

THE ETELCO BULLETIN

No. 37
JULY, 1958

Editor : S. DENTON.

Tech. Adviser : J. T. STRINGER, M.Sc.

EDITORIAL COMMITTEE

C. W. COLLIER
L. H. DRYSDALE
L. S. FISHER
W. E. HUNT, B.Sc.
G. H. PRINCE
J. R. H. STEVENS
R. C. WOODS, M.I.E.E.

CONTENTS

Page 50	Lightning Protectors for Telephone Lines	<i>S. Steggle</i>
Page 54	A Three-Channel Carrier Telephone System for Open-Wire Lines	<i>J. Attewell, A.M.I.E.E.</i>
Page 65	Subscribers' 50-Point Linefinder System (Reprinted from the P.O. Electrical Engineers' Journal)	<i>W. H. Fox, A.M.I.E.E., J. L. K. Ashwell and A. L. Weaver</i>
Page 74	A Catapult End-Speed Recorder (Reprinted from "British Communications and Electronics")	<i>J. R. Pollard, M.A., M.I.R.E., A.M.I.E.E.</i>
Page 81	An Echo Suppressor for the Trans-Atlantic Cable	<i>W. Proctor</i>
Page 85	New Electronic Switching Laboratories	
Page 87	Simplified Power Cabling in Small Exchanges	

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

LIGHTNING PROTECTORS FOR TELEPHONE LINES

S. STEGGLES — Production Laboratory

Some form of spark-gap is conventionally employed to protect telephone equipment against high voltages caused by lightning. In many areas only relatively low-energy discharges occur, but in others conditions are much more severe and lightning protectors must withstand repeated surges of high intensity. Specially developed materials are necessary for the electrodes of protectors which may be subjected to high-energy discharges and the construction must be such as to prevent bridging of the gap by particles detached from the electrodes by the energy of the discharge. There must be no possibility of the electrodes being fused together, and alteration in the breakdown voltage caused by erosion of the electrodes must be avoided. Several types of protectors are described in the article, including one designed to meet the conditions prevailing in South Africa.

DURING the last fifty years, it has been established that the extent to which telephone equipment is subject to damage by lightning varies greatly according to its location and other conditions. Overhead lines may be charged to potentials ranging from a few volts to very dangerous levels of 100kV. or more, with associated current surges of several thousand amperes ; the rate at which lightning-induced voltages occur varies from a few times in a year to several times per hour, and the amount of damage caused depends on the duration of the discharge, the height of the line above the earth and the exposed length. In some areas the increasing use of underground cables has reduced the risk of lightning damage to the point where it is not considered necessary to fit protective devices. However, in most installations the line circuits are safeguarded by spark gaps which discharge the lines to earth when voltages caused by lightning (or contact with power lines) reach dangerous magnitudes.

Carbon is often used for the electrodes of lightning protectors on account of its high melting point and non-corrosive and non-welding properties. In one early pattern of protector, which has been widely used, the carbon electrodes are separated by a thin mica plate which is perforated to allow the passage of the discharge (Fig. 1). Low energy discharges cause the electrodes of this type of protector to emit carbon dust in quantities which give rise to short-circuits or low resistance across the gap. Heavy discharges may shatter the electrodes, and the retaining springs may be distorted in consequence.

The need for the mica insulator has been eliminated in the 'varnished' protector, in which a suitable

varnish film separates the electrodes. With this type of protector the formation of carbon dust is largely prevented, but the liability of the electrodes to shatter when exposed to a heavy discharge is still present.

Another variety of protector, known as the knife-edge pattern, is shown in Fig. 2. This consists of a section of metal, usually copper, held in a plastic moulding at right angles to a carbon block. The knife-edge protector is self-cleaning, but again is satisfactory only with low energy discharges, since the metal edge is burned away under heavy discharge conditions, causing the breakdown voltage to increase and the protection afforded to the apparatus to be reduced. Corrosion of the metal may also occur.

Fig. 3 shows the current British Post Office pattern of lightning protector. The plastic moulded body supports two metal electrodes which are separated by a slotted plastic insulating strip. Although this type of protector gives satisfactory service in many areas, it is not suitable for use where more severe conditions are experienced ; high-energy discharges may cause the electrodes to be welded together, and in humid atmospheres condensation and capillary action may result in the bridging of the gap by a low-resistance moisture film.

South Africa is one of the countries in which lightning protectors capable of withstanding heavy current discharges are required, and the South African Posts and Telegraphs Department Specification No. 236 deals with the design and performance of suitable units. The considerations which led to the development of this specification are discussed in a

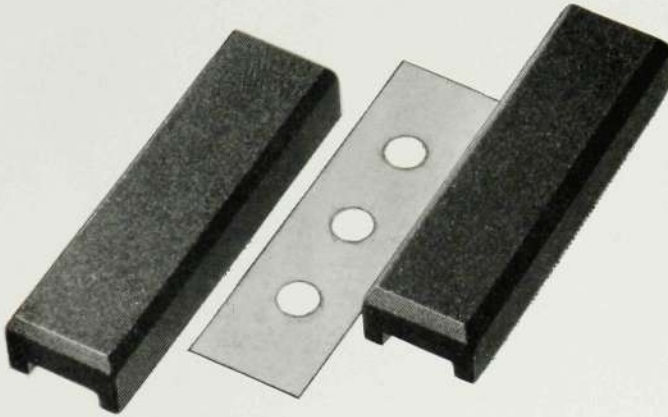


Fig. 1—Carbon electrodes with mica separator



Fig. 2—'Knife-edge' type Protector

monograph by C. T. Boyce and others, published in June 1955 by the South African Institute of Electrical Engineers. It is pointed out that metal electrodes in air are subject to corrosion by the nitric acid formed during a discharge, and that non-corroding metals of high melting point, such as tungsten, are too expensive for this application. The monograph indicates that carbon used for lightning protector electrodes must be of high quality, only dense, hard 'retort' or 'coke' carbon of low resistivity and containing a minimum of volatile material being suitable. Absorption of moisture in the carbon must be avoided, since the heating during a discharge is usually localized and in consequence high temperatures occur ; the resulting rapid expansion of water

vapour might lead to shattering of the electrode. It is stated that powdery is the most serious disadvantage of the carbon electrode, and that varnishing does not entirely overcome this because once the varnish film is punctured, succeeding discharges tend to concentrate at the same point. Powdery causes difficulties when mica or plastic insulating strips are used to separate the electrodes, since a separator designed to permit the escape of electrode dust cannot at the same time exclude atmospheric dust and moisture. It is concluded that a hermetically sealed protector with metal electrodes may be superior when only low-current discharges have to be considered, but that a carbon-electrode protector is more efficient under heavy discharge conditions.

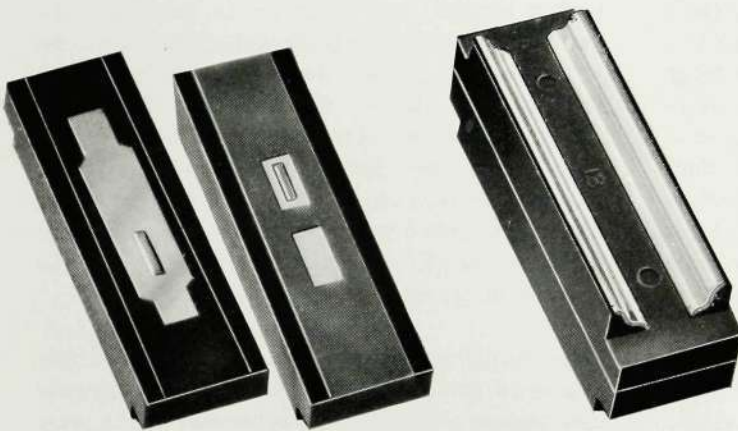


Fig. 3—Sectional and external views of the standard British Post Office type Protector with metal electrodes

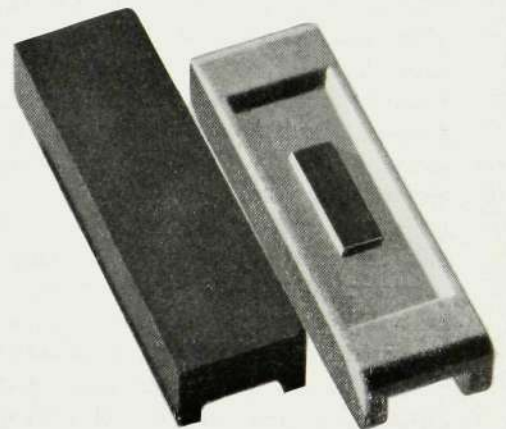


Fig. 4—Type 236 Protector with carbon insert (South Africa P & T Dept. Specification No. 236)

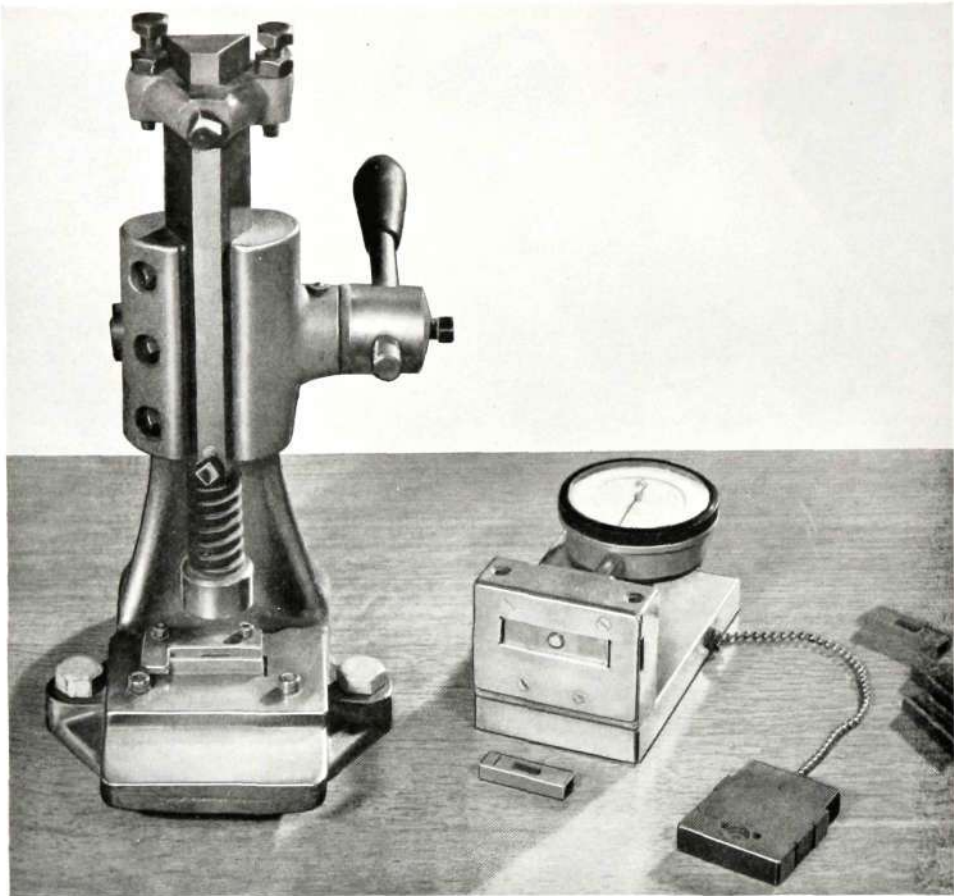


Fig. 5—Press for inserting carbon electrode into the moulding of the Type 236 Protector

A protector produced by the Company to comply with the South African Posts and Telegraphs Department specification No. 236 is shown in Fig. 4. The carbon electrodes are made from a special grade of material developed by the Morgan Crucible Co. Ltd. This carbon is manufactured by bonding amorphous carbon particles with pitch and firing to produce a hard, dense material from which pieces of the required size and flatness can be obtained without removing the outer die skin ; the denser outer surface gives high resistance to powdering. One electrode takes the form of a small insert accurately located in a body moulded from glass-filled melamine. The body has a slight recess in the operating face, and its edges are raised above the face of the carbon insert. The second electrode is located on these edges, so that the gap is fixed without the use of a separator. The original design of the protector specified a ceramic body, but a moulding has been developed which can be made to more precise dimensions. This is

produced in a grade of glass-filled melamine which has exceptional dimensional stability under long exposure to wet or dry heat, high insulation resistance, surface hardness and resistance to tracking. The protectors are made with gaps of various sizes, the melamine being pigmented to indicate the breakdown voltage. The edges of the moulded body tend to exclude atmospheric dust from the gap, and carbon dust formed when heavy current discharges occur falls into the recess in the body and does not bridge the gap or cause low resistance to earth ; the grade of material used for the electrodes ensures that the quantity of carbon dust is very small.

In assembling the protectors, the smaller electrode is inserted into the moulding and pressed accurately into position (Fig. 5). The lower part of the press tool has a location for the moulding and its centre is raised to a height equal to the distance by which the carbon is to be recessed into the holder. The



Fig. 6—A Type 236 Protector after subjection to one hundred discharges each of 100 joules at 1500 volts

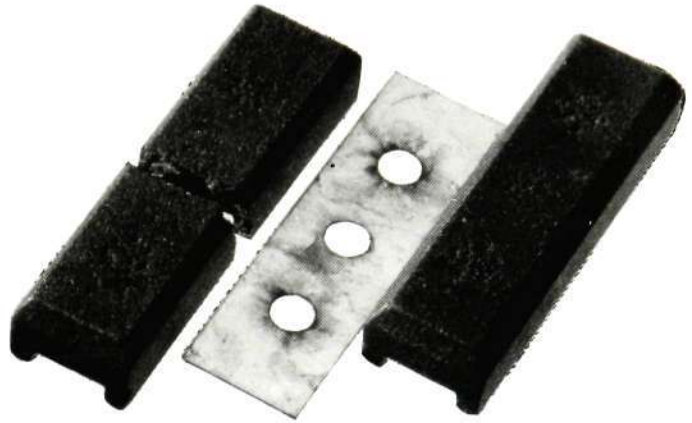


Fig. 7—A 'Mica' type Protector showing an electrode shattered after one discharge of 100 joules at 1500 volts



Fig. 8—This 'Knife-edge' Protector, also, shows noticeable damage after one discharge similar to that applied in Fig. 7



Fig. 9—Showing the effect of one discharge of 100 joules at 1500 volts on a standard British Post Office type Protector

upper part of the tool consists of a punch which forces the electrode into the body until it meets the raised centre of the lower tool. The punch is surrounded by a metal ring backed by a heavy spring to ensure that the moulding is held securely while the carbon insert is pressed into place, being then secured by a suitable adhesive. The position of the insert relative to the edges of the body is checked by a dial gauge, as indicated in the figure. Since the gap between the electrodes of the protector is controlled by the height to which the centre of the lower press tool is raised, the breakdown voltage can be adjusted to any desired value by using a tool with the appropriate centre height. The accuracy of this simple assembly procedure ensures that the discharge in the protectors occurs within 300 volts of the specified nominal breakdown value.

