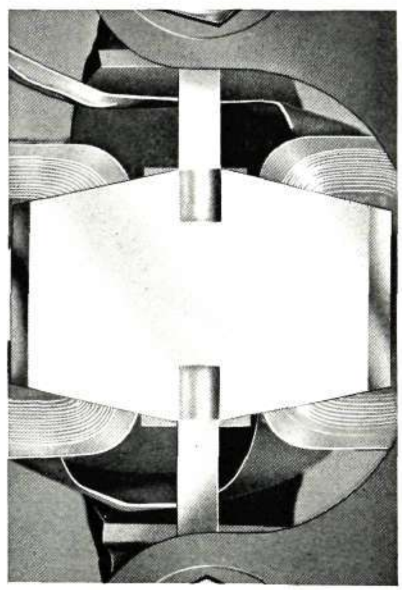


**Fig. 5B—Enlarged view of Rocking Armature as seen from reverse side of Fig. 5A(1)**

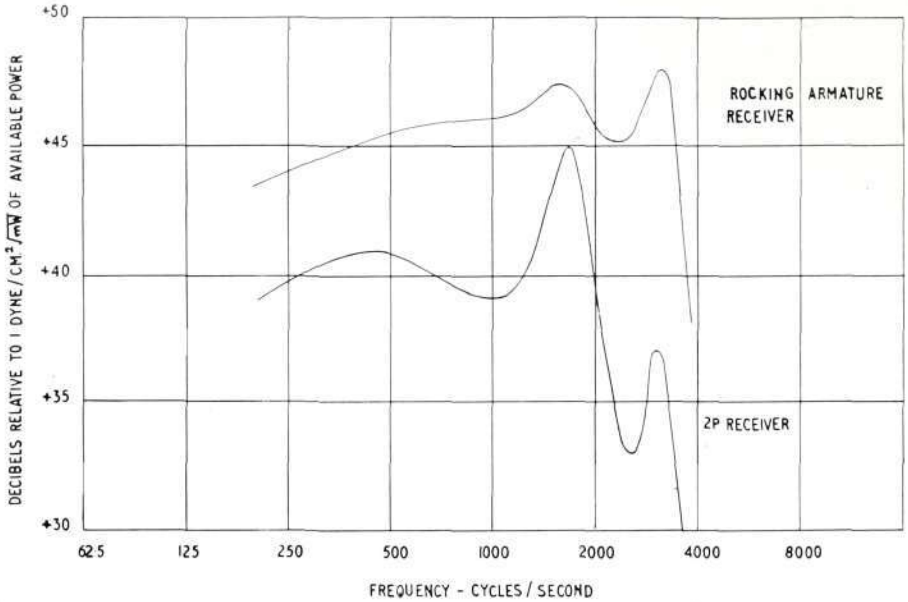



**Fig. 6—Receiver Response**

The maximum current is about 100 milliamps. It is obtained when the telephone is connected by a very short length of line to an exchange employing a 50-volt battery and 200+200-ohm feeding bridge, the combined resistance then being just under 500 ohms. The minimum current in conditions of satisfactory operation is just under 30 milliamps, through a line loop resistance of 1300 ohms. Fig. 8 shows the variation of line current and telephone resistance for varying loop resistance.

PERFORMANCE

The efficiency of a telephone can be measured in several ways, some objective, some subjective. For production testing objective methods are used. In this case the sending, receiving and side-tone performance of the set is measured over a band of frequencies in comparison with a standard instrument of the same type. In assessing the relative merits of different types of instrument, however, subjective methods are desirable since these can take into account the fact that in determining the performance of a telephone the main criterion is the degree of satisfaction experienced by the user. Subjective measurements may involve comparisons of volume between two instruments, articulation or intelligibility of messages or groups of phrases, or expression of opinions after a normal conversation over a telephone circuit. In some cases a trained speech-testing team is employed, in others it is found preferable to use untrained people. Mathematical treatment of the results is generally necessary to obtain figures expressing transmission performance ; hence such methods are neither suitable nor necessary for testing on production lines where the tests are carried out on a ' pass-reject ' basis.

The performance curves of the new telephone and the B.P.O. standard telephone No. 332 (dotted lines) determined by two methods are shown in Figs. 9-12. Figs. 9 and 10 show the sending and receiving performances assessed on the basis of volume. The scale on the left gives the rating relative to a minimum standard defined by the British Post Office. This minimum is the performance obtained from a Telephone No. 162 (the predecessor of the 332 type) connected by a 450 ohm loop of 10 lb. per mile cable to a 50-volt exchange with a 200+200-ohm feeding circuit. The scale on the right gives the rating with reference to the datum fixed by S.F.E.R.T. (*Système Fondamental Européen de Référence pour la transmission Téléphonique*). This master telephone transmission

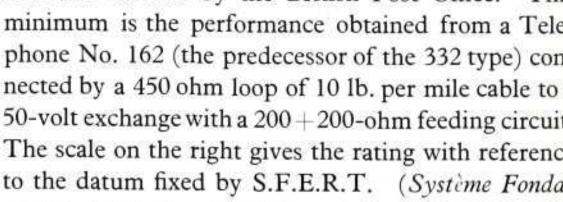



**Fig. 7—Transmission Schematic**

COLOUR RANGE OF THE
TYPE 1000
TABLE TELEPHONES

Aircraft Grey Green and Forest Green

Silver Sage

Ivory

Imperial Red

French Grey and Dark Elephant Grey

Colonial Blue

Blush Ivory
and Maroon

Black

Forest Green

Topaz Yellow

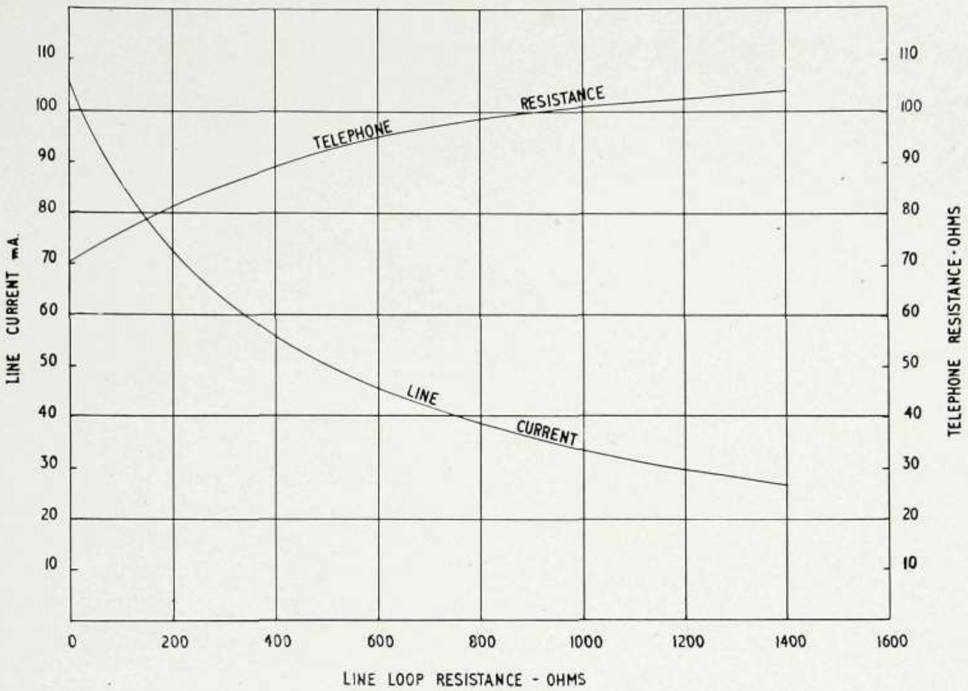



**Fig. 8—Line Current and Telephone Resistance**

reference system, maintained by the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.) at Geneva, consists of a high quality microphone and receiver which can be coupled via amplifiers, attenuators and distorting networks to enable comparison to be made between the reference system and telephone circuits. The reference levels are arbitrary. The C.C.I.T.T. recommendations for the minimum levels for national local circuits are as follows :—

Sending : −18 db } with reference
Receiving : −13 db } to SFERT datum.

These are somewhat lower than the minimum levels maintained on local lines in the United Kingdom.

It will be seen from the graphs that the rating for the new telephone compared with the 332 type is 5 db higher for sending and 3 db higher for receiving.

The different performance which each telephone exhibits using cables of various gauges is explained by the fact that the capacitance per unit length of the three types of cable is the same, hence the capacitance and attentuation per unit *resistance* is greater for the heavier gauge cables.

Articulation ratings are shown in Figs. 11 and 12. In this case the performance is determined by the percentage of meaningless syllables which are received correctly. The A.R.A.E.N. (*Appareil de Référence pour la détermination des Affailblissements Equivalents pour la Netteté*) takes into account the effect of the side-tone and room noise on reception. The acoustic intensity of the room noise employed for the tests is 60 db above a reference point fixed at $2 \times 10^{-4}$ dyne/cm$^2$ at 1000 cycles/second. The figures show that although the performance on short lines is about equal, the new instrument has considerably improved performance on longer lines and reduces the limitations imposed by line length and gauge.

Articulation rating for reception can be seen to increase initially with increasing line length. This is due to the side-tone effect. Fig. 13 shows the relative electrical side-tone suppression achieved by the two telephone circuits, from which it can be seen that the side-tone suppression of the new instrument is more effective on longer lines than on very short lines. The graphs are derived from the side-tone levels at 500, 1000, 2000 and 3000 cycles per second.

The improved appearance of the 1000 type telephone is thus accompanied by enhanced performance, so that the new instrument shows advantages over its predecessor in all respects.