The efficiency of the 236 type protector under heavy discharge conditions may be judged from Figs. 6, 7, 8 and 9. Fig. 6 shows a 236 protector after subjection to a hundred discharges of 100 joules at 1,500 volts. The shattered mica-separated protector in Fig. 7, the cratered and burnt knife-edge protector in Fig. 8, and the welded metal electrode air-gap protector shown sectioned in Fig. 9 were each subjected to one such discharge.

Thousands of protectors have been supplied to the South African Posts and Telegraphs Department. Other Authorities with similar lightning problems have tested these protectors, with the result that they are now being supplied to Administrations in most parts of the world.

ETL 35/2 - A THREE-CHANNEL CARRIER TELEPHONE SYSTEM FOR OPEN-WIRE LINES

J. ATTEWELL, A.M.I.E.E. — Carrier and H.F. Development Department

ETL 35/2 is the latest of the Company's three-channel carrier telephone systems. It has been designed to comply with C.C.I.T.T. recommendations, and can provide three two-way carrier circuits and four duplex telegraph circuits over a single pair of wires which may also carry a voice-frequency circuit. Single-sideband suppressed carrier amplitude-modulated transmission is used, and either two-wire or four-wire working may be adopted for the speech circuits. The mechanical design conforms to the British Post Office 51 type equipment practice.

SINCE the introduction of the Company's first three-channel carrier system in 1948 (Bulletin No. 16), development has been carried on continuously, and in 1950 the ETL 33 equipment was produced. This was smaller and lighter than the previous equipment, and a reduction in the number of types of components was achieved by using a group modulation to form the upper group. Provision was made for dialling over the carrier channels by a 1 v.f. technique using 2280 c/s. In 1954 the mechanical features of the ETL 33 equipment were substantially redesigned, and the electronic automatic regulator was replaced by a simpler mechanical one. The redesigned system was mounted on a British Post Office 51 type rack and was designated ETL 34.

The latest system, ETL35/2, has further improvements. It is designed to meet the current C.C.I.T.T. recommendations (Green Book 1954), and provides wide-band speech channels with facilities for dialling over each carrier circuit on an out-of-speech-band signalling channel at 3825 c/s. In addition, four telegraph channels may be modulated into the frequency spectrum; the level regulating equipment and repeaters serve the telegraph as well as the speech circuits. Modern space and weight saving components are used, and the complete terminal, which includes telegraph panels, monitoring and current testing facilities, level regulating equipment, transmission measuring set and power panels, may be mounted on one British Post Office 51 type rack 9 feet high, 1 foot 8½ inches wide and 8½ inches deep, as shown in Fig. 1. The rack is single-sided and two terminals may be mounted back-to-back without reducing the accessibility of the components. If the

telegraph channels are not needed, omission of the telegraph panels makes it possible for a terminal to be mounted on a 6-foot rack. An example of such a mounting can be seen in Fig. 2, which shows a short-haul system supplied by the Company to the Eire Posts and Telegraphs Department.

FACILITIES

The equipment provides three 300 to 3,400 c/s two-way carrier circuits and four duplex telegraph circuits on a single pair of wires, the normal physical circuit facilities being unaffected. For the speech circuits, single-sideband suppressed carrier amplitude-modulated transmission is employed with the channel carriers spaced at 4 kc/s intervals. Different frequency bands are used for each direction of transmission, the basic group of 4 to 16 kc/s being transmitted in one direction and an upper group of 18 to 31 kc/s in the other.

The apparatus is designed to permit either two-wire or four-wire operation of the speech channels. Four-wire access points are available for the operation of speech plus duplex telegraph circuits, etc., and the hybrid balance points are brought out so that 'tail-eating' connections can be employed or the nominal balance network replaced.

APPLICATION AND FREQUENCY ALLOCATION

If several three-channel systems are operated on the same pole route, line crosstalk must be taken into account. If two identical systems are used on the same pole route, the higher frequency channels may suffer from intelligible cross-talk to a greater or lesser degree depending upon the route construction and

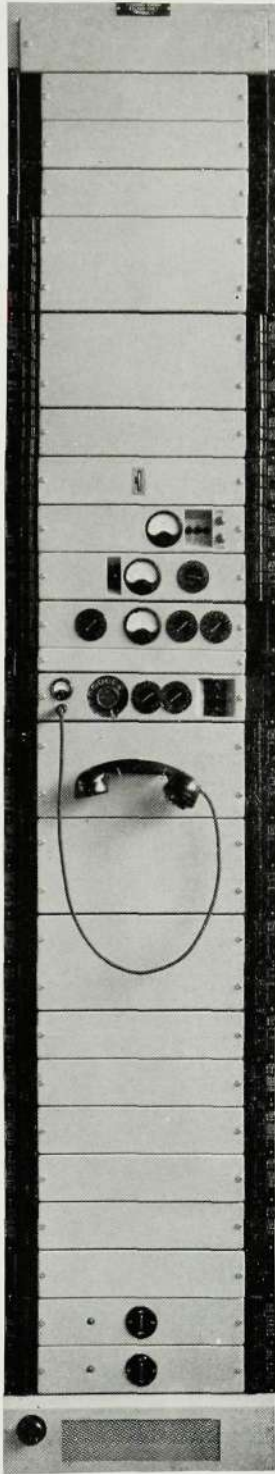


Fig. 1—A typical 3-Channel Terminal, Type ETL 35/2
9 ft. high by 1 ft. 8½ ins. wide

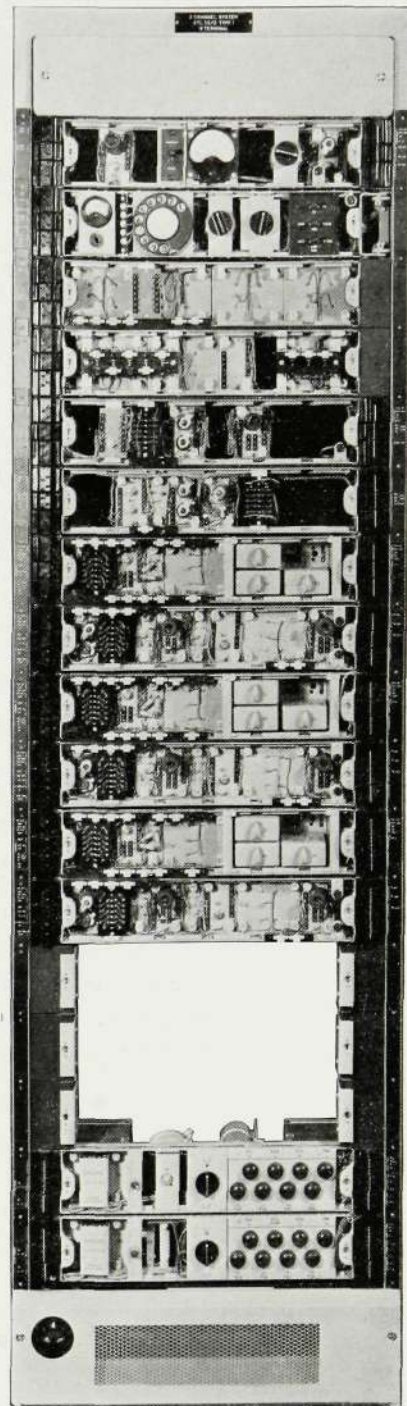


Fig. 2—A Terminal Equipment, without telegraph
and auto regulator panels, mounted on a rack 6ft. high
by 1 ft. 8½ ins. wide

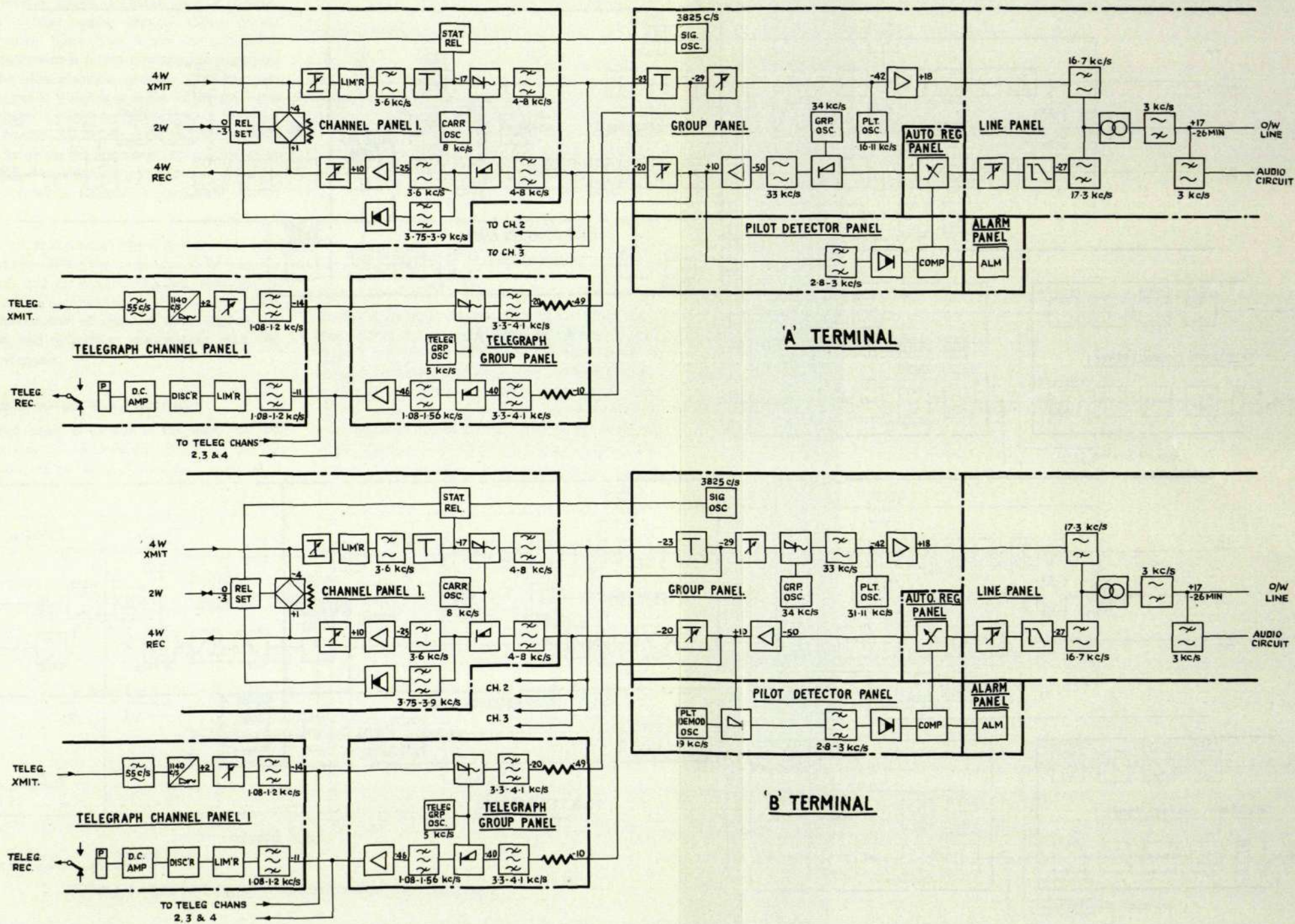


Fig. 4—Block schematic and Level diagram for the ETL 35/2 Type 1 system

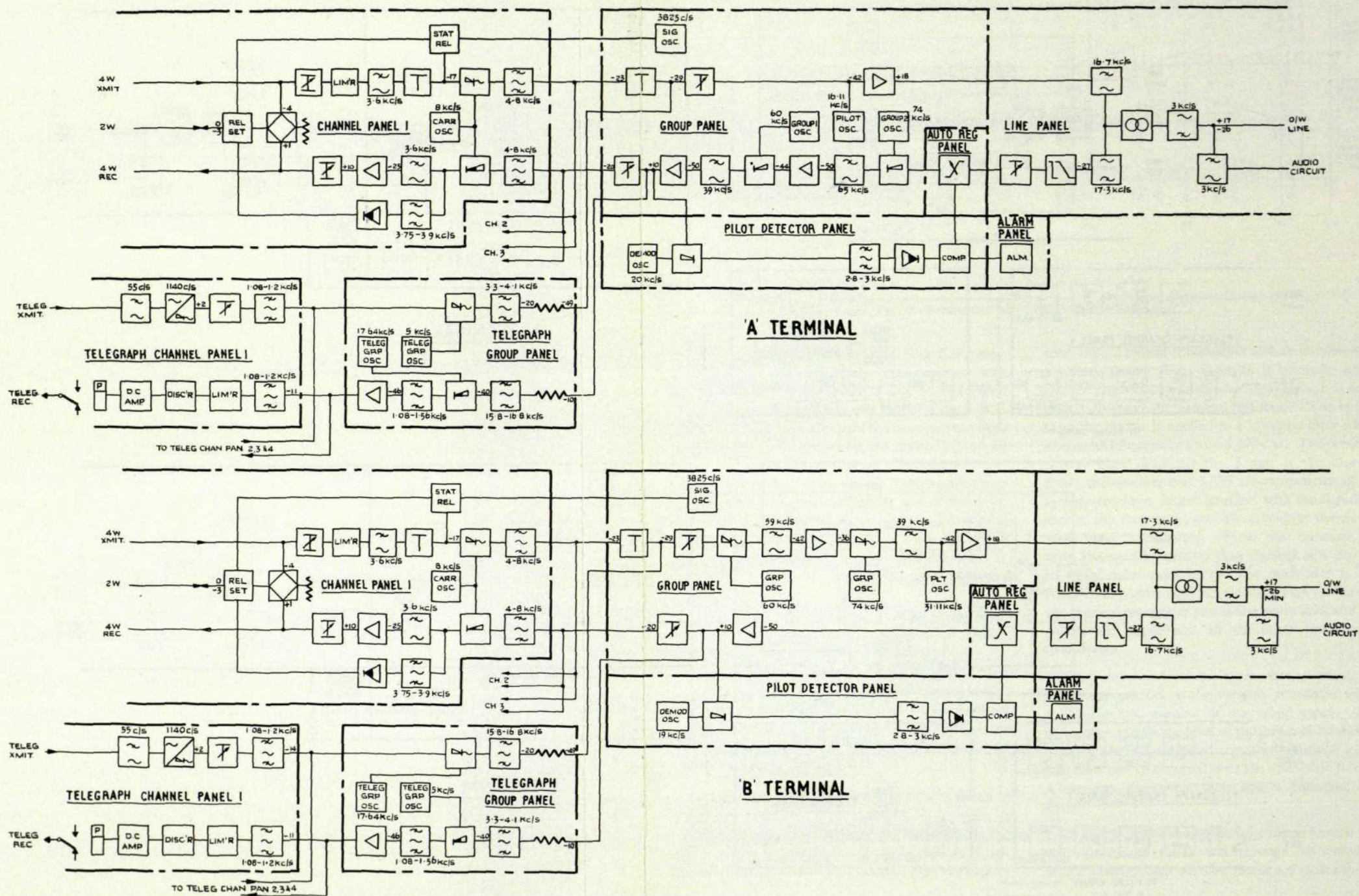


Fig. 5—Block schematic and Level diagram for the ETL 35/2 Type 3 system

the directional and line filters at both terminals. The distortion introduced by the frequency/attenuation characteristic of the line is corrected by the regulating equipment, and the group is then applied via the receive group amplifier and a variable attenuator to the receive channel filters on the channel panels. Each filter selects the appropriate sideband and passes it to the corresponding demodulator. The demodulation process produces two sidebands, one of which is at audio frequency. The audio sideband is passed by the receive v.f. filter and amplified by the channel amplifier before being sent to the exchange via the attenuator, hybrid, and relay unit. Channel equalization is provided by a variable reactance network in the feedback path of the channel amplifier.

For the v.f. and channel filters, a design has been evolved which enables the same type to be used for the transmit and the receive direction, although the requirements are not the same in the two cases. This reduces the number of types of filter used in the equipment and simplifies maintenance and the provision of spares.

TRANSMISSION IN THE B-A DIRECTION

The basic group is formed in the same way for both directions of transmission (Figs. 4 and 5). For transmission in the B-A direction, however, a

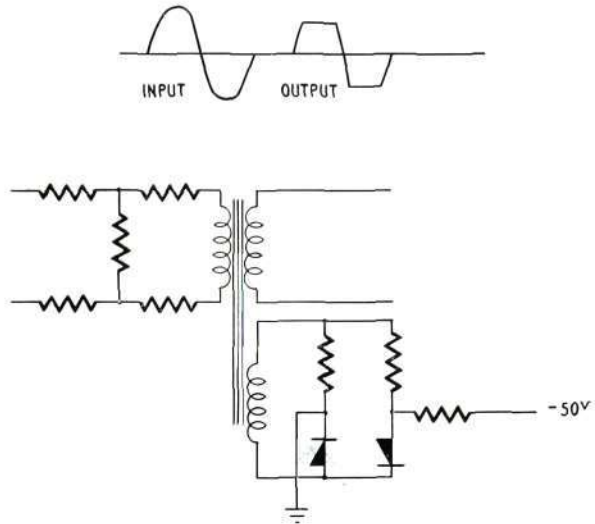


Fig. 6—Diagram of Voltage Limiter

further modulation into the range 18 to 31 kc/s takes place before the group is passed to the line. In the Type 1 and Type 2 equipments, the basic group is applied to the group panel and after passing through a variable attenuator modulates a 34 or 35 kc/s carrier in the group modulator. The lower of the two resulting sidebands, which forms the required upper group, is selected by the transmit group filter and is transmitted to line via the transmit group

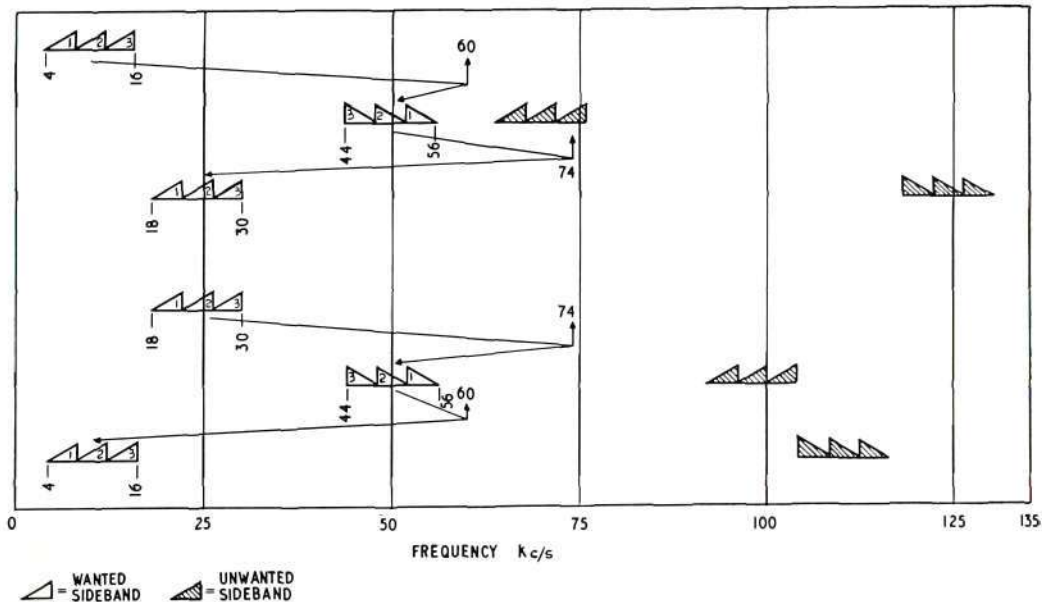


Fig. 7—ETL 35/2 (Type 3) modulation plan for upper group

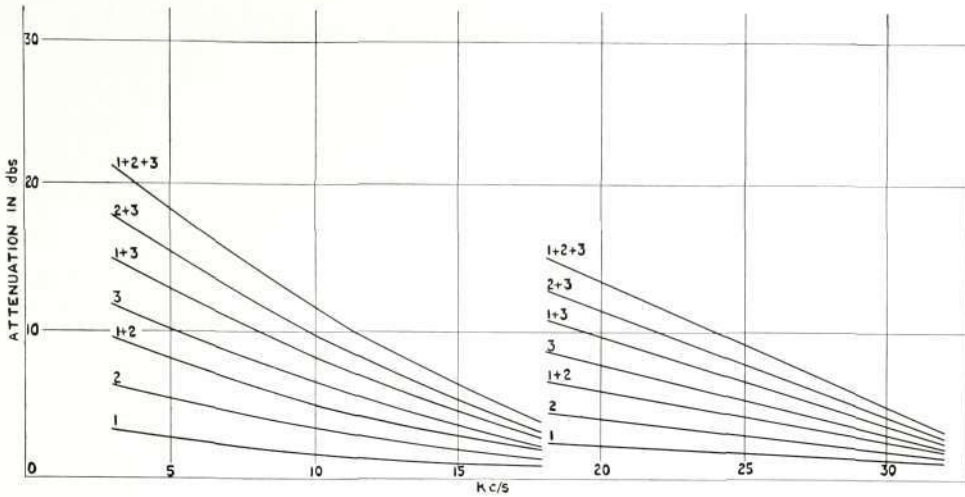


Fig. 10

Left: Attenuation of low frequency Line Equalizer

Right: Attenuation of high frequency Line Equalizer

reliable than those required for a pulsed v.f. system. Either "ring-down" signalling or dialling may be used, and conversion from one to the other is carried out simply by changing U-links on the channel panels.

A schematic diagram of the signalling system is shown in Fig. 8. Each channel panel includes a built-in signalling circuit which provides separate channel suppressed-v.f. signalling at a frequency of 3,825 c/s and 20 db below the nominal sideband. The signalling tone is injected via an auxiliary winding on the modulator input transformer, the static relay being opened by earthing the M wire. The tone is transmitted in the same way as the associated speech channel, and at the receiving terminal a narrow-band filter passes it to a receiver; the filter protects the

receiver from operation by speech frequency voltages. Application of tone to the receiver causes the high-speed relay in the valve anode circuit to release, and the relay contact earths the E-wire. Provision is made for adjusting the receiver to reduce pulse distortion to the minimum.

AUTOMATIC GAIN CONTROL.

The arrangements for line equalization are indicated in Figs. 4 and 5. The main equalization for the frequency/attenuation characteristics of the line (Fig. 9) is carried out by the line equalizer on the line panel, and variations due to climatic conditions are taken up by the automatic regulator. To enable the line attenuation to be measured and its variations corrected, a pilot tone is transmitted in each direction, 16.11 kc/s being used for the A-B direction and 31.11

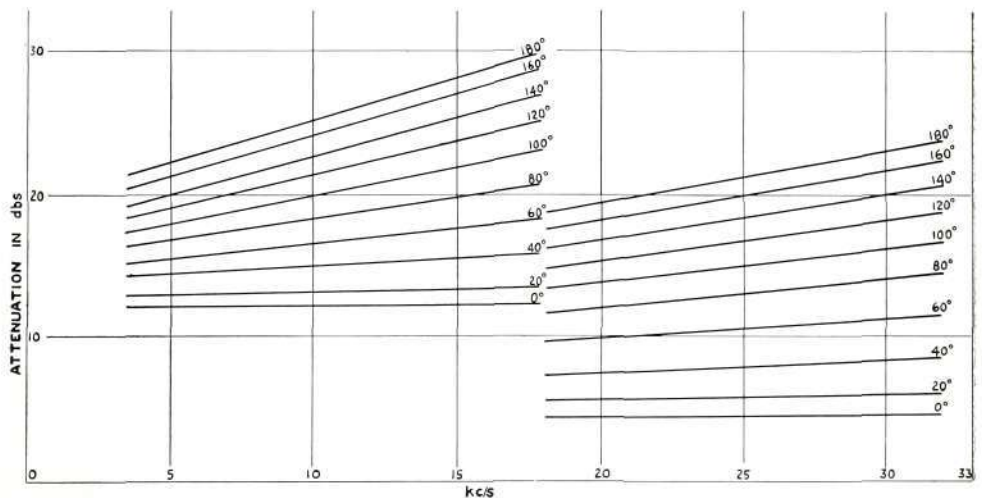


Fig. 11—Attenuation of Regulators with various scale settings

Left: Low frequency Regulator

Right: High frequency Regulator

kc/s for the other. The pilot tones are generated by crystal oscillators giving constant output levels, and each is applied to the input of the transmit group amplifier at an amplitude 17 db below the nominal sideband level. At the receiving terminal, the pilot tone passes through the line and directional filters to the line equalizer and attenuator, which are set to over-compensate for a line in its worst condition ; the equalizer is made up of three units which may be plugged in or out by U links in various combinations to give seven different frequency/attenuation characteristics (Fig. 10). The attenuator also can be adjusted by means of U links. From the attenuator, the pilot tone is applied via the automatic regulator to the group panel, where it is picked off from the output of the receive group amplifier. After demodulation to a lower frequency if necessary, the tone is passed by a narrow-band filter to an amplifier-detector which converts it to a d.c. voltage. The magnitude of this voltage is directly proportional to the level of the pilot tone and inversely proportional to the line attenuation, and it controls relays which in turn control a small electric motor on the regulator panel. Mechanically coupled to the motor is a variable capacitor which forms part of the automatic regulator network in the main transmission path (Fig. 11). The voltage from the amplifier-detector also controls the reading of a centre-zero milliammeter, mounted on the alarm panel, which gives a visual indication of the pilot level.

The amplifier-detector is set so that when climatic variations change the line attenuation sufficiently to bring about a 0.4 db change in the pilot level, the motor is started and drives the capacitor in a direction such as to compensate for the change ; when the pilot level has returned to its nominal value the motor is stopped. On a route with repeaters there are several regulators in series, but the time delay inherent in the level correction circuits prevents hunting from occurring. The level on any link in such a route can change by 0.4 db before the correcting circuits come into operation. However, this error is not cumulative over the route, since the pilot tone is passed right through from one terminal to the other ; the maximum level error at any point is 0.4 db.

If because of some breakdown the pilot level moves more than 2 db from its nominal value, visual and audible alarms are given after a delay of thirty seconds. The regulator is then automatically switched to a " manual " condition in which the capacitor may

be adjusted by hand by means of a calibrated control on the panel.

TELEGRAPH CIRCUITS

Provision is made for four frequency-modulated telegraph channels designed for double-current working up to 75 bauds. The basic v.f. group frequencies are as recommended by the C.C.I.T.T., namely, odd harmonics of 60 c/s with 120 c/s channel spacing. The four frequencies employed are 1140, 1260, 1380 and 1500 c/s, and the group is modulated into the three-channel frequency spectrum by a group modulation on the telegraph group panel (Figs. 4 and 5). To accommodate these telegraph allocations, the upper frequency of the audio circuit on the physical pair has been restricted to 2,700 c/s.

In the transmit direction, an oscillator, tuned to the mid-frequency of the channel over which it is to operate, is controlled by the incoming telegraph current ; a positive current increases the oscillator frequency by 30 c/s and a negative current decreases it by a like amount. The frequency-modulated output from the oscillator is fed through a variable attenuator to the band-pass transmit filter, which removes all unwanted modulation products. At the filter output terminals, which are common to all four transmit filters, the four telegraph channels are combined into a basic group. The group is modulated on the telegraph group panel to its appropriate position in the frequency spectrum, and is injected into the main transmission path on the group panel at a level 20db below the nominal sideband amplitude.

At the far terminal, the telegraph signals are selected from the receive group amplifier output and demodulated into the basic telegraph frequency group. They are then amplified and fed to the commoned input terminals of the receive band-pass filters. These filters pass the wanted components of the demodulated signals through a limiter amplifier to the discriminators.

Each discriminator consists of two tuned circuits, one resonant above and one below the mid-band frequency of the channel. The a.c. outputs from the tuned circuits are rectified and the resulting voltages appear in series opposition to form the discriminator output. This output is therefore a d.c. voltage proportional in sign and magnitude to the deviation of the input frequency from the mid-band frequency ; the output voltage is zero if the discriminator receives

a signal at the mid-band frequency. The frequency-modulated telegraph signals are thus reconverted to d.c. signals, and the discriminator output is applied to an amplifier which drives a high-speed relay. The relay has change-over contacts which feed telegraph current to the receiving device.

Bias adjustment is provided on the discriminator output so that the channel can be set up for minimum distortion.