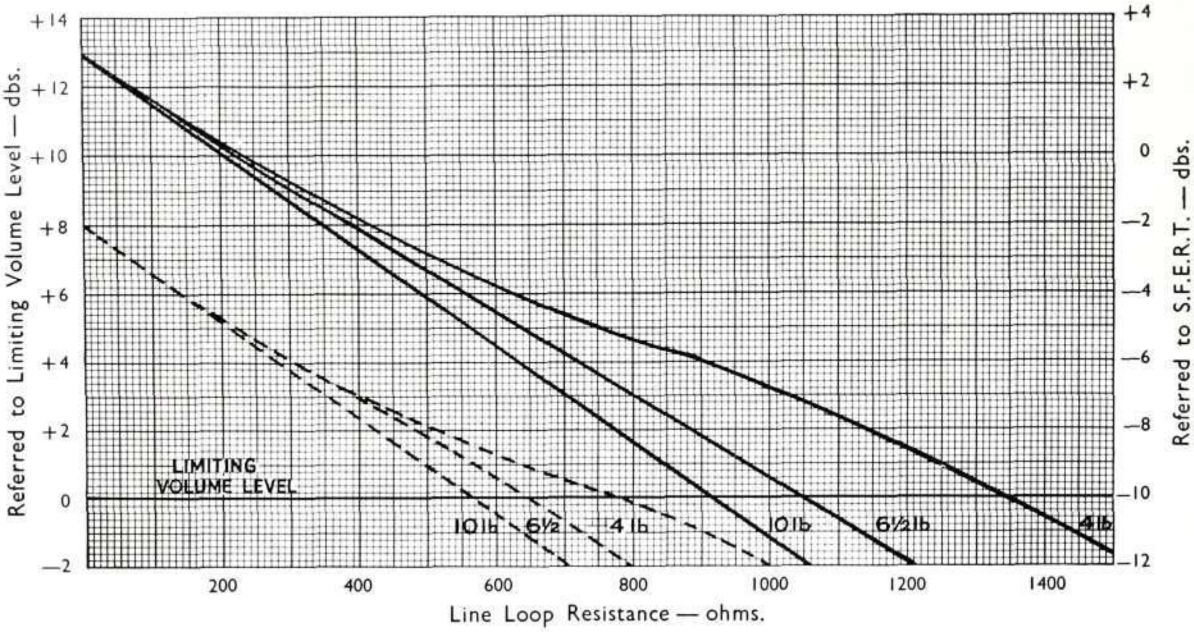



**Fig. 9—Volume ratings for the telephone—sending**

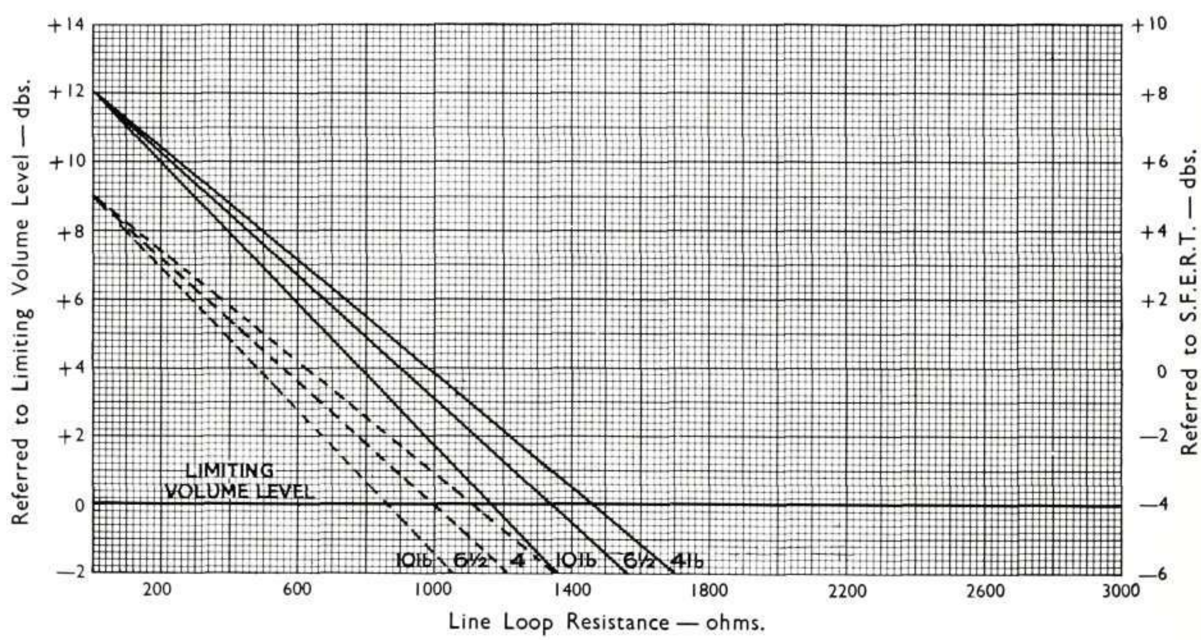



**Fig. 10—Volume ratings for the telephone—receiving**

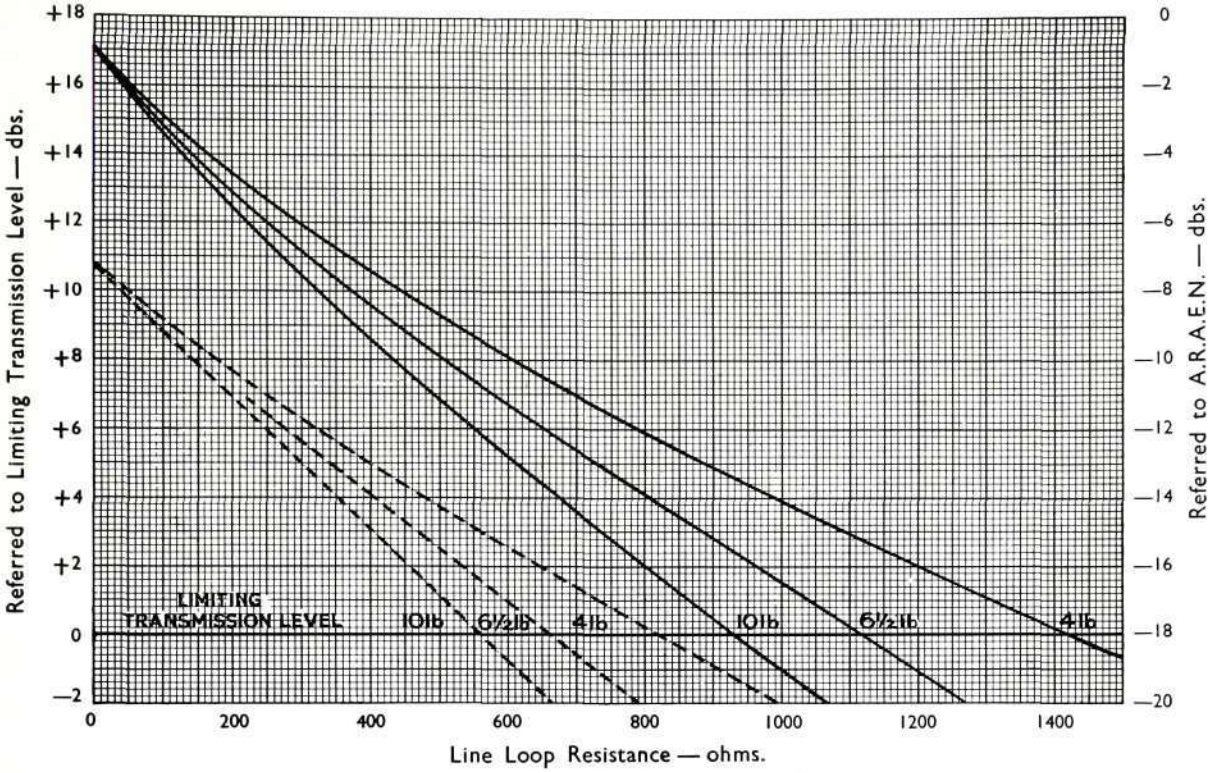



**Fig. 11—Articulation ratings for the telephone—sending**

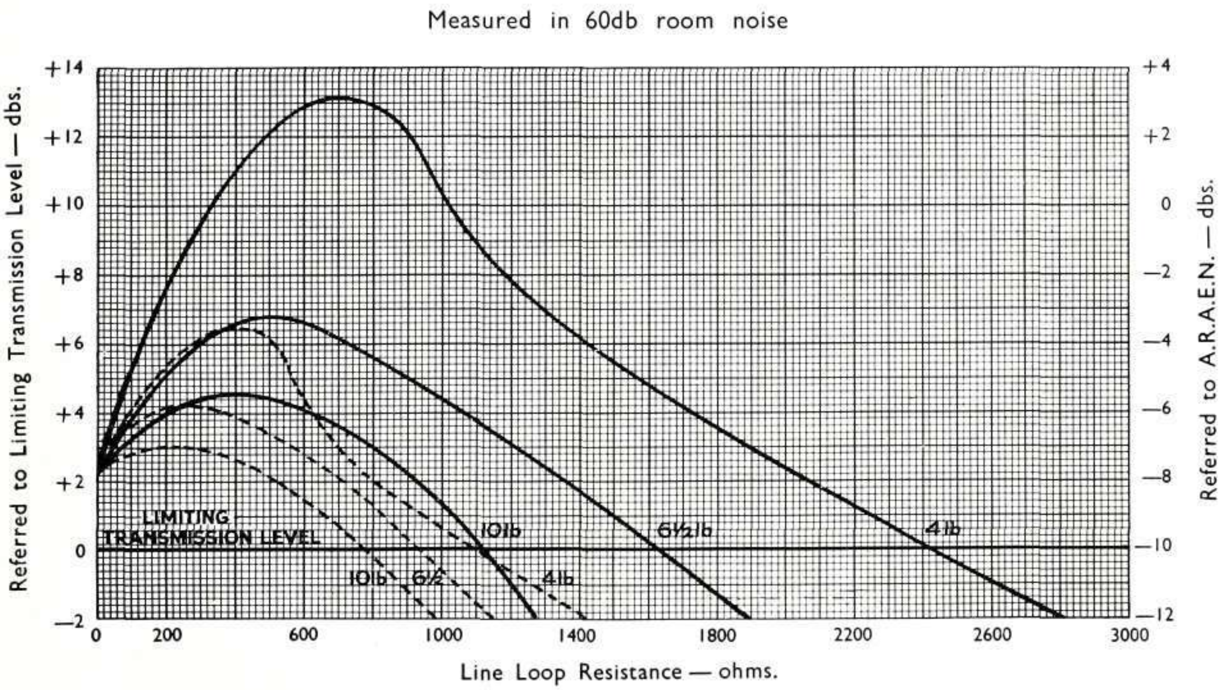



**Fig. 12—Articulation ratings for the telephone—receiving**

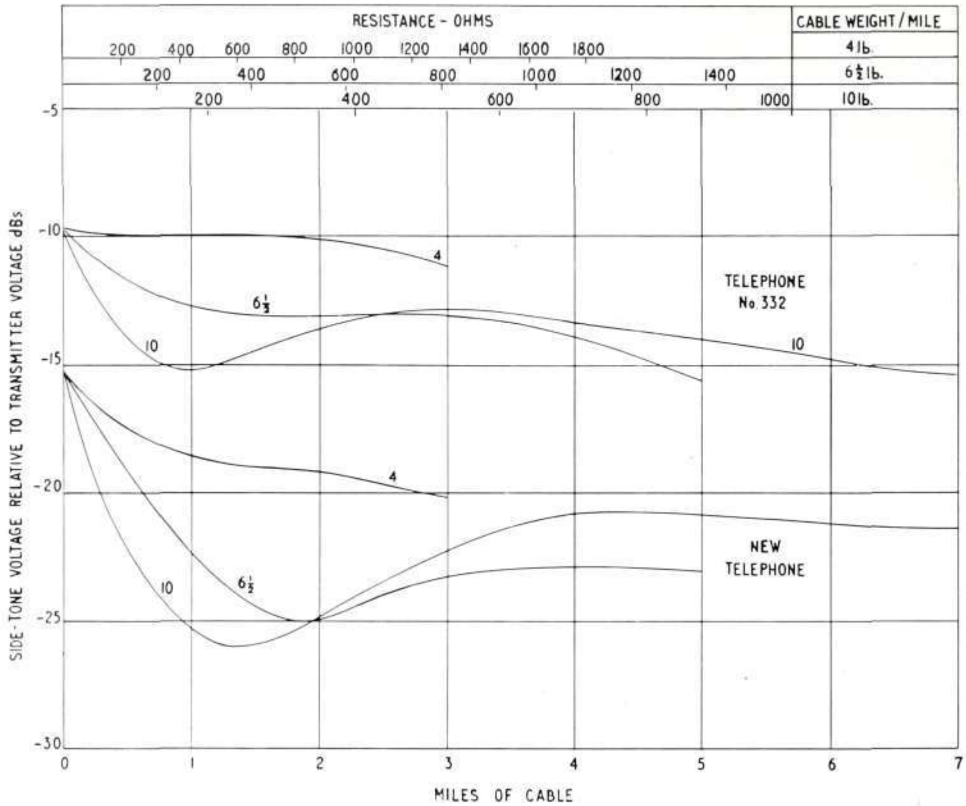



**Fig. 13—Electrical Side-Tone Suppression**

*Transmission data in this article is published by permission of the British Post Office.*

*The rocking armature receiver has been standardized by the B.P.O. and was developed by Messrs. Standard Telephones & Cables Ltd. in conjunction with the B.P.O. engineers.*

# ELECTRONIC AUTOMATIC TELEPHONE EXCHANGES

*In recent years much interest has been expressed in the possibility of using other than electromechanical switches for telephone exchanges. Our Research Laboratories have been investigating the application of electronic switching elements to telephony and have set up several experimental exchanges in which some or all of the switching functions are carried out by electronic devices. It is natural that all telephone companies have been pursuing similar objectives, and in a recent announcement the Postmaster-General gave details of collaboration which had been arranged between the Post Office and principal telephone companies.*

*The announcement is reprinted below, and it can be seen from it that the first public electronic telephone exchange is expected to come into service early in 1960. Details of system operation and of the part the Company is playing in its development will be announced in papers in professional journals and in the technical press. Reprints or synopses of these papers will appear in the Bulletin in due course.*

## Official Announcement of Electronic Automatic Telephone Exchange Development

It is expected that the first all-electronic telephone exchange, now in an advanced stage of design, will be opened in the North London Telephone Area known as Highgate Wood in March, 1960. This " guinea pig " exchange will help to provide valuable data about cheaper and more efficient telephone working. It will give the same facilities, as with the present mechanical exchange, to over 1,000 subscribers. It will be fully electronic and fully automatic. Subscribers' trunk dialling and other facilities as these become general practice in the country are also likely to form part of the future services.

The new exchange is being designed so that the principles of electronic working can be tested in actual practice without affecting the existing service to subscribers. The present exchanges use mechanical switching to make telephone connections and they have been developed to a particularly high degree of efficiency. Development trends are, however, leading to the use of electronic switches which have no moving parts or metal contacts and consequently no material wear and tear. Recent research indicates that they will provide even more efficient service to telephone users once the many complicated problems of practical application have been solved.

Experts from the Post Office and five leading manufacturers of telecommunications equipment (Automatic Telephones and Electric Ltd., Ericsson Telephones Ltd., General Electric Co. Ltd., Siemens Edison Swan Ltd., Standard Telephones and Cables Ltd.) are undertaking research in connection with electronic exchanges and it is expected that in future this co-ordinated research will lead to exchanges which will show overall economies and may permit the use of cheaper forms of lines.

Many complicated problems are as yet to be solved by the scientists and engineers engaged on this telephone system of the future, but this combined telecommunications operation will keep the United Kingdom telephone service in the forefront of modern developments.

UDC.621.398.

# FLOOD WARNING SYSTEM FOR THE NEW ZEALAND RAILWAYS

J. R. H. Stevens — Development Engineering Department

*Level indication is essential for the effective control of water. A system of remote level indication is described which although designed for a particular application is readily adaptable for use with any form of water mass.*