NUMBER OF REPEATERS	MAX. GAIN PER REPEATER, IN db's	MAX. OVERALL LINE ATTENUATION IN db's	MAX. LENGTH OF 200lb COPPER IN MILES
1	41	82	480
2	39	117	680
3	38	152	890
4	37	185	1080
5	36	216	1260
6	35.5	248	1450
7	35	280	1640
8	34.5	310	1820

Fig. 12—Typical Repeater spacings

REPEATERS

The repeater designed to increase the range of line attenuation over which the ETL 35/2 system may be operated has a maximum gain of 43 db. Fig. 12

shows typical repeater spacings, and Fig. 13 is a schematic diagram of the repeater equipment which is illustrated in Fig. 13A. The physical circuit is first separated from the carrier channels by the line filter. In the A to B direction, the basic group passes through the low-pass filter to the filter and line equalizer and the automatic regulator. The group is then amplified and transmitted to the line via the low-pass directional filter and the line filter. A similar circuit arrangement is used for the B to A direction.

To simplify maintenance and replacement, the repeater panels are as far as possible made interchangeable with the panels which perform the same functions at the terminals. However, the repeater amplifier panel has only two group amplifier units (the units being the same as those on the terminal group panel) and the crystal used on the repeater pilot detector panel is different from that used on the terminal equipment.

TESTING AND MONITORING FACILITIES

Access to the transmission circuits for testing and monitoring is obtained by plugging test cords into sockets in the panel-end links or by removing the links and plugging into the bay or panel-end sockets. All transmission testing points have a nominal

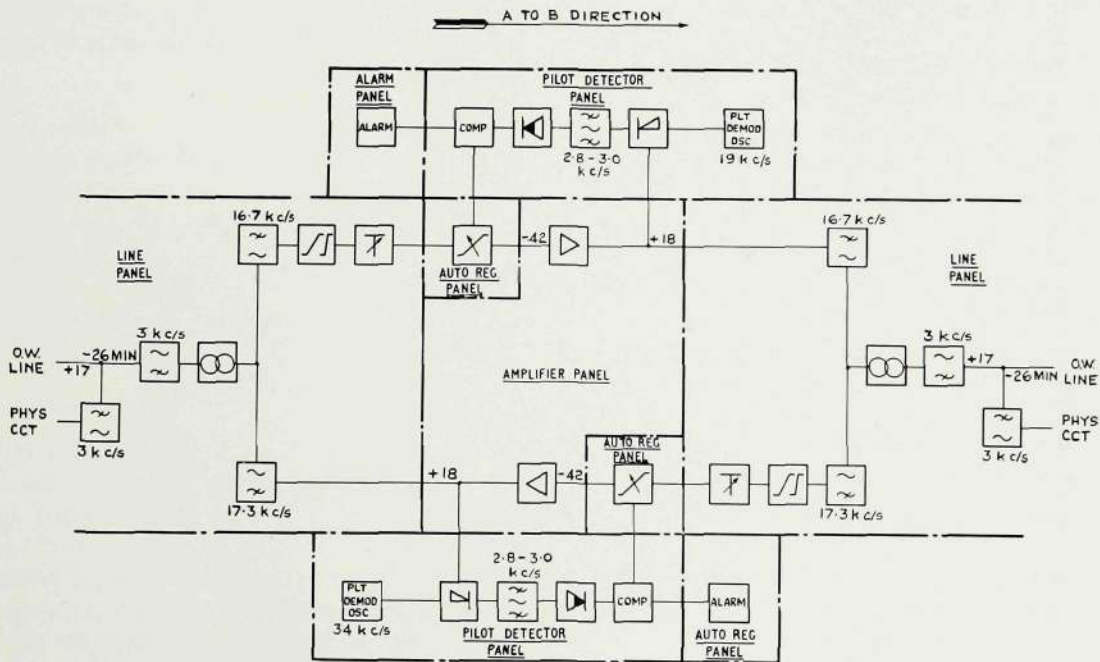


Fig. 13—ETL 35/2 Repeater block schematic and Level diagram

impedance of 600 ohms. A current test and monitoring panel, provided with a telephone handset, gives facilities for two-wire and four-wire monitoring and speaking over the carrier circuits and the line physical circuit. If "ring-down" signalling is being used, ringing can be initiated and received at the panel, and when the circuits are set up for automatic signalling, calls can be established from the carrier terminal in either direction. An exchange line can be terminated on the panel for communication between the panel and the exchange. A meter and switches are provided for rapidly checking the valve anode currents and the relay, filament and h.t. voltages. The meter gives a centre-scale reading when voltages and currents have their nominal

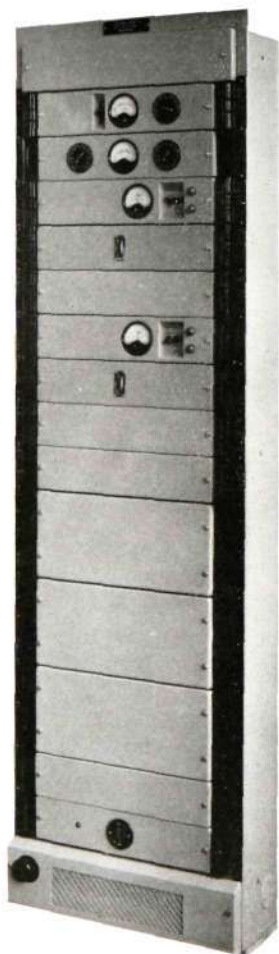


Fig. 13A—Repeater Equipment

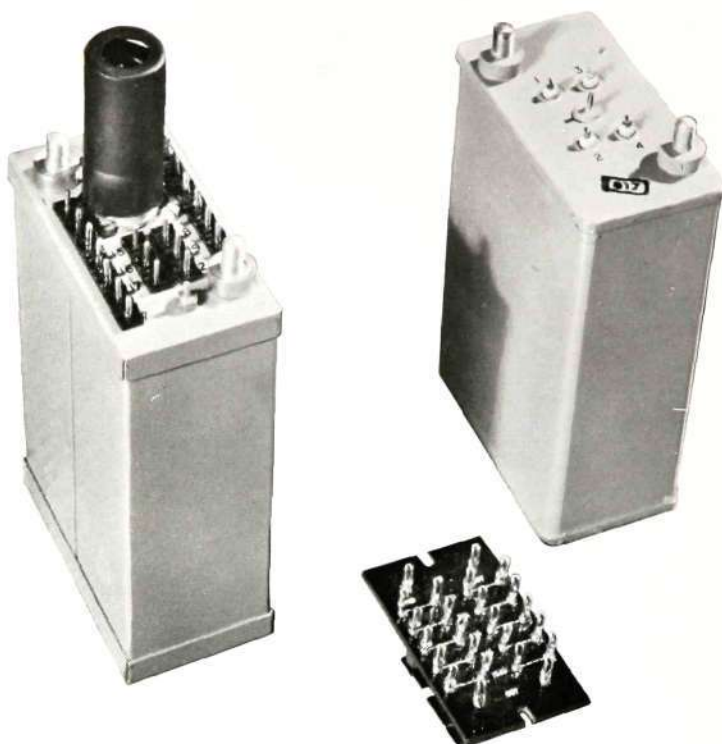


Fig. 14—Typical equipment units. Channel Amplifier (left), Channel Filter (right) and Variable Attenuator (centre)

values, so that any deviation from normal is immediately apparent. For the telegraph panels, a telegraph current test panel is provided on which the supply voltages, anode currents and line currents may be checked in a similar way.

A transmission measuring set suitable for the setting up and maintenance of the system is mounted on the terminal bay. It consists of an oscillator giving an 800 c/s output at 0 dbm and a level measuring set with an operating range of -40 to $+30$ dbm at 300 c/s to 30 kc/s. The level measuring set mounted on the repeater bay is similar but does not include the oscillator.

POWER SUPPLIES

The terminals require a 40 to 60 c/s a.c. supply at either 200 to 250 or 100 to 125 volts. The total power consumption of a complete terminal is 200 watts. The mains supply is converted to 6.3 volts, 14 amps a.c. for valve heaters, 230 volts, 320 milliamps d.c. for anode supplies, 50 volts, 100 milliamps for relays and an 80+80 volts d.c. supply for the telegraph circuits. The 50 volts supply is capable of delivering one ampere to an external load and may be

used in conjunction with a floating battery if desired. The 80+80 volts supply can deliver a maximum of 200 milliamps, which is sufficient to provide send and receive power for all four channels, with a no-load to full-load regulation of 8 volts.

EQUIPMENT DESIGN

The mechanical design of the equipment mainly conforms to the standard adopted by the British Post Office under the designation "51 type". The circuit elements are built up in units, each unit usually being a complete functional component of the system, such as an amplifier, a filter or an attenuator (Fig. 14). Units such as filters, to which access is seldom required, are enclosed in sealed cans filled with dry air. Other units are protected by removable dust-proof covers.

The units are assembled on panel frames in such a way that each panel constitutes a functional section of the equipment. For example, the channel panel, illustrated in Fig. 15, includes all the apparatus for modulating one speech channel into the basic group and for demodulating a sideband in the basic group back to audio frequency in the receive direction. The panel also includes all the signalling apparatus for one channel, excepting the common equipment. The rack on which the panels are mounted consists of a pressed steel frame with built-in earth bars, power distribution, connection strips etc. The connections between the bay cables and the panel cables are

completed by plug-in links. Each panel has a separate front cover, held in place by quick-release studs, and the fronts of the covers are flush with the front of the rack. Labels which identify the test points are attached to the front of the rack adjacent to the panel ends.

LINE TERMINATIONS

When the distance between the open-wire terminal pole and the channelling equipment exceeds about 30 yards, the mis-match between the 600-ohm line and line filter and the 150-ohm connecting cable requires correction to avoid an increase in far-end crosstalk. If the length of cable is less than 120 yards it may be considered as a capacitance, (assuming that carrier quad cable with a capacitance of approximately $0.04 \mu\text{F}$ per mile is used) and the addition of a series coil at each end, as in Fig. 16A, will convert it to a simple low-pass filter section with a nominal impedance of 600 ohms. To cover variations in cable length, at each end of the cable a building-out capacitor must be added to increase the effective capacitance to 3000 pF. If the length of the lead-in cable exceeds 120 yards, it must be treated as a 150-ohm transmission line, and 600 to 150-ohm matching transformers must be used as shown in Fig. 16B. The length of cable between the matching units and the line and the carrier equipment must be kept as short as possible; the maximum permissible length is about 30 yards. For this reason it is usual to

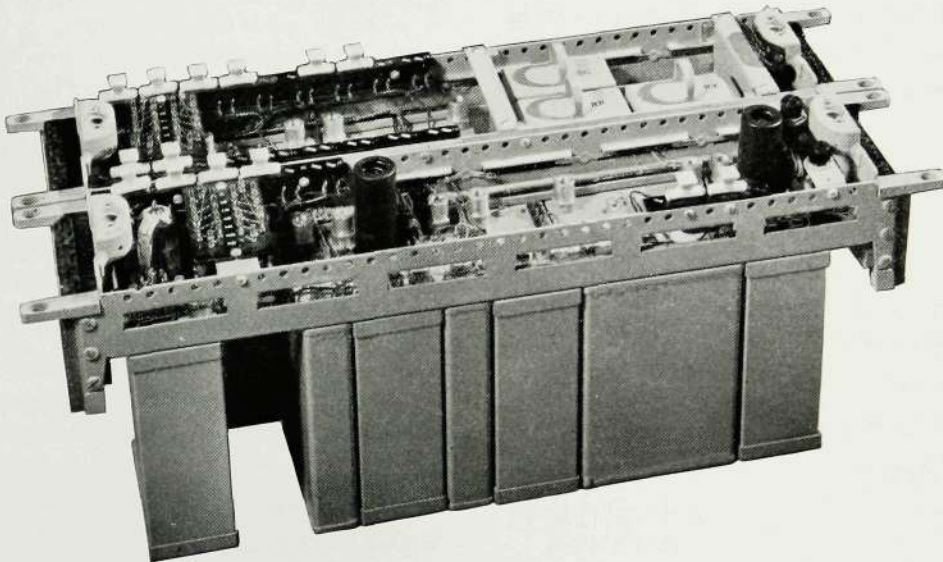
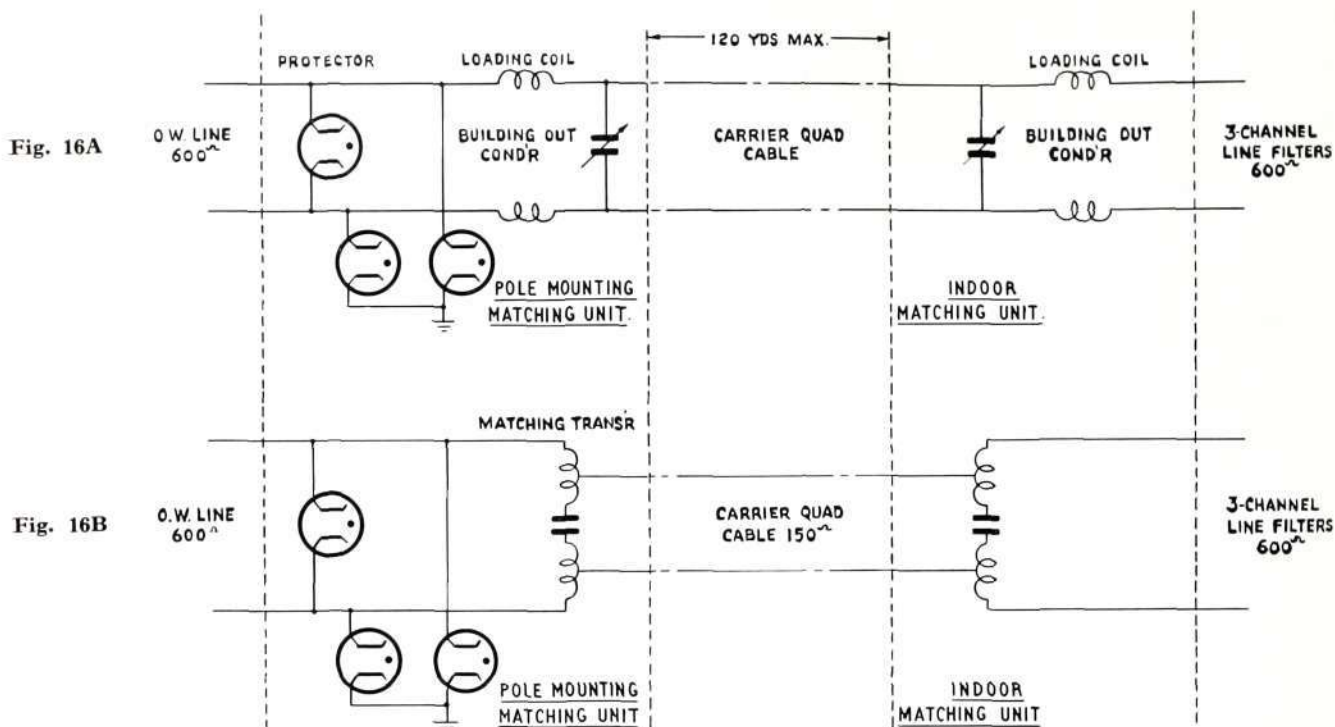


Fig. 15—Channel Panel



Method of matching 600 ohm line and line filter and carrier quad cable :—
 Fig. 16A When channelling equipment is less than 120 yards from the O.W. line.
 Fig. 16B When it is more than 120 yards from the O.W. line.

mount the matching unit at the equipment end in the same room as the equipment, while at the line end the

matching unit is normally mounted either on the terminal pole or in a filter hut nearby.

SUMMARY OF CHARACTERISTICS

Maximum gain of system	43 db	Telegraph level	20 db below nominal test level
Maximum gain of repeater	43 db	Telegraph speed	up to 75 bauds
Maximum output transmitted to line	+17 dbm	Pilot frequency : A to B	16.11 kc/s
V.F. input levels :		B to A	31.11 kc/s
two-wire operation	0 dbm	Pilot level	17 db below nominal test level
four-wire operation	-13 to +17 dbm	Power supply	100-125V or 200-250V, 40-60 c/s
V.F. output levels :		Power consumption of terminal	200 W (Approx)
two-wire operation	up to 0 dbm	Power consumption of repeater	100 W (Approx)
four-wire operation	-20 to +10 dbm	Valve types	CV 138, CV 455, CV 2136 and CV 2225
Bandwidth of carrier circuits	300 to 3,400 c/s	Weight of terminal bay	500 lbs (Approx.)
Bandwidth of line physical circuit	up to 2700 c/s	Weight of repeater bay	350 lbs (Approx.)
Signalling frequency	3825 c/s		
Signalling level	20 db below nominal test level		

SUBSCRIBERS' 50-POINT LINEFINDER SYSTEM

W. H. FOX, A.M.I.E.E., J. L. K. ASHWELL AND A. L. WEAVER*

This article was first published in the Post Office Electrical Engineers' Journal (Vol. 51, Part 2, July 1958) and is reproduced by permission of the Board of Editors of that Journal.

Although linefinders have been used in the past by the Post Office for the connexion of telephone subscribers' lines to 1st selectors, the present standard practice is to provide a subscriber's uniselector for each line. Recent studies of subscribers' calling rates have shown that there is a wide field of application for a simple linefinder scheme for lines that have a low calling rate. This article reviews the circumstances in which linefinders or uniselectors are advantageous, outlines the recent studies of subscribers' calling rates and describes a new linefinder scheme that has been adopted by the Post Office.

INTRODUCTION

IT is the present practice of the British Post Office to provide exchange equipment on the basis of the average busy hour traffic per line, and to equip each subscriber's line with a uniselector, regardless of whether the particular subscriber originates many or few calls. Line finder schemes, which were used earlier, have certain disadvantages, particularly for lines with high calling rates, but for lines with low calling rates they can undoubtedly offer economies. It was therefore decided to re-examine the present basis of design of exchanges to determine whether it would be possible, by using linefinder working for some of the subscribers in an exchange, to reduce the overall equipment costs without adversely affecting the service. A limited statistical study was made of the distribution of calling rates of subscribers in this country, and this indicated that a large proportion of the total subscribers account for a very small proportion of the total traffic, and hence must have very low calling rates. This suggested that substantial economies might be achieved if a new linefinder system were to be developed to cater for low-calling-rate subscribers whilst retaining the present uniselector system for the comparatively small number of heavier users. It was also recognized that added economies would result if such a linefinder system could be designed, at little extra cost, to cater for shared service (with separate metering) by means of a single calling equipment.

* Mr. Fox is an Executive Engineer and Mr. Ashwell an Assistant Engineer in the Telephone Development and Maintenance Branch, E.-in-C's Office. Mr. Weaver is with Ericsson Telephones, Ltd.

This article describes the main features of such a linefinder system, which has been developed jointly by the Post Office and the British telephone manufacturers, and will, in due course, become the standard method of providing service for both exclusive-service and shared-service subscribers with low calling rates at all standard automatic exchanges equipped with 2000-type uniselector line circuits. The system may also be used at most exchanges equipped with pre-2000-type uniselector line circuits.

HISTORY OF THE USE OF LINEFINDERS AND UNISELECTORS

Before describing the new system it is desirable to refer briefly to the considerations which have, hitherto, influenced the use of linefinder and uniselector systems in this country. It has long been recognized that the comparative economics of uniselector and

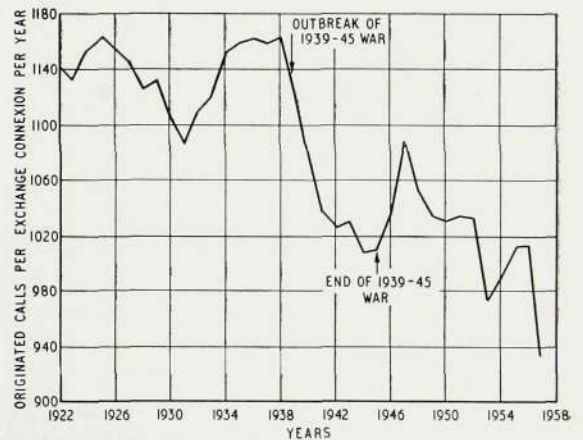


Fig. 1—National Calling Rate characteristics

linefinder systems are directly related to the average calling rates of the lines to be served, the advantage resting with linefinder systems where the average calling rate is low. From Fig. 1 it will be seen that between the years 1925 and 1931 there was a gradual fall in the average calling rate for the country as a whole, and it is not, therefore, surprising that in 1931, following an economic study, a 200-point linefinder system, with partial secondary working, was developed, and subsequently adopted as standard for all new exchanges. Experience showed, however, that at exchanges with high average calling rates, involving extensive use of secondary finders, congestion frequently occurred. Although this condition was to some extent attributable to weaknesses in the initial circuit design, investigation showed that the linefinders were less efficient than uniselectors in catering for unexpected increases in calling rate.¹ In September, 1938, following a comprehensive cost study, a decision was taken to restrict the use of the line finder system to exchanges where the average busy hour calling rate was below 0.6 calls per line.

It will be seen from Fig. 1 that a gradual rise in the calling rate occurred between 1931 and 1938, and this undoubtedly contributed to linefinder congestion which, in turn, gave rise to this change in policy.

As might be expected, the average calling rate fell sharply during the 1939-45 war, but towards the end of the war, when the question of post-war exchange design was being considered, there were signs of an increase in the average calling rate which it was expected would continue in the immediate post-war period. This influenced a decision to employ the unselector system as the future standard for all new exchanges and extensions to existing exchanges. A revised cost comparison made at that time indicated that uniselectors were more economical than linefinders for calling rates of 0.4 and over, and, as some 96 per cent of the exchanges were shown to have average calling rates in excess of this figure, it was not considered worth while to produce and maintain a second standard type of equipment for the remaining 4 per cent.¹ The decision to adopt uniselectors as the standard system did not preclude the possibility of the future development of a simpler and cheaper linefinder system when a measure of stability had been reached in post-war conditions and it was possible to estimate with some reliability the rate of growth and distribution of telephone traffic. The gradual fall in average calling rates which has occurred since 1947 provided further justification for the re-

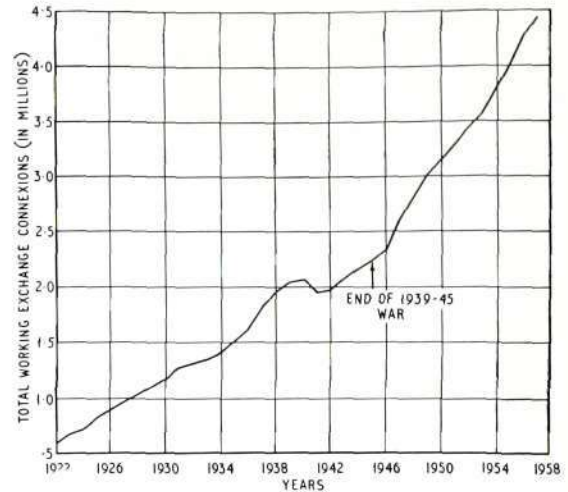


Fig. 2—Growth of Exchange connexions

examination of the merits of linefinder and unselector systems, and has, in turn, led to the development of the system described in this article.

PRESENT DISTRIBUTION OF SUBSCRIBERS' CALLING RATES

The large expansion of the telephone service since the 1939-45 war (Fig. 2) has taken place primarily in residential areas, and the resultant increase in the proportion of residential to business subscribers—except in the purely city business exchanges—doubtless accounts to a very large extent for the marked fall in the average calling rate that has occurred since 1947.

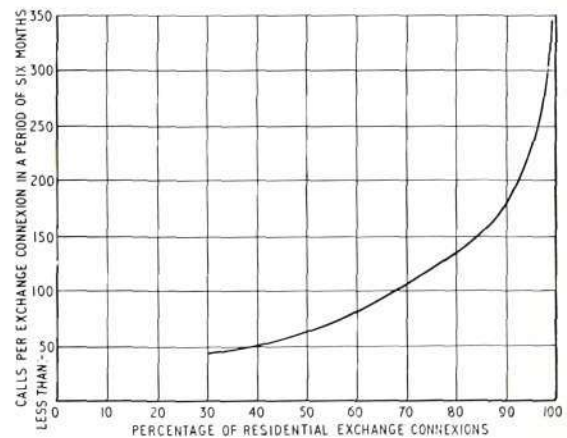


Fig. 3—Distribution of calling rates of residential connexions based on three provincial non-director Exchanges and one London director Exchange

¹ FRANCIS, H. E. Post-War Exchange Design. *I.P.O.E.E. Printed Paper No. 181*, 1943.

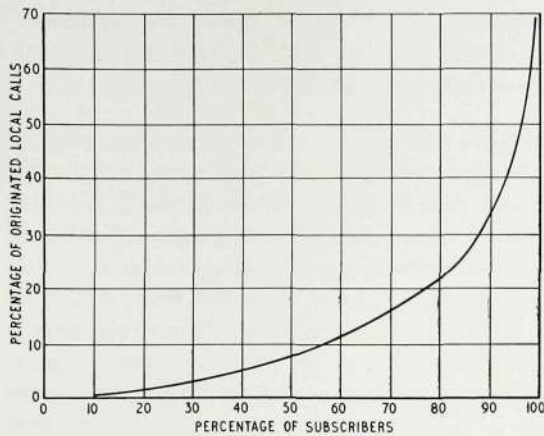


Fig. 4—Local call distribution at Chelmsford Exchange (4,500 Exchange connexions of which 38 per cent are business connexions)

Recent records of the numbers of calls originated by a random sample of residential subscribers at four selected exchanges, Bedford, Colchester, Torquay and Wimbledon, have confirmed that the proportion of the total lines with low calling rates is very high. The distribution of calling rates at each of these exchanges followed a remarkably similar pattern, and the curve shown in Fig. 3 represents the average for the four exchanges. It will be seen that as many as 90 per cent of the subscribers originated less than 175 calls per half year, or less than one call per day. Although these figures relate to residential subscribers, a record taken of all metered calls at Chelmsford exchange over a 6-month period (Fig. 4) showed that 99 per cent of the subscribers originated 70 per cent of the total local calls, i.e. about 30 per cent of the total traffic was originated by only 1 per cent of the subscribers. As 38 per cent of the subscribers at Chelmsford are in the business category, this suggests that, in addition to the residential subscribers, many of the business subscribers must have low calling rates. Such conditions are thought to be typical of many exchanges in this country.

Consideration of these data suggested that substantial savings would be achieved if a simple linefinder system were to be developed to cater for both

exclusive-service and shared-service subscribers with low calling rates—principally residential subscribers—whilst continuing to employ individual uniselectors for the heavier users.

THE NEW LINEFINDER SYSTEM

Outline of the System

The new linefinder system is based on the use of 50-point, non-homing, rotary-type linefinders (standard Post Office Type 2 uniselectors) arranged in groups of five, on the banks of which are multiplied 49 subscribers' line circuits. The 50th outlet is used for testing purposes only. Each linefinder is trunked to a regular subscriber's uniselector, which functions as a selector hunter. The trunking arrangements are shown in Fig. 5.

The group of 49 line circuits is divided into five sub-groups, each with a different linefinder as first choice. This arrangement enables calls originated simultaneously in each of the sub-groups to be set up simultaneously. Calls originated simultaneously within any one sub-group are set up sequentially but without appreciable delay.

The system incorporates facilities for shared service by means of a single line circuit—comprising two Post Office 600-type relays—per pair of sharing subscribers. Hence, each group of linefinders can accommodate either 49 exclusive-service subscribers or up to 98 shared-service subscribers, dependent on the average calling rates of the subscribers within the group.

The avoidance of both secondary working and common control equipment has contributed to a

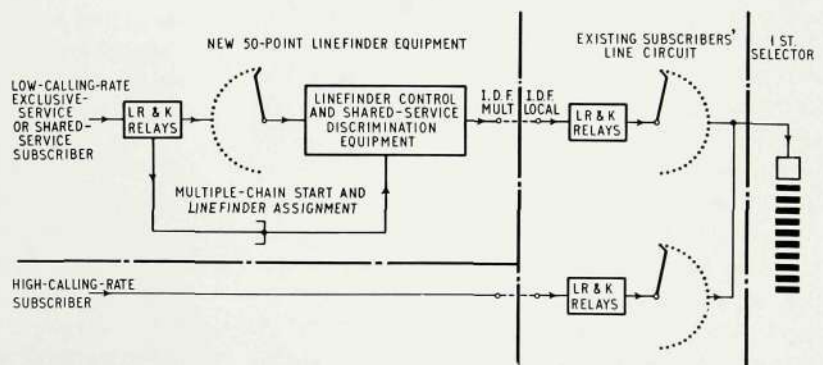


Fig. 5—Block schematic diagram showing trunking arrangements for high- and low-calling rate subscribers

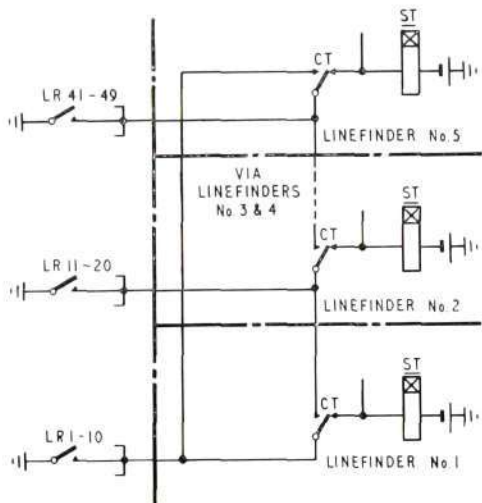


Fig. 6—Linefinder start arrangement

simplification of the general circuit arrangements as compared with earlier linefinder systems.