THE centre of the North Island of New Zealand is dominated by a chain of volcanic mountains. At the southern end lies the dormant volcano Ruapehu (9,175 feet) and its crater contains a lake of hot water. This discharges over the rock-bound rim through a cave beneath the glacial ice. The water emerges on the mountain side at about 8,000 feet to flow into the Whangaehu river in the valley below. Twenty-four miles from the glacier base, the river passes under the Main Trunk railway bridge at Tangiwai. During the late evening of Christmas Eve 1953 the bridge was partially destroyed by a torrent of water carrying ice and boulders. A few minutes later, the Wellington to Auckland express with some 280 passengers arrived at the bridge. The train plunged into the swollen river and 151 persons lost their lives. At the height of the torrent, the water reached a level just below the girder of the bridge in Fig. 1 which shows the scene of the disaster. Within a very short time the level of the river was back to normal.

At the Board of Enquiry it was revealed that the water of the crater lake had been impounded by a blockage of the ice cave and was released suddenly when the barrier collapsed. It was recommended that a flood warning device be installed to protect the bridge by indicating the approach of abnormal river conditions.

## Technical Investigations

The New Zealand Railways investigated all systems commercially obtainable and found that none supplied the complete answer to the peculiar problems involved. The unpredictable nature of the conditions existing during a destructive flood, the high solid content of the water and the inaccessibility of the river precluded all usual flotation and flume measuring devices. However, analysis of the water in the crater lake showed it to be extremely acid and the river water above the bridge normally gave a pH value of 2.6. This suggested that a solution could be found in utilizing the electrical conductivity of the water. The New Zealand Railway Engineering Department worked out the preliminary specification and design details of a warning system and the Company was entrusted with the engineering design and manufacture.

Fig. 1—Scene of the Railway Disaster at Tangiwai in December 1953

**ERRATA**

Under "RIVER SITE", replace lines 11 to 14 by the following:-

Inside the pylon, shown in Fig. 3, the electrodes on one side of the pairs are connected in groups, from the bottom electrode upwards, to divide the height of the pylon into five level-detecting zones. The depth of each zone was determined by the Civil Engineer's Department from the relationship, as defined by the physical features of the river, between the height of the water at the gauging site and its potential danger to the bridge. The other electrodes of the pairs are connected together to form a common return path for all the zone electrodes.

connected together to form a common return path for all the zone electrodes.

On the river bank a small hut shelters two watertight and tamperproof cast iron cases. The right-hand case, (Fig. 5), contains the relays required to obtain remote control of the river site installation and provides a termination for the cable from Waiouru station. The other case is used to terminate a cable from the pylon electrodes and to couple the zones to the control relays. A telephone is provided for communication with the station.

**Fig. 2—The Gauging Point**

**Fig. 3—Inside the Pylon**

### Site-to-Control Cable

The cable is polythene insulated and armoured and was ploughed underground through six and a half miles of difficult country to the station. One reason for burying it was to avoid damage from irresponsible marksmen, a hazard against which the whole of the river site equipment had to provide self-protection. The cable carries one conductor from the electrodes of each zone and one conductor from the relays in the hut. These insulated conductors are positioned around a central bare wire connected to the common return path electrodes. Since the centre wire is not insulated it can be used in conjunction with the metallic sheath of the cable to provide an insulation test. Fig. 6 shows the work of laying the cable in progress.

### Control Equipment

The control equipment at Waiouru station is seen in Fig. 7. It consists of two jacked-in relay sets in a metal cabinet. The cable termination is below the cabinet and the battery charger is mounted above. A 50-volt battery is kept fully charged to ensure that the system will remain in operation during a power failure lasting up to 24 hours. To avoid interference from earth currents, all circuit paths are physical and the battery is not earthed.