Shared-service working is free from the principal disabilities of the present system. The use of a single line circuit per pair of sharing subscribers, however, necessitates a minor change in operating procedure. The Y subscriber can call only by depressing the "Call Exchange" button on the telephone *after* removing the receiver. Depression of the button by the X subscriber may take place either before or after removal of the receiver, but in the interests of uniformity it has been decided to instruct all shared-service subscribers to remove the receiver before depressing the button.

Circuit Operation

Linefinder Start. A simple linefinder start arrangement, as shown in Fig. 6, is provided by commoning together the "start" contacts of the line relays (LR) in groups of ten, and associating each group directly with one linefinder circuit; thus, line circuits within the same 10-line group are usually seized by that linefinder. Exceptions to this are:—

(a) When the linefinder is already engaged, relay CT is operated, and the start signal is then passed to the next free linefinder.

(b) When simultaneous calls are originated in different 10-line groups, several linefinders search, and the first linefinder to arrive on the outlet of a calling line will seize it, irrespective of the 10-line group in which it is situated.

Outgoing Calls. Fig. 7 shows the subscriber's line circuit, together with the elements concerned with switching a linefinder to a calling line.

When a subscriber removes the receiver, relay LR in the line circuit operates to the loop and in turn operates relay ST in a linefinder circuit, as described above. Unless the linefinder is already resting on the outlet corresponding to the calling line it self-drives to find the outlet marked by battery via relay K in the line circuit of the calling line. When this outlet is reached, relay KA in the linefinder operates to cut the drive circuit of the linefinder. Relay KA operates relay K in the line circuit and relay KB in the linefinder. The operation of relay K switches the subscriber's line through to the linefinder and the restoration to normal of relay LR disconnects the start condition. The operation of relay KB provides a holding circuit for relay K and releases relay KA.

It will be seen from Fig. 7 that the final selector multiple of a calling line is unguarded until a linefinder finds the marked outlet. To guard the multiple immediately relay LR operates would require an additional contact on that relay, the provision of which would reduce the line loop resistance limit below the requirement of 1,000 ohms. Apart from this, however, it is considered an advantage that an incoming call should be permitted to switch to a line on which a call is being originated, provided that the originating call has not reached the stage of receipt of dial tone. It is possible that, if the incoming call is to a shared line, the call may be connected to the wrong party, but the chance of this occurring has been calculated as less than two in a million.

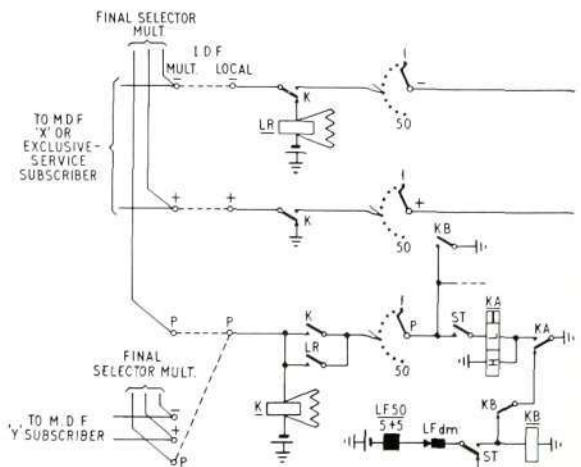


Fig. 7—Subscriber's line circuit and linefinder switching circuit

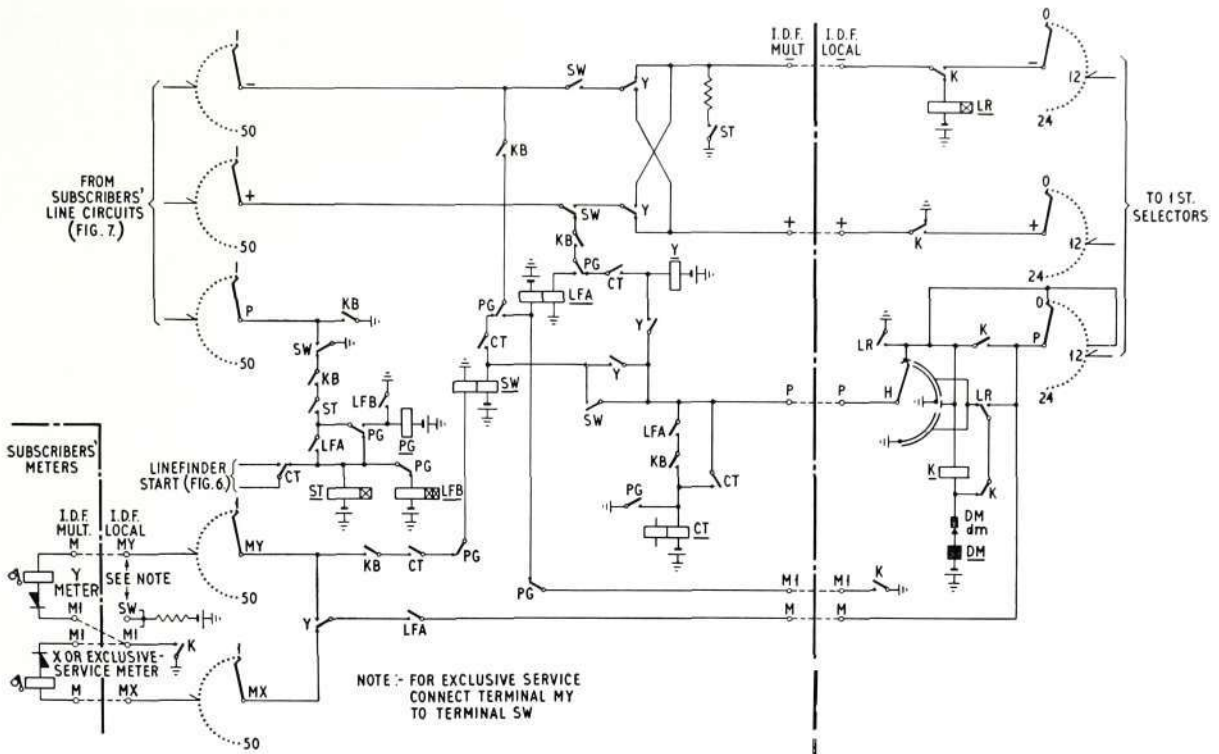


Fig. 8(a)—Linefinder circuit, showing method of discriminating between calls from shared-service and exclusive-service subscribers

Fig. 8(b)—Subscriber's 2000-type unselector circuit used as selector hunter

Simultaneously with the linefinder searching, the unselector (selector hunter) associated with the linefinder taken into use searches for a free 1st selector (Fig. 8(b)). When a selector and the calling line have both been found, relay SW in the linefinder circuit is offered via arc MY to terminal MY (Fig. 8(a)). If the call is from an exclusive line, relay SW operates to battery connected to terminal MY, and the call is switched through to the 1st selector. Should the call be from a shared line, relay SW will not operate at this stage as terminal MY of a shared line is not connected to battery, but relay SW will operate when the caller presses the Call Exchange button on the telephone.

When an X subscriber presses the Call Exchange button, earth is connected to the B wire of the line (Fig. 9) to operate relay SW (Fig. 8(a)), whereas for a Y subscriber, earth is connected to the A wire to operate relay Y in the linefinder, which, in turn, operates relay SW. The operation of relay SW switches the call through to the 1st selector, while the operation of relay Y disconnects the meter circuit of the X subscriber, and prepares for the operation of the Y subscriber's meter.

Each linefinder has a thermal device, relay LFB (Fig. 8(a)), which is operated within 20-30 seconds of a start condition being applied if either,

- (a) the linefinder fails to find the calling line, or
- (b) a shared-service subscriber, whose line has been found, fails to press the Call Exchange button.

Linefinder Fails to Find. The start condition that operates relay ST, via a contact of relay CT, also energizes relay LFB. Consequently, if relay CT does not operate within the operate lag of relay LFB (20-30 seconds) then relay LFB will itself operate. The contact of relay LFB operates relay PG, which in turn operates relay CT, thus transferring the start condition to the next free linefinder (Fig. 6).

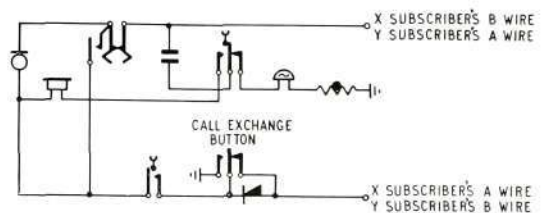


Fig. 9—Shared-service Telephone circuit

Shared-Service Subscriber Fails to Press "Call Exchange" Button. The application of a loop to a shared-service line will cause a linefinder to find the line concerned, but relay SW will not operate unless the Call Exchange button is pressed. Hence, relay LFB remains energized, and on operation completes the circuit for the operation of relay PG, which, in turn, connects relay LFA to the positive and negative wires. If the loop condition is still present, relay LFA operates and holds relay ST. The P.G. condition at the 1st selector is maintained by earth connected to the negative wire by a contact of relay ST as long as the loop condition persists.

Should the caller now press the Call Exchange button (i.e. after operation of relay LFB) it will be ineffective, and in order to make a call it will be necessary for the caller to clear and call again.

Metering. The four basic types of metering, i.e. positive battery, 4-wire earth, 4-wire battery, and booster battery metering, are catered for by alternative connexions on U points and adjacent connexion strip terminals. This is a particularly useful feature as it allows equipment that may be installed in an

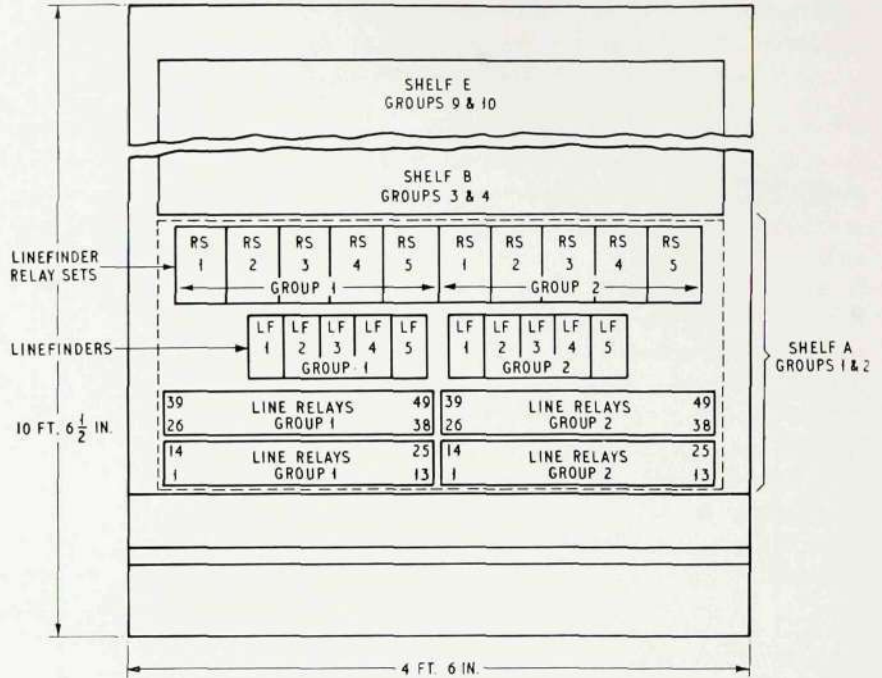


Fig. 11—Layout of Linefinder rack

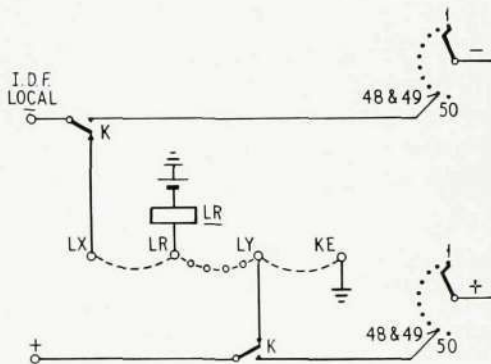
exchange nearing the end of its life to be subsequently recovered and re-used in another exchange having a different type of metering. The various alternative connexions for the different types of metering are not, however, shown in Fig. 8.

Incoming Calls. Incoming calls are dealt with in the usual way, the final selector taken into use testing into relay K of the appropriate line circuit.

Temporarily Out-of-Service (T.O.S.) Facilities. T.O.S. facilities are given on exclusive lines in the usual way, but, due to the use of a single calling equipment per pair of sharing subscribers, special arrangements are necessary for giving these facilities to individual subscribers on a shared line.

A Y subscriber is made T.O.S. by insulating the K relay contact that normally connects earth to line. This prevents the Y subscriber operating relay LR, and makes the operation of relay LR by the X subscriber dependent on earth from the Call Exchange button.

An X subscriber is made T.O.S. by disconnecting the straps between terminals LY and KE and between terminals LR and LX in Fig. 10, and providing a strap between terminals LR and LY. This prevents the X subscriber operating relay LR, and



For normal service use connexions ————
 To make X subscriber T.O.S. omit connexions - - - - - and use
 connexions - - - - -
 To make Y subscriber T.O.S. insulate contact of relay K which normally
 connects earth to line

Fig. 10—T.O.S. arrangements for shared-service lines

makes the operation of relay LR by the Y subscriber dependent upon the Call Exchange button.

Number Unobtainable (N.U.) tone is given in the normal manner on incoming calls to X and Y subscribers' lines to which T.O.S. conditions have been applied.

If either subscriber on a shared line is made T.O.S., a P.G. condition is not given should the line be looped. This is not considered to be a serious shortcoming as T.O.S. conditions are not normally applied for long periods.

The special T.O.S. facilities referred to above are provided only on outlets 48 and 49 of the linefinder, it being considered uneconomic to provide four additional tags per calling equipment merely to provide T.O.S. facilities for X subscribers' lines. When it is necessary to make an X subscriber T.O.S. the line concerned must be connected to line circuit 48 or 49 in a linefinder group in order that use can be made of the special tags provided. Re-jumpering of lines for this purpose should be infrequent as statistics show that the incidence of T.O.S. is low, and it is often the same subscribers that are concerned in each half year.

Rack Design. In order to conform with standard exchange layouts it has been decided to use a standard 4 ft. 6 in. wide rack for mounting the equipment. As a rack 10 ft. 6 in. high will accommodate ten linefinder groups—thus providing calling equipment for 490 exclusive lines, or up to 980 shared-service lines—an appreciable saving in space is achieved compared with the standard uniselector rack.