### Display Panel

The display panel, shown in Fig. 8, is mounted in the instrument room at the station. It indicates the

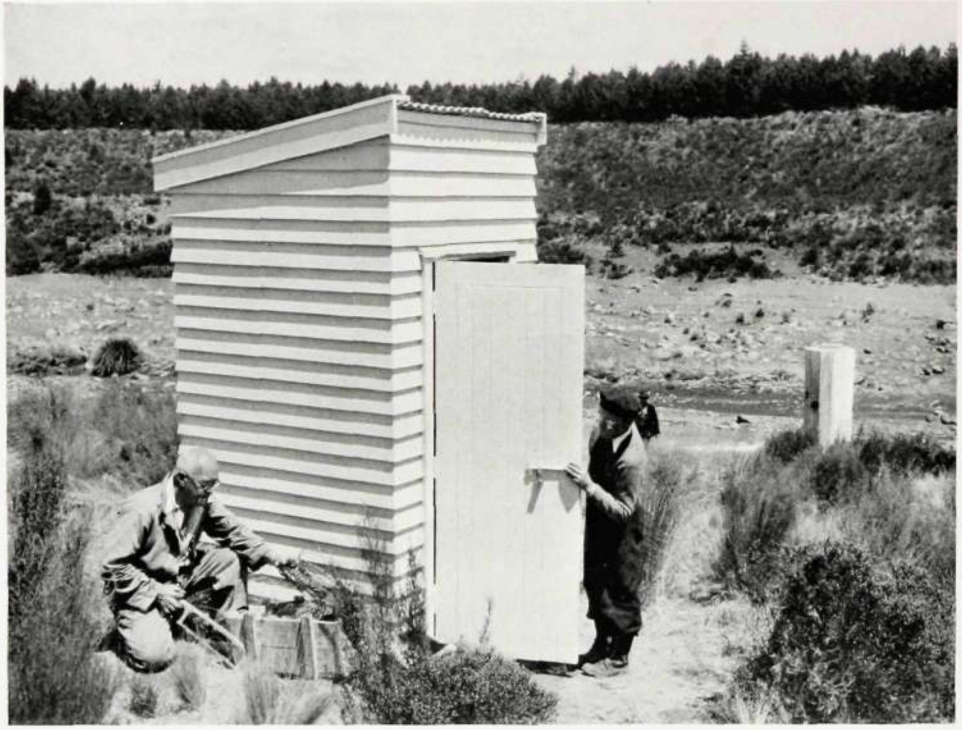


**Fig. 4—The River Site Installation**

zonal depth of the water from which, with local knowledge, the degree of impending danger to the bridge can be estimated, thus permitting cautionary measures for railway traffic to be taken in good time. The height of the water is shown by a white illuminated column which is easily seen even at a small viewing angle. The column is divided into five sections and each section is illuminated as the level enters the corresponding zone. The illumination thus rises or falls as the water depth varies. The column has an amber coloured ' rising ' section at its base and is surmounted by a red ' flood ' section. The rising section is associated with zone 1 and the flood section with zone 5. These sections are normally not illuminated until the level has remained continuously within the associated zone for longer than 30 seconds. When they are illuminated an audible alarm is given.

With a normal gradual rise in level, the entry into zone 1 can be observed but no alarm is given if it is intermittent on account of wave motion on the surface of the water. When the level becomes stabilized within zone 1, the rising alarm is given and attention is drawn to the increasing depth as the illumination of the column moves upwards. The zone 5 section is illuminated upon entry but the flood alarm is not given until the lower limit of zone 5 is fully submerged and the level constant. A rapid rise of short duration is potentially the most dangerous and the warnings must be given without delay. If within 30 seconds of entering zone 1 the level has reached a selected higher zone the rising alarm is given at once. Should the rise be so rapid that zone 5, or a selected lower level, is reached in this time an immediate flood alarm is given. The visual and audible rising and flood alarms are maintained until acknowledged by the operation of the alarm cut-off key so that should the level quickly recede the display panel retains an indication of the urgency of the river conditions.

The system was designed so that under fault conditions it will give whatever indications are possible in the circumstances. Circuit failure may modify the way in which the indications are presented but, suitably interpreted, they will still provide a true picture. While circuit conditions are normal, the ' system normal ' lamp is lit on the display panel but should a fault occur the ' system failure ' lamp is lit and an audible alarm given.

The whole system can be tested from the display panel. Operation of the test key sends a signal to the relays at the river site to connect all zone electrodes to two test electrodes at the base of the pylon. These are always submerged, so the system reacts as it would to a sudden surge of water reaching zone 5, but the rising and flood alarms are not given until the 30 seconds have elapsed.

### Alarm Signals

Supervision of the traffic along the Main Trunk line follows normal railway practice and is centred upon the District Train Control Office. Waiouru and other stations are connected by omnibus line to this office where a continuous listening watch is kept by the Train Despatcher. When a rising or a flood alarm occurs, the apparatus injects a series of tone signals into the train control circuits to warn the Controller. The signals are coded to convey the identity of the station and the nature of the alarm.

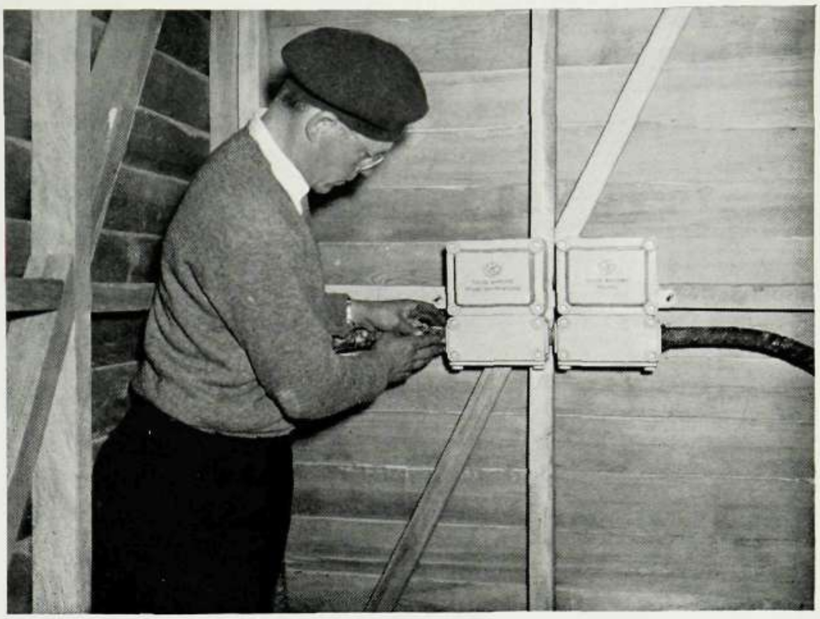


**Fig. 5—The River Site Equipment**

### Circuit Elements

The relative remoteness and difficulty of access of much of the New Zealand railway network demands a minimum of maintenance on any equipment employed. The design of the system was influenced by this and the maximum of facilities was extracted from a minimum of apparatus. This reduces the fault liability but makes the explanation of the circuits in detail more involved ; only the general arrangement of the circuit elements and their functions will be described here.

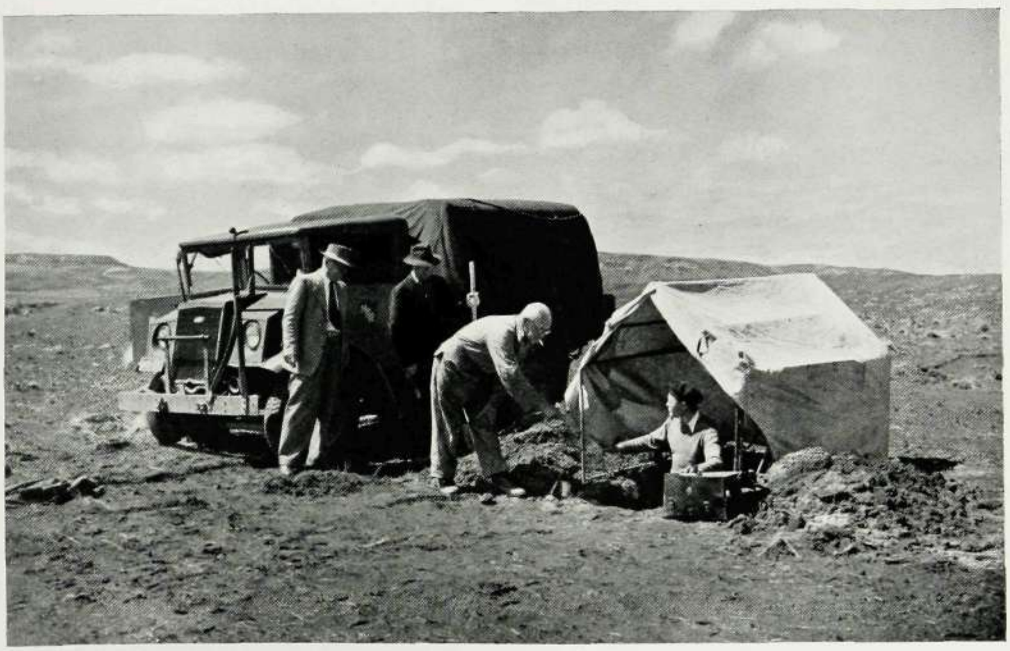


**Fig. 6—Laying the Cable**

The elements are shown diagrammatically in Fig. 9. The five zone conductors leave the cable and that from zone 1 enters the zone 1 circuit and the others go to the cable test circuit.

*Cable Test Circuit.* With the system quiescent, that is with the water level below zone 1, the five conductors are connected in series by this circuit at one end and by the river site relays at the other end. A path is thereby formed starting at negative battery within the zone 1 circuit, through the five conductors in series and finishing along the return conductor to positive battery. A very sensitive polarized relay is included between zone 4 and 5 conductors at the control end and a high resistance is inserted between the zone 5 and the return conductor at the river site. The polarized relay maintains a continuous continuity test on the cable conductors, using such a low current that the zone 1 circuit is not affected.

*Zone 1 Circuit.* When the water enters zone 1, a leakage path appears between the electrodes of zone 1 and those of the return path. This presents to the zone 1 circuit a low resistance by-pass around the high resistance continuity path. The increased current operates a polarized relay within the circuit which then operates the buffer circuit, starts the rising delay circuit and illuminates the zone 1 section of the display panel column.

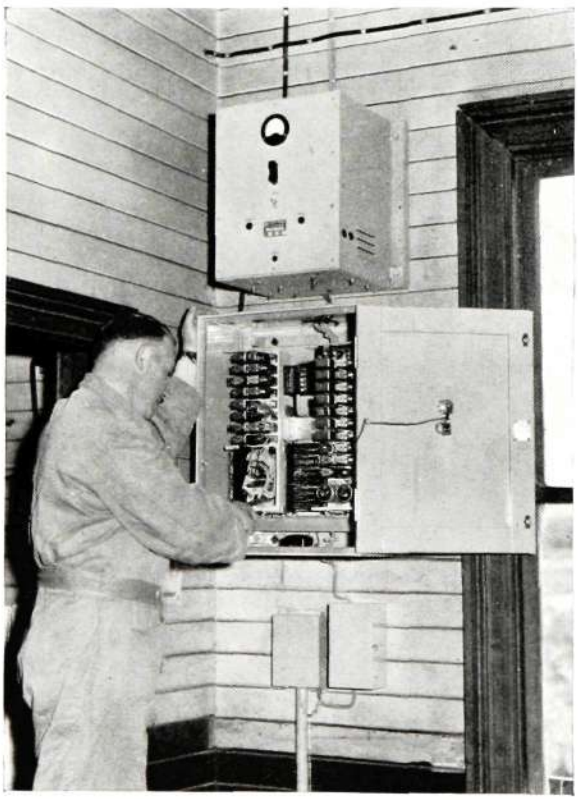


**Fig. 7—The Control Equipment**

*Buffer Circuit.* The surface of the water may be disturbed and the zone 1 circuit may be brought into action intermittently by wave action. The buffer circuit, once triggered into operation, passes through a circuit cycle before it can be triggered again. All zone 1 circuit responses occurring during the cycle are absorbed. At the end of the cycle the control circuit is brought into action ; thus the buffer circuit protects the control circuit against too frequent operation.

*Control Circuit.* When brought into action, the control circuit sends a signal over the control conductor to the relays at the river site and another signal to the cable test circuit. The series connections of the cable continuity test are removed at both ends and the conductors for zones 2 to 5 are extended into the zone relay circuit.

*Zone Relay Circuit.* In this circuit a polarized relay is connected to each conductor and the system is then ready to respond to a further rise of water level. Each zone relay will operate to the return path leakage current as the water enters its zone and will illuminate the associated section of the display panel column.

*Rising Delay Circuit.* This circuit is brought into operation by the zone 1 circuit and its function is to ensure that an alarm is not given unless the water remains continuously within zone 1 for thirty seconds or more. The circuit is based on a thermostat which is given a controlled heating period when the zone 1 circuit operates. At the end of the heating period, the thermostat is allowed to cool and the delay function of the circuit is derived from its cooling time. Should the water recede and re-enter the zone, the full delay time must again elapse before an alarm can be given. To make this possible it is arranged that each repetitive heating period is related to the thermal condition of the thermostat so that


Fig. 8—The Display Panel

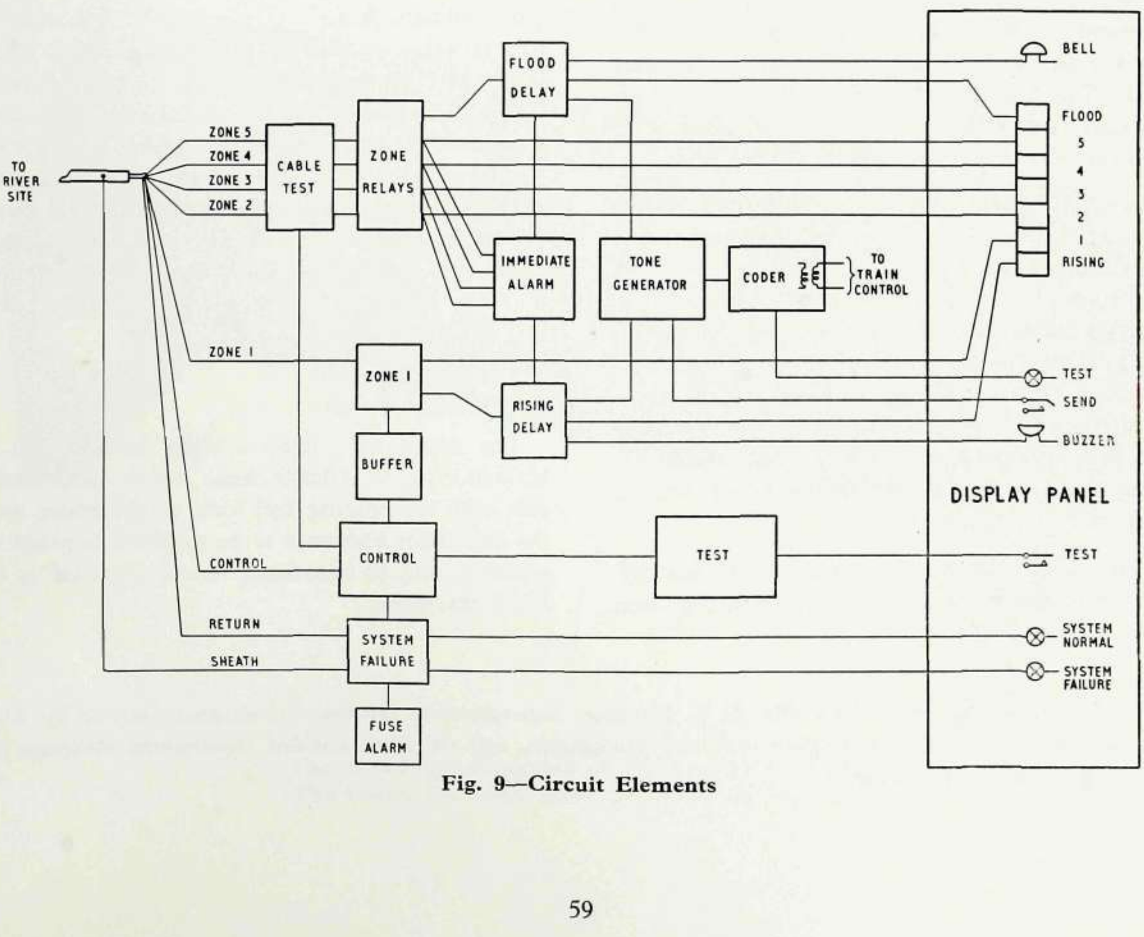



Fig. 9—Circuit Elements

just sufficient additional heat is generated to produce the required delay. If the water level remains constant within zone 1 for the full delay period, the rising delay circuit illuminates the rising section on the display panel, brings in the audible alarm and starts the tone generator circuit.

*Tone Generator Circuit.* This controls a 400-cycle tone source with an adjustable output ranging from -15 db to +7.5 db with reference to one milliwatt into 600 ohms. When started it generates tone for 24 seconds and then returns to normal.

*Coder Circuit.* This divides the output of the tone generator into twenty-four one-second periods. Strappings on a code selecting panel determine whether or not tone is injected into the train control system during each period. A coded signal can be chosen which contains both station identity and the rising alarm information. The number of periods is sufficient to allow more than one repetition of the code to be sent.

*Flood Delay Circuit.* Should the water reach zone 5, this circuit is operated by the zone relay circuit. It is similar to the rising delay circuit and, should the level remain within zone 5 for the full delay period of 30 seconds, it will illuminate the flood section of the display, give an audible alarm and start the tone generator. The audible alarm is given by a bell whereas for the less urgent rising alarm a buzzer is used. The tone generator and coder circuits inject the alarm signal into the train control circuits but with the code changed to indicate a flood alarm.

*Immediate Alarm Circuit.* A selecting panel within this circuit permits the zones, not including zone 1, to be divided into a lower and an upper group. A zone in the lower group may be selected and if the level should reach this zone before the 30 seconds rising delay is completed, the delay period is immediately brought to an end and the rising alarm given. Similarly, a zone in the upper group may be chosen and an immediate flood warning given should the water rise to this zone before the rising delay is completed.

*Test Circuit.* Upon the operation of the test key, this circuit can be brought into action at any time, irrespective of the water level. A signal is sent to the river site relays to connect all zone conductors to the test electrodes. If the system is functioning correctly, all zone relays will operate and the display column will be fully illuminated. To ensure that the delay circuits are tested, the immediate alarm circuit is rendered ineffective, so that after the delay periods the rising alarm will be given—if it has not already been given by the existing water level—followed by the flood warning. The alarm signals are not injected into the train control circuits unless the ' send tone ' key is operated, but their coding can be checked from the test lamp. This is flashed by the coder circuit in accordance with the code which would have been sent. When the test is completed, the equipment returns automatically to the state it was in before testing commenced.

*System Failure Alarm Circuit.* The system is designed so that most of its elements are self-proving, will fail to safety and will indicate the fault condition. Partial failure of the system will not render it ineffective but the indications may require some interpretation. It will retain its functional value should some of the cable conductors be broken or should partial failure of the control circuit or complete failure of the zone 1 circuit, the buffer circuit or the delay circuits occur. Circuit failure indication is centred upon the system failure alarm circuit which lights the ' system normal ' or ' system failure ' lamp. This circuit also maintains a continuous insulation test of the cable by means of a very sensitive polarized relay connected to the cable sheath. A fall in insulation resistance between the bare return conductor and the sheath will produce a leakage current to operate this relay. The cable is indicated as faulty when its insulation resistance falls below 200,000 ohms.