Details of the rack layout are shown in Fig. 11. The rack is arranged to accommodate five shelf units, each comprising two linefinder groups. A front view of a shelf unit is shown in Fig. 12. A rack may be installed initially either fully or partially equipped, but, due to the arrangement of pairs of linefinder groups in a shelf unit, a partially equipped rack will always have an even number of groups. Conse-

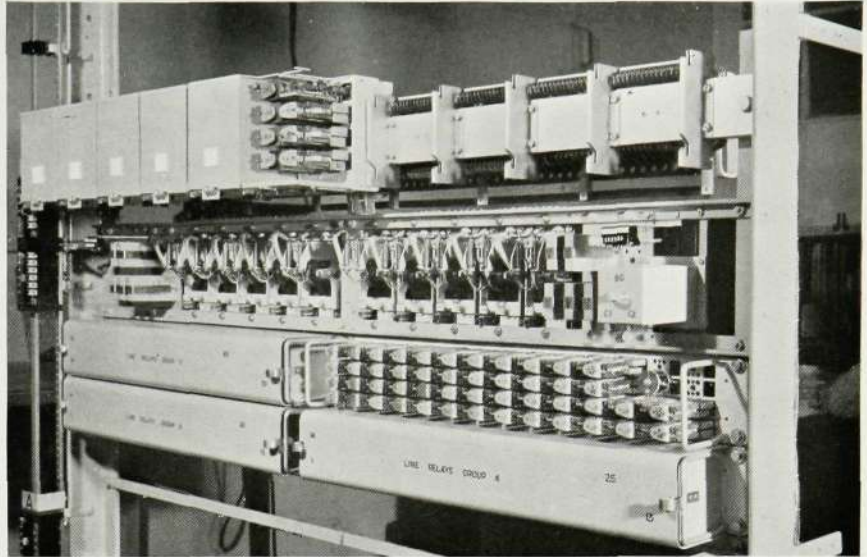


Fig. 12—Front view of shelf unit

quently, extensions will need to be planned on the basis of shelf units, i.e. extensions of 98 lines or multiples thereof.

Cabling Arrangements. Fig. 13 shows the rear view of a shelf unit. The incoming cables from the I.D.F. are terminated on five 7 x 20 connexion strips, a sixth connexion strip being provided for miscellaneous purposes, e.g. T.O.S. connexions. Outgoing cables from the linefinder circuits to the I.D.F. are directly connected to the relay-set shelf jacks.

TRAFFIC ASPECTS

The total traffic carrying capacity of the present standard uniselector rack with grading facilities, which accommodates a maximum of 300 calling equipments, is governed by physical considerations which limit to 80 the number of tie circuits that can be provided to 1st selectors. Reference to standard traffic tables shows that the total traffic capacity of such a rack, at a grade of service of 1 in 500, is approximately 50 erlangs, or an average of 0.166 erlang per subscriber, but as this is in excess of the highest average calling rate experienced in any exchange in this country, which is 0.12 erlang, the limitation of the number of tie circuits to 80 is, at least under present conditions, of no consequence. It follows, however, that there is scope for improving the overall efficiency of uniselectors, and thus effecting economy, if a simple means can be found for concentrating the small amounts of traffic originated by low-calling-rate

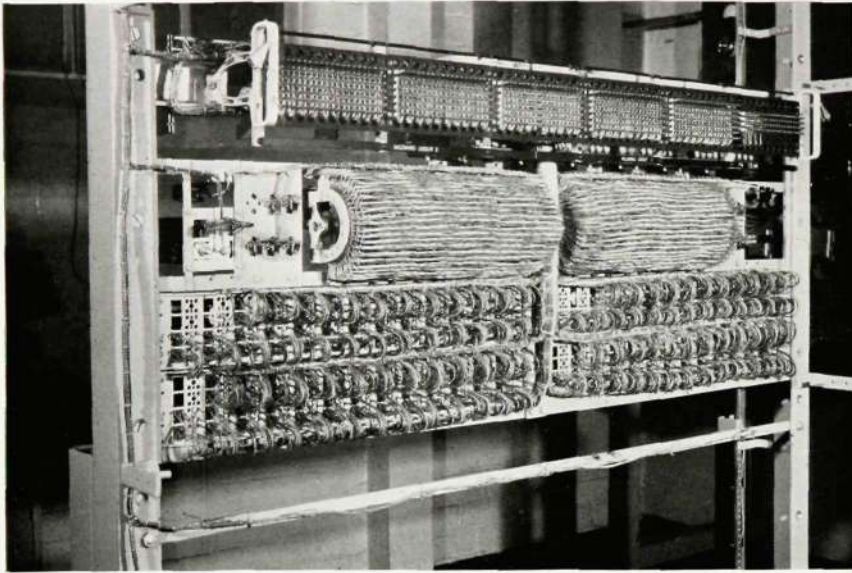


Fig. 13—Rear view of shelf unit

subscribers and feeding the aggregated traffic to a lesser number of uniselectors, thus increasing the amount of traffic carried per uniselector. The system described in this article is based on the application of this principle.

The total traffic carrying capacity of five linefinders at a grade of service of 1 in 500 is approximately 0.9 erlang, and therefore the average traffic which might be passed to each of the five uniselectors (selector hunters) is 0.18 erlang, which compares reasonably with the average of 0.166 erlang per subscriber that can be carried by the standard uniselector rack.

Traffic tables show that the use of six linefinders—assuming the connexion of low-calling-rate subscribers—would result in inadequate loading of the uniselectors (selector hunters), and that the use of four linefinders would be likely to degrade the service unduly, particularly if a fault condition resulted in one of the linefinders being out of service.

Traffic measurements by means of pen recorders have recently been made on a number of lines selected at random but known to have low calling rates, and these have shown that over long periods less than a quarter of the lines originate calls in the busy hour ; many originate less than one call per day, and some less than one call in three days. More detailed examination showed that among the busier lines in any randomly selected 50-line group, two or three lines often account for the bulk of the traffic originated

by the group. This has the effect of smoothing the traffic flow as each of these busier subscribers can only make one call at a time, and so offer their traffic sequentially throughout the busy hour. The overall effect is that a given number of linefinders can carry more traffic than that predicted by traffic tables based on Erlang's formulae for a specified grade of service. Insufficient data has yet been collected to assess the effect in precise terms of traffic capacity, but it has been satisfactorily established that residential lines as a class may

be connected to the new linefinder equipment without regard to their individual traffic characteristics, and without fear of congestion occurring. It also seems probable that a substantial proportion of business lines—other than P.B.X. lines—may be served similarly, but this awaits the outcome of further investigations to determine a suitable method of selecting these lines.

The fact that the new system caters for shared service by means of one line termination per pair of sharing subscribers might, on first consideration, lead to the conclusion that the inclusion of shared-service lines in any group of 49 lines would so increase the traffic offered that the grade of service within the group would be lowered. The grade of service, however, relates to the busy hour traffic for the group of lines concerned, and a preliminary study of the characteristics of shared-service lines indicates that the chance of two sharing subscribers originating calls in the same busy hour is small. It appears, therefore, that the inclusion of shared-service lines is unlikely to result in congestion until the proportion of such lines becomes large. Study of the traffic characteristics of shared-service lines is continuing in order to obtain reliable data on which to base conclusions as to the proportion of such lines which might be connected to the system.

CONCLUSIONS

It has been satisfactorily established that as the telephone service of this country has expanded, so the

proportion of subscribers with low calling rates has increased to a point where the provision of individual uniselectors for such subscribers' lines can no longer be justified. The simple linefinder system described in this article is designed to handle traffic from low-calling-rate subscribers. As an adjunct to the present unselector system it enables existing uniselectors to be used more efficiently, and confers the following overall advantages :-

(a) The capital cost and annual charges per line are reduced as compared with the present unselector system, particularly in respect of shared-service lines.

(b) Less accommodation is required.

(c) Maintenance is easier than it was with earlier linefinder systems, due to the absence of secondary working and common control equipment and to the use of standard unselector mechanisms of proved reliability.

(d) Shared service is provided by means of a single calling equipment per pair of sharing subscribers.

(e) Shared service is free from the principal disabilities of the present system, e.g. with the new system :-

(i) A shared-service line is guarded against connexion of incoming calls should the receiver be left off the cradle, thus avoiding false metering against the caller.

(ii) The need to modify calling equipments to provide shared service is avoided.

(iii) External identification of positive and negative wires is made possible.

(f) The use of standard racks, together with means of catering for all types of metering, enables equipment to be employed for extension of existing exchanges, and subsequently re-employed at another exchange with a different type of metering.

(g) The equipment is suitable for integration with exchange layouts based on a unit-construction principle.





Fig. 1—A Scimitar launched from Ark Royal port steam catapult while another is being prepared for launching from the starboard catapult. (Official Admiralty photograph).

A CATAPULT END-SPEED RECORDER

J. R. POLLARD, M.A., M.I.R.E., A.M.I.E.E. — Assistant Controller of Research

Reprinted from "British Communications and Electronics" (September 1958) to whom acknowledgments are due for permission to reprint and for the loan of blocks for certain illustrations.

The introduction of turbojet carrier-borne aircraft has demanded a greatly increased performance from the launching catapult. In the system described, this has been assisted by an elaborate electronic system of instrumentation which gives an indication and record of the launch speed reached at the end of the catapult travel.

IN spite of the ever-increasing performance of carrier-borne aircraft, catapults of one kind or other still play a very important part in aircraft operations in the Royal Navy. Recent developments in aircraft performance, and in particular the introduction of larger turbojet types, have made it clear that a corresponding improvement would be required in catapult performance both in respect of the weight

to be launched and the launching speed to be attained.

Until recently, all catapults in use in H.M. carriers were operated by an arrangement in which the acceleration force was produced by applying compressed air to one side of a piston; the piston was coupled to the launching shuttle by wire ropes, and

further ropes were used to retard the shuttle and to return it to the launching position. In this arrangement, the entire system of ropes, pulleys and other moving parts has to be accelerated during the launch and rapidly decelerated at the end. As the size and performance requirements of the pneumatic catapult are increased, however, a condition is soon reached where all the additional force developed is used in accelerating the larger mass of rope involved, with the result that no further increase in performance is possible.

STEAM AS PROPULSIVE FORCE

For this reason it was decided that development should proceed on a new type of catapult which does not require such a complex and heavy arrangement of ropes, and a type was evolved which has many advantages over previous types. In this version, steam is used as the propulsive force, and the system makes use of a pair of cylinders running the full length of the catapult. The cylinders are slotted along their length, and pistons moving in them are coupled directly to the launching shuttle on the deck above. To avoid loss of steam through the slots, an arrangement is adopted whereby the slot is sealed by a flexible steel tape which is displaced in a wave motion as the piston moves along. The piston is extended sufficiently behind the coupling rod to make a good seal with the cylinder and tape, so as to avoid loss of steam. In this way it becomes possible to extend the catapult performance to produce a considerable increase in launching force, length of travel, and acceleration.

INDICATING AND RECORDING LAUNCH SPEED

In common with any development, this increase in catapult performance inevitably means that more extensive instrumentation is required to give adequate control. One instrument considered to be necessary on the steam catapult was a device giving an indication and record of the launch speed reached at the

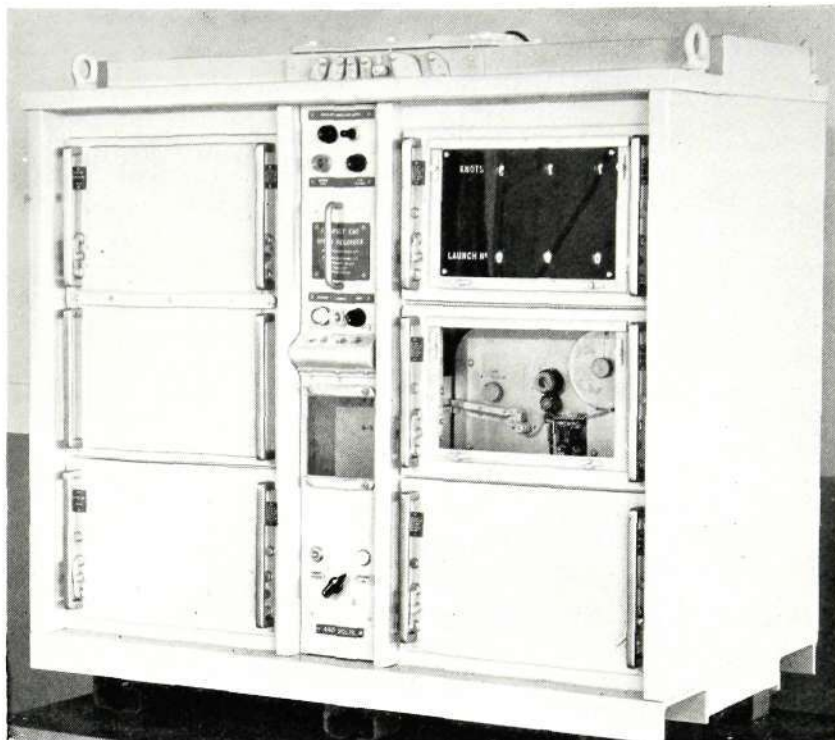


Fig. 2—Complete End-speed Recorder Equipment

end of the catapult travel. Consideration of the timing problems involved suggested an electronic solution and the technique finally adopted is shown in Fig. 3. A small magnet *M* is attached to the shuttle in such a position that it passes close to a pair of detector heads *D1* and *D2* which are mounted near the end of the shuttle track below the flight deck. A signal is induced in the heads as the magnet moves past each in turn; the time interval between these transits is measured using a gate circuit to allow pulses from a crystal-controlled pulse generator to pass into a counter. The count indicated, which is a measure of

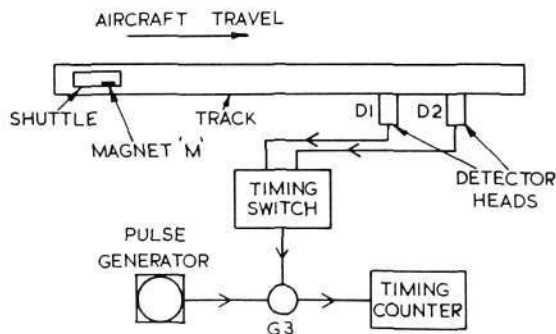


Fig. 3—Block schematic of the timing system

the time interval, is divided into a constant proportional to the distance between the heads, and the quotient represents the mean velocity, achieved by the catapult, between the heads. By a suitable choice of oscillator frequency, and distance between the detector heads, and assigning an appropriate value to the constant used in the divider circuit, the quotient produced gives the launch speed directly in knots.