OPERATIONAL RANGE.

The system will detect a water leakage path of resistance up to 100,000 ohms. Tests have shown that with the spacing and form of electrodes used the maximum resistance to be expected between an electrode and its associated return electrode is far below this figure.

*The author wishes to thank Mr. E. J. Marklew, Superintending Engineer (Communications) of the New Zealand Railways for the local information and photographs, and the New Zealand Government Railways for permission to publish this article.*

UDC.621.318.572.
UDC.621.357.7.

# SOME APPLICATIONS OF THE ADD-ON COUNTING EQUIPMENT

G. Bishop — Instrument Division

*Many scientific and industrial techniques involve counting electrical impulses which occur in rapid succession, and hard-valve binary counters based on the well known Wynne-Williams circuit are often used for this purpose. Such counters will function at rates up to several million pulses per second, but the number of valves required and hence the size, cost and power consumption of the instrument tend to become unduly great if large totals are involved. Moreover the number of pulses counted is indicated in the scale of two, and errors may occur in conversion to the decimal scale. By using the dekatron [1,2] it is possible to design counters suitable for pulse rates up to several thousand per second without these disadvantages, since the dekatron is an inexpensive and reliable cold-cathode tube of low power consumption which requires a minimum of associated components to make a counter operating directly in the scale of ten and giving a visual display of the number counted.*

*The Add-on counting equipment is a dekatron counting apparatus in which great versatility has been attained by adopting a unit construction with a variety of units available to perform a wide range of functions. The diversity of applications in which the equipment can be used is illustrated by the examples which follow.*

---

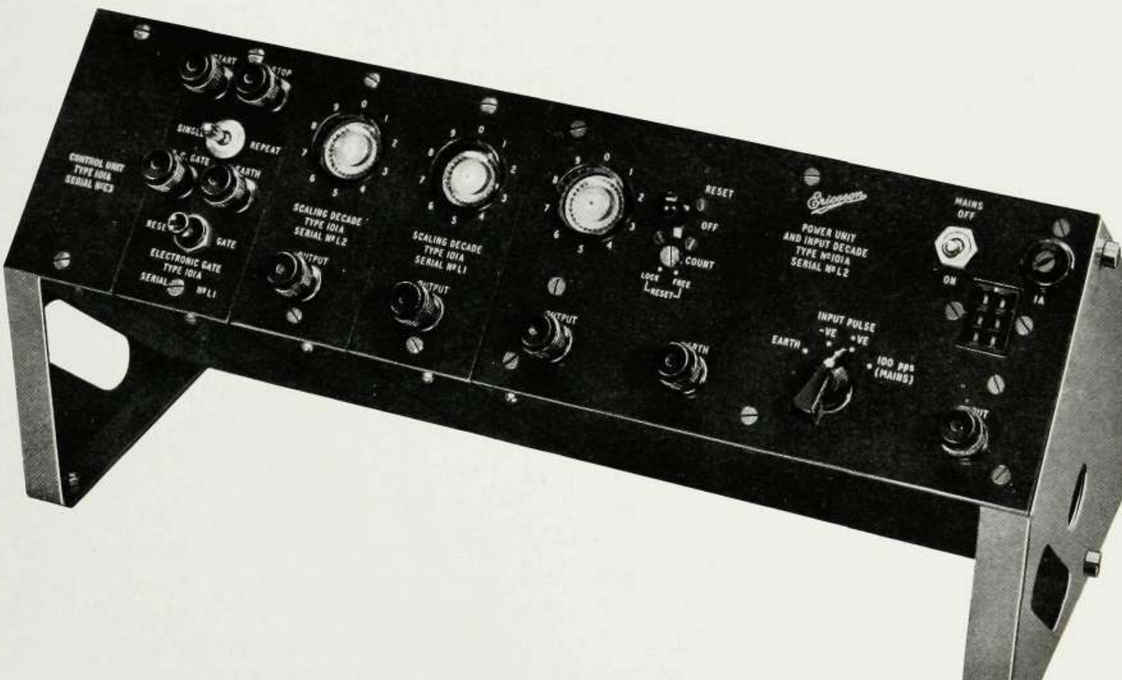



**Fig. 1—Typical Assembly of Units on End Stands. The Power Unit and Input Decade is on the right**

THE basic item of the Add-on equipment is the Power Unit and Input Decade. Auxiliary units which can be associated with it include a Pre-amplifier with a gain of 50, a Scaling Decade, a Selector Decade employing a selector type dekatron which enables output pulses to be obtained from any cathode or group of cathodes, a Selector Scale-of-Twelve, a four-digit Electromechanical Register, an Electronic Gate and a Control Unit. The mains-operated Power Unit and Input Decade supplies power to the auxiliary units ; electrical connections are made by twelve-way plugs and sockets and the units are joined mechanically by O BA captive screws and hank bushes. Fig. 1 shows a typical assembly of units consisting of a Control Unit, an Electronic Gate and two Scaling Decades in addition to the Power Unit and Input Decade. The assembly is mounted on End Stands which support the units at a convenient angle for viewing the dekatron display. A Rack Adaptor is also available which enables a Power Unit and Input Decade together with a maximum of four auxiliary units to be mounted in a standard nineteen inch rack.

The Input Decade can be driven by pulses of 5V minimum amplitude with rise time between 300V/sec. and 5V/microsec, the maximum pulse rate being 3,500 per second. By setting the input selector appropriately, either positive or negative pulses can be accepted. Earth pulses or a sine wave of 5V peak amplitude can also be used to operate the Input Decade, and a further position of the input selector applies a signal of twice the mains frequency to the input circuit for testing or to serve as a reference in timing applications. Counting can be started and stopped and the display reset to zero by a key mounted on the front panel.

Fig. 2—Nuclear Particle Counter

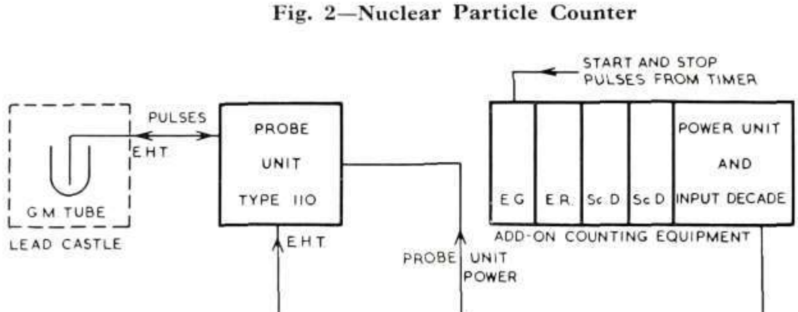



Fig. 3—Block Diagram of the Equipment shown in Fig. 2

## Nuclear Particle Counting

An assembly of Add-on units with a Probe Unit and an EHT Power Unit for counting Geiger-Muller tube pulses is shown in Fig. 2, and Fig. 3 is a block diagram of the arrangement. Pulses originating in the GM tube are conveyed by way of the EHT line to the probe unit and thence via the power cable to the EHT unit, where they appear at a terminal on the front panel. This terminal is connected to the Input Decade input terminal, so that the pulses are counted and the total is displayed on the dekatrons and electro-mechanical register of the Add-on assembly. The Electronic Gate is included to allow remote control of counting either by a manually-operated switch, counting taking place only while the switch contacts are closed, or by timing apparatus which provides start and stop pulses. Such a timer could be made up from a further assembly of Add-on units as described below. The main function of the Probe Unit is to establish a paralysis time which is more precisely known than the GM tube dead time, so that the number of pulses lost during the paralysis time can be accurately determined[3]. It also prevents spurious pulses from reaching the counter.

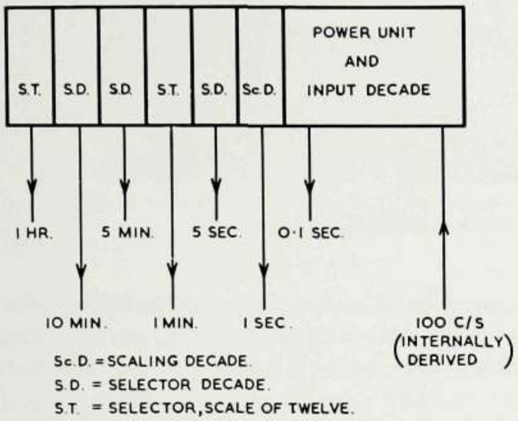



**Fig. 4—An Assembly for providing Pulses at Various Time Intervals**

### Timing Pulse Generation

Fig. 4 shows in schematic form an assembly for providing pulses at various intervals from 0.1 second to one hour. In this arrangement the input selector switch is set to the position which applies a signal of twice the mains frequency (assumed to be 50 c/s) to the Input Decade, so that the dekatron steps a hundred times per second and produces output pulses at 0.1 second intervals. In addition to being available at the output terminal of the Power Unit and Input Decade, these pulses are applied to the Scaling Decade, which thus steps ten times per second and produces output pulses at one-second intervals. These one-second pulses drive a Selector Decade which has output signals taken from cathodes 0 and 5 to provide pulses at five-second intervals. The next unit, a Selector Scale-of-Twelve, provides pulses at one-minute intervals, and this is followed by another Selector Decade giving output signals from cathodes 0 and 5, that is at five-minute intervals. The five-minute pulses drive a further Selector Decade in which output pulses are taken from cathodes 0, 2, 4 and 8, producing signals at ten-minute intervals. The final unit is a Selector Scale-of-Twelve with cathodes 0 and 6 connected to the output circuit so that pulses at one-hour intervals are obtained.

Timing pulses at other intervals can be generated by a suitable combination of Selector Decades and Selectors Scale-of-Twelve with output signals taken from appropriate cathodes. Each selector unit carries a terminal strip at the back which allows the cathode output connections (and also the resetting connections) to be arranged as required simply by altering the positions in which screws are inserted. If the use of the signal at twice mains frequency does not give sufficient accuracy or a short enough interval for a particular application, a tuning fork or crystal controlled oscillator can be employed.

### B.N.F. Jet Test

The British Non-Ferrous Metals Research Association and Messrs. British Drug Houses Ltd. have devised a method of determining plating thickness in which the plating is subjected to a jet of a standard test solution. The solution dissolves the plating and a change of colour occurs when the base metal is exposed. The time interval between the application of the jet and the colour change is measured, and from this time, the temperature of the solution and other known factors the plating thickness can be deduced. A stop clock is often used for measuring the interval, but in our laboratories it has been found advantageous to employ an assembly of Add-on units as a timer.

The arrangement of the apparatus is shown in Fig. 5. The test solution and specimen form part of the electrical circuit of the Add-on equipment, and when the jet impinges on the specimen, earth potential is applied to the cathode of a diode in the Power Unit and Input Decade so that the diode conducts and counting begins, the input selector switch being set so that the internally generated 100 c/s signal is applied to the Input Decade. The test operator stops the count by turning off the jet when the colour change takes place, and the time interval can then be read from the dekatrons in seconds and decimal fractions. Since timing begins automatically when the jet strikes the specimen, the timer does not function if the specimen is not situated in the solid column of the jet, and the invalidity of the test is immediately exposed. Human error in starting the jet and timer at the same instant is also eliminated, so that the test can be carried out by less skilled operators when Add-on equipment is used instead of a stop clock.

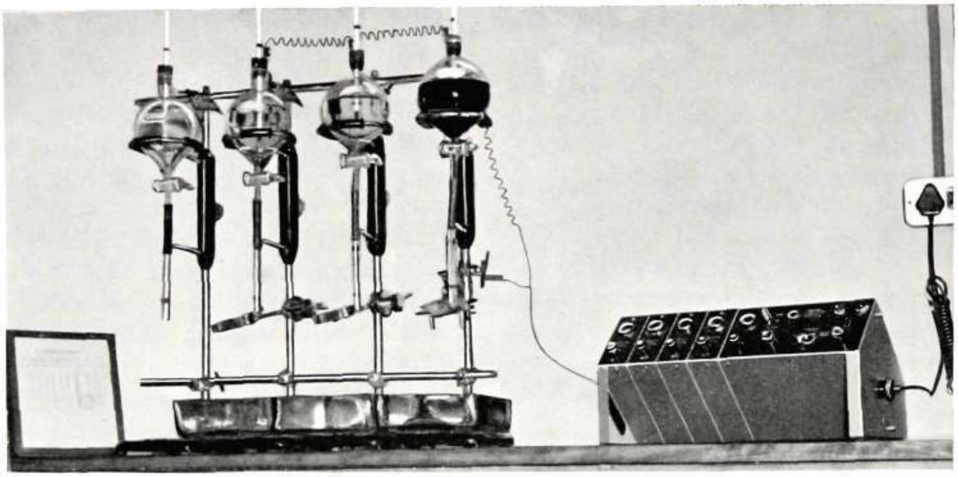


**Fig. 5—Interval Timer used in testing surface plating thickness**

FLASHING INDICATOR TESTING

Add-on equipment is used by some manufacturers to check that flashing direction indicators for motor vehicles comply with Ministry of Transport flashing-rate standards. An arrangement for this purpose, using two assemblies of Add-on units, is shown in Fig. 6. One assembly functions as a time pulse generator providing output signals at 30 second intervals, while the second assembly registers a pulse each time the flasher contacts make. The Electronic Gate in the second assembly is opened by a pulse from the first assembly, allowing counting of the flasher pulses to begin, and closed 30 seconds later by the next timing pulse, so that counting is then stopped.

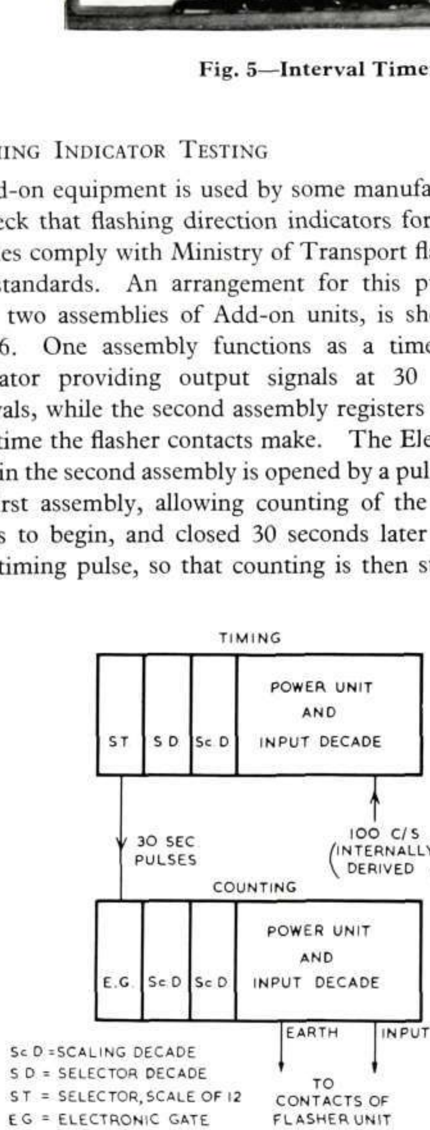



**Fig. 6—Units used for Checking Vehicle Direction Indicator Flashing Rate**

The number of contact operations in thirty seconds can then be read from the dekatrons in the counting assembly, after which the dekatrons may be reset to zero in readiness for the next test. If facilities for rapid connection and disconnection of the flashers are provided the test operation can be completed in less than one minute, so that testing can proceed continuously without interrupting the working of the timing assembly. For a more accurate measurement of the flashing rate, timing pulses at one-minute intervals can be produced by changing one connection in the Selector Scale-of-Twelve.

TACHOMETRY

Add-on equipment can be used to measure rotational speeds if each revolution of the shaft of which the speed is required can be made to generate a fixed number of electrical impulses. There are various ways of obtaining such pulses ; some form of magnetic pick-up is often the most convenient because it is usually possible to take advantage of irregularities in the shaft such as bolt-heads or key-ways so that the necessity of adding devices which might upset the balance is avoided.

Fig. 7 shows an arrangement giving a repetitive display reading directly in revolutions per minute with an accuracy of approximately $\pm 0.2\%$ at 1,000 r.p.m. rising to $\pm 0.007\%$ at 50,000 r.p.m. and increasing still further at higher speeds. The maximum speed which can be measured is 210,000 r.p.m. Two assemblies of Add-on units are used, one for timing purposes and the other for counting the pulses generated by the shaft rotation. A crystal controlled

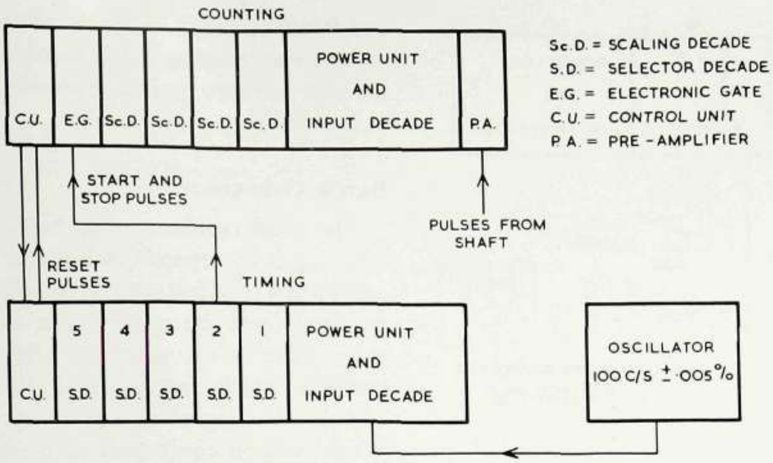
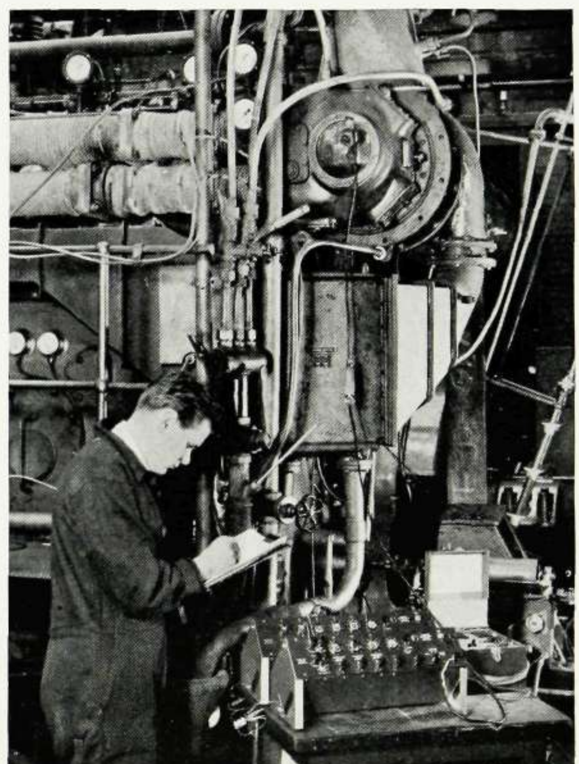



**Fig. 7—Units used for Measuring and Displaying Rotational Speed of a Shaft**

oscillator drives the Input Decade and Selector Decade 3 in the timing assembly at 100 c/s ±0.005%, Selector Decades 3, 4 and 5 form one counting chain and the Input Decade with Selector Decades 1, and 2 form another, so that the dekatrons in decades 2 and 5 step coincidentally once per second. Hence output pulses at any interval between one and ten seconds can be obtained from either of these decades by making appropriate connections to the dekatron cathodes. Output pulses from decade 2 are applied to the commoned start and stop channels of the Electronic Gate in the counting assembly so that the gate is alternately opened and closed by successive pulses. The pulses generated by the shaft rotation are counted only while the gate is open. Pulses from Selector Decade 5 in the timing assembly are applied to the Control Units and cause all dekatrons in both assemblies to be reset to their initial conditions. The connections to the cathodes of the dekatrons in Selector Decades 2 and 5 are made in such a way that decade 2 produces a start pulse followed after a suitable interval by a stop pulse ; then after a pause sufficient to allow the dekatrons in the counting assembly to be read, decade 5 produces a resetting pulse and the cycle repeats. The counter assembly thus repeatedly indicates the number of pulses generated by the shaft rotation which occur in the interval between the start and stop pulses. Since this interval is set at a fixed value, the number of shaft pulses is proportional to the rotational speed, and by choosing the interval suitably with regard to the number of shaft pulses per revolution, the counter display can be made to read directly in revolutions per minute.

If the shaft produces N pulses per revolution, the interval between the start and stop pulses must be 60/N seconds to give a direct-reading display. For example, if there are twelve pulses per revolution, a counting period of five seconds is required, and this may be obtained by arranging for Selector Decade 2 to reset to cathode 9 and give output pulses from cathodes 0 and 5. (If the required counting period is greater than ten seconds, extra decades must be added to the timing assembly). A resetting pulse occurring four seconds after the stop pulse from cathode 5 of decade 2 may be obtained from cathode 9 of decade 5, this decade also being arranged to reset to cathode 9 ; all other dekatrons in the equipment are reset to cathode 0. With the connections arranged in this way the sequence of operations is that a start signal is generated and pulses from the shaft are counted for five seconds ; a stop pulse then occurs, followed by an interval of four seconds to



*Reproduced by kind permission of Messrs. Ruston and Hornsby Ltd.*

**Fig. 8—Measurement of Turbo Charger Speed**

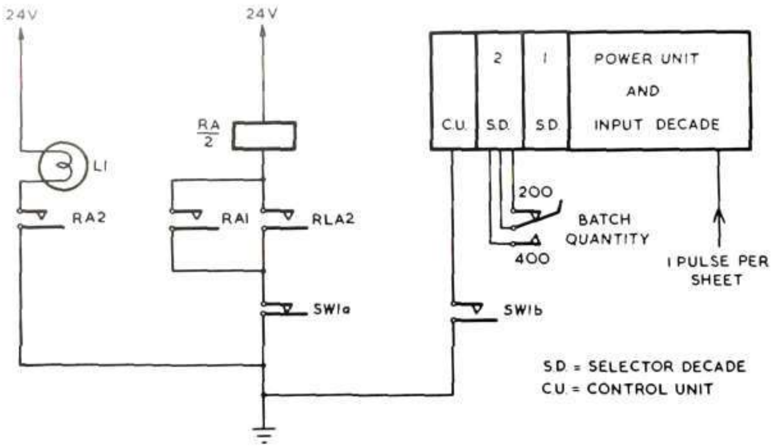



**Fig. 9—Typical Arrangement for Batch Counting**

allow the shaft speed in r.p.m. to be read from the dekatron display ; a reset pulse is then produced and after a delay of one second, during which the dekatrons in decades 2 and 5 of the timing assembly step from cathode 9 to cathode 0, a further start signal is generated and the cycle is repeated. Readings of rotational speed are thus obtained at ten-second intervals. Fig. 8 shows Add-on equipment in use to measure turbo-charger speeds.

This type of tachometer has certain limitations. Since the Add-on counter has a maximum operating rate of 3,500 pulses/second, the highest rotational speed which can be measured is 210,000/N r.p.m., N being the number of pulses per shaft revolution as above. As N decreases the interval between readings increases if a direct-reading display is required ; if N is given the value one, to enable the highest possible speed to be measured, each reading requires one minute for counting shaft pulses as well as a few seconds for reading the display. In some circumstances so long an interval between measurements could not be tolerated. The accuracy of measurement falls off exponentially at low speeds. At 400 r.p.m. $\pm$ 2% can be obtained but for lower speeds other methods are usually required. Add-on equipment can still be used, one technique being to generate one pulse per shaft revolution and count the number of cycles from an oscillator of precisely-known frequency which occur in the interval between two shaft pulses. This method is not direct reading but is capable of very accurate results especially at low speeds.

### Batch Counting

The usual requirement in batch counting is to register each object and when a specified total is reached perform some operation such as the closing of a pair of relay contacts which can be used for control or signalling purposes. When Add-on equipment is used for batch counting the Power Unit and Input Decade is used in conjunction with selector Decades or Selector Scale-of-Twelve and a Control Unit.

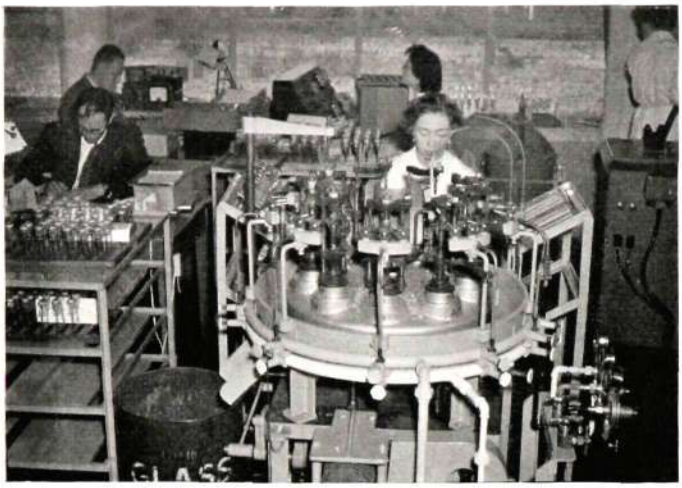
A typical arrangement of units is shown in Fig. 9, which also includes the signalling arrangement for a particular application. In this case it is required to count metal sheets as they are placed in a loading bay and signal to the loader when the required number of sheets is in place. The number involved may be 200 or 400 depending on the size of the sheets. A slight modification has been made to Selector Decade 2 so that the change from one batch quantity to the other can be made by operating a switch instead of adopting the usual procedure of changing the position of screws in the terminal panel of a Selector Decade. As each sheet is placed in the bay a pulse is applied to the Input Decade. At the end of a batch an output pulse from Selector Decade 2 is applied to the Control Unit and the relay in that unit operates, momentarily closing contacts RLA2. These operate relay RA/2 which locks via its own contact RA1 and also completes the circuit for the lamp L1 via RA2. The lamp indicates to the operator that the required number of sheets is in the bay. The operator then operates the reset switch SW1 momentarily and contact SW1a breaks the circuit of RA/2, thus extinguishing L1. Contact SW1b applies earth to the reset terminal in the control unit, so resetting all dekatrons to zero and preparing the equipment for counting the next batch.

*References :*

1. *Bacon, R. C. and Pollard, J. R.* *The Dekatron* *Electronic Engineering XXII* 173 (1950)
2. *Acton, J. R.* *The Single Pulse Dekatron* *Electronic Engineering XXIV* 48 (1952)
3. *Taylor, D.* *The Measurement of Radio Isotopes* (*Methuen* 1951 *pp.* 86 *et seq*)

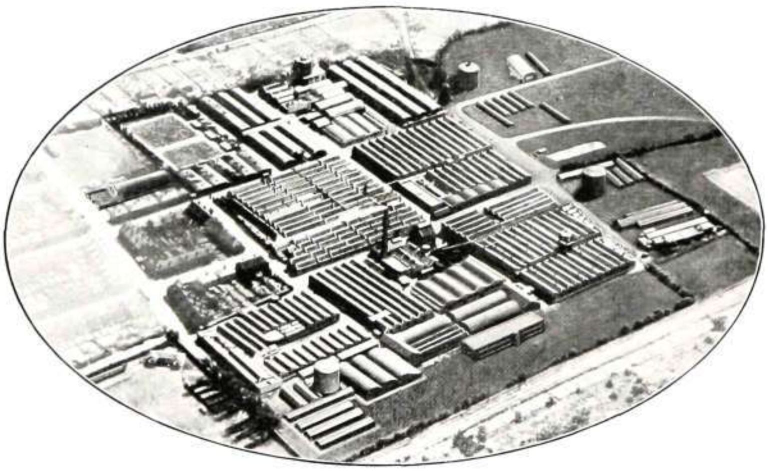


DERRY & SONS, LTD.
PRINTERS
NOTTINGHAM, ENGLAND

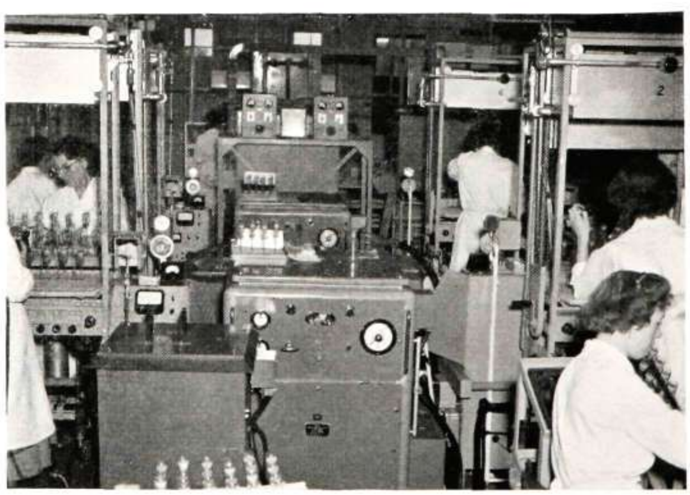


**In the Valve Factory at Beeston**

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.