As soon as the division process is complete, the quotient is transferred to a set of three rotary switches, so that their setting corresponds to the hundreds, tens and units of knots of the launch speed ; contacts on these switches are used to extend suitable control signals to a remote indicator in the launch control position, and other contacts are used to select the numbers to be printed on the paper tape record which is produced after each launch.

In addition to the display and printing operation which is initiated automatically on every launch, it is possible to check the operation of the equipment by throwing a test key. This sets up a check counter to one of three values. The equipment then goes through a normal division process and displays and prints a figure which should agree with the test figure selected. This operation tests the whole of the timing, control and dividing circuits and provides a quick check on the reliability of the equipment.

TIMING AND DIVISION PROCESS

The operations involved in the timing and division process are as follows : If t is the time taken for the shuttle to move the distance s between the heads— s is made short enough for the speed to be assumed constant—the launch speed, $v = s \div t$. The measurement is made by allowing pulses from a crystal oscillator to pass into the timing counter during the interval t . At the end of this period, the counter indicates that n pulses have been recorded. If f is the frequency of the pulse generator,

$$n = ft$$

from which the shuttle speed is given by

$$v = \frac{s}{t} = \frac{fs}{ft} = \frac{fs}{n}$$

For v to be given in knots, s must be expressed in nautical miles and f in impulses per hour. The values of f and s used are 5 kc/s and 51.375 in. respectively, giving in the appropriate units, $fs = 12675$.

The division process would normally be carried out by writing fs (12675) into a dividend store and subtracting the count n repeatedly from it until the remainder in the dividend store reaches zero. The number of times this process is performed—i.e. the quotient—is the required velocity. For circuit convenience, however, the arrangement shown in Fig. 4 is used. In this, the division process is carried out by repeatedly adding n to the dividend store until its contents have been increased by 12675. This operation is further simplified by using a 14-stage binary counter for the dividend counter ; this has a total capacity of 16384.

Before the division process starts, the dividend counter is reset to the binary equivalent of 3709 ; the required increase of 12675 is then indicated by the whole counter changing from a pattern of all stages in the '1' state to all stages in the '0' state. When this change takes place, the last stage produces an output pulse which stops the division process. If the dividend counter were not used in this manner, it would be necessary to employ a 14-input coincidence circuit to detect when a count of 12675 in binary notation had been reached.

Referring to Fig. 4, the distributor supplies a sequence of pulses over the group of leads u which pass to the dividend counter via division gates controlled by the timing counter over a corresponding group of leads. The circuit is so arranged that each time the distributor goes through one complete cycle the number n in the timing counter is added to the dividend counter. Thus after the first distributor cycle the dividend counter registers $3709 + n$, after the second cycle, it registers $3709 + 2n$, and so on. Eventually it reaches $3709 + 12675$, i.e. 16384, and its output stage sends a pulse over lead s to the division switch causing it to close $G4$ and stop the division process.

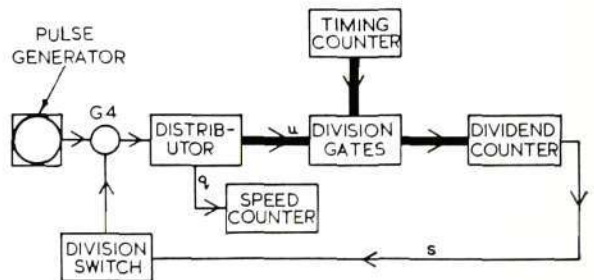


Fig. 4—Block schematic of the division process

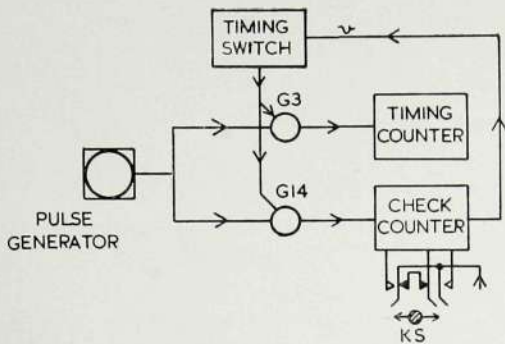


Fig. 5—Block schematic of the test operation

Once during each distributor cycle a pulse is sent over lead q to the speed counter; thus when $G4$ closes, the speed counter registers the required speed v .

THE TEST OPERATION

The test operation is shown diagrammatically in Fig. 5. An additional eight-stage binary counter is provided, with a key KS which allows the counter to be set to one of three initial values according to the position of KS . In addition, there is a 'test' key which, when operated, sets the timing and speed counters to zero, the dividend counter to 3709 and the check counter to the selected value.

The timing switch circuit is then operated over lead v in a manner similar to its normal operation by the first detector head; it opens gates $G3$ and $G14$ and allows pulses to pass both to the timing counter and to the check counter. The initial values which can be set into the check counter are the binary equivalents of 1, 128 or 192, and so 255, 128 or 64 pulses will be needed to fill the check counter to its capacity of 256 pulses. On receipt of the last pulse, a reset signal is applied to the timing circuit—as if a signal had been received from the second detector head—and the timing circuit closes $G3$ and $G14$. At this stage in the operation, the timing counter should register 255, 128 or 64, and division takes place as

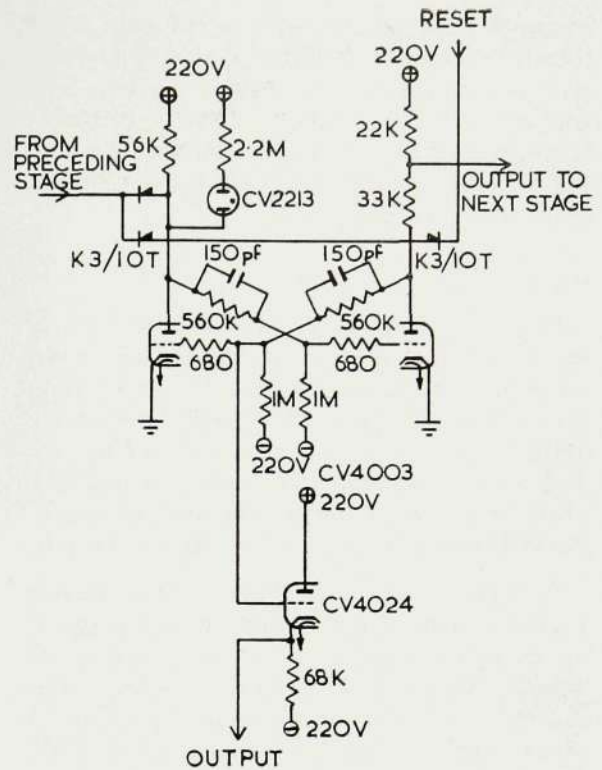
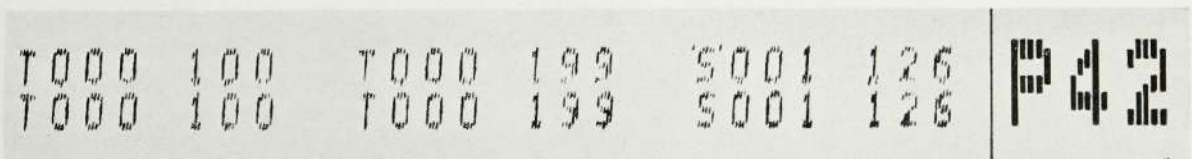


Fig. 6—The standard Eccles-Jordan circuit

previously described. If the circuits are operating correctly the speed counter will read 50, 100 or 199 according to the initial setting of the check counter, which was controlled by the position of KS .

To simplify logical and circuit design, the timing, check and dividend counters operate in the binary mode and use the standard Eccles-Jordan circuit shown in Fig. 6. The values used in the circuit allow it to function satisfactorily with all components including the valve being simultaneously at the most adverse combination of 'end-of-life' performances and in addition any or all of the supply voltages also being in error by ± 5 per cent. As it is extremely improbable that the most adverse combination of drift of component characteristics will ever be found



(a)

Fig. 7—(a) A typical printed record. (b) Build-up of printed character.

(b)

in practice, this means that a typical stage is extremely tolerant of wide variations of valve performance and will give very reliable service. This approach to design¹ produces extremely satisfactory binary counters and two-state devices and is the main reason for the extensive use made of binary arithmetic in the end-speed recorder.

DEKATRON SPEED COUNTER

The output is, however, required to be displayed and printed in standard decimal notation and for this reason the speed counter works in the decimal mode. In view of the modest counting speed required, it is convenient to use a Dekatron counter and to cover the required speed range, three stages are employed. These operate in an entirely conventional manner² and so detailed description will not be included here.

The Dekatron cathodes are brought out individually so that a separate lead is available for each integer to be displayed. During the division cycles, the Dekatron counter forming the speed counter operates once for each complete distributor cycle, with a normal carry from the 'units' stage to the 'tens' stage, and from the 'tens' stage to the 'hundreds' stage. At the end of the division process, a signal is sent to a follow-up circuit controlling three wafer-switches driven by Ledex solenoids. The 'units' switch then self-drives until its wiper coincides with the contact marked by the lead which is connected to the 'units' Dekatron cathode on which the discharge stands. The self-driving operation is then stopped, leaving the 'units' switch in the position corresponding to the 'units' Dekatron indication. The 'tens' and 'hundreds' switches are positioned similarly to correspond with the indications of the 'tens' and 'hundreds' Dekatrons. Illuminated stencil discs mounted on the switch spindles give a local indication of speed on the speed recorder display panel; other wafers mounted on the switches are used to control the printer mechanism and to provide operating potentials to the remote indicator unit mounted in the flight-deck control room.

Three more wafer switches driven by Ledex solenoids are used to form a three-stage counter having a maximum capacity of 999. The control circuit of the 'units' switch is arranged so that it is stepped one position each time a launch operation takes place. Stencil discs on these switch spindles display the launch

serial number, and an additional wafer on each switch is associated with the printer circuits. A further solenoid-driven switch is used to control the sequence of display and printing operations.

THE PRINTING PROCEDURE

The printer produces records on paper tape of the form P 049 153. The first letter will be P, S or T indicating port or starboard catapult or 'test'. The first group of three figures is the serial number of the launch, and the remaining group is the end-speed of the launch or the result of the test. A typical printing is shown in Fig. 7(a). The printed characters are built up from a series of near-vertical lines as shown in Fig. 7(b). These lines are produced on the moving tape by a metal straight-edge pressing the paper tape for varying time intervals against an inked rotating helix as shown in Fig. 8(a). The straight-edge is actuated by a low-inertia relay system which receives its signals from cam-operated spring sets. Each cam provides the signals for one complete printed character. The paper tape feed, printing helix and cam assembly are operated by a grease-packed gear box driven by a small electric motor. Fig. 8(b) shows a general view of the printer unit, and Fig. 8(c) shows details of the scanning helix, printer head relay and tape feed.

After the division and switch follow-up sequence, the printing sequence switch operates one step at a time. The first step starts the printer motor, and thereafter a cam-operated contact steps the sequence switch once for each cam shaft revolution. At the end of the first revolution, the switch steps but no further circuit change takes place. One revolution later the switch steps again; during these two revolutions approximately one half-inch of blank tape is fed out of the printer to leave a space between successive records. During the third revolution, the sequence switch, in conjunction with relay contacts, connects the printer head relay to the cam-operated spring set

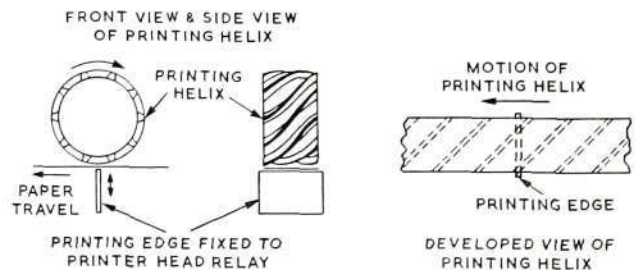


Fig. 8—(a) The action of the printer

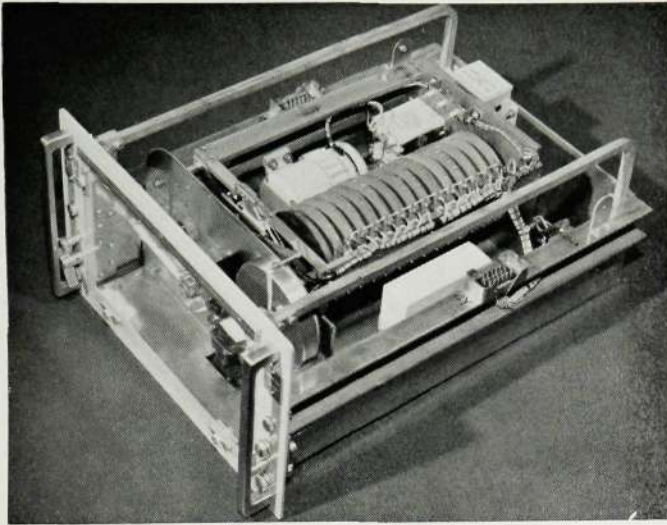


Fig. 8 (b)—Printer unit showing character-generating cams

producing the signals for the P, S or T character. At the end of the revolution, the switch steps again but during the next revolution the printer head is connected to one of the spring sets producing the characters 0-9.

The character actually printed is controlled by the setting of the 'hundreds' switch of the launch serial number counter. During subsequent revolutions the 'tens' and 'units' of the launch serial number counter are selected and printed. A blank is left for one revolution, and the hundreds, tens and units of launch end-speed or test are printed in the same way. This printing process is a little slower than, for example, using the techniques exploited in a teleprinter or electric typewriter. It makes use, however, of printing apparatus and character generating systems which are insensitive to shock and vibration which might seriously impair the operation of type-hammer mechanisms.

REMOTE INDICATION OF LAUNCH SPEED

Remote indication of launch speed is given by an indicator unit containing three Magflip receivers. These are operated from resistor networks energized from a 50 to 60 c/s supply. The potentials actually applied to the Magflip receivers are controlled by additional wafers on the end-speed display unit switches in such a way as to repeat the indication of these switches. As

the indicator may be required on the flight-deck, it is mounted in a standard water-proof case shown in Fig. 9.

POWER SUPPLIES

The power supply arrangements follow conventional lines; tappings are provided for operation from 110, 220 and 440 volts nominal mains supply of 50 to 60 c/s. Metal rectifiers are used for both h.t. and relay supplies, and the h.t. supplies are regulated by a normal series valve stabilizer circuit. Two control keys are provided to allow the positive and negative supply lines to be raised or lowered by five per cent. In conjunction with the normal test key, this marginal check facility provides an early warning of valve or component deterioration.

PROTECTION OF DETECTOR HEADS

The detector heads are mounted in close proximity to the water-filled retardation cylinder at the end of the catapult and so are subjected alternately to exhaust-steam and cold sea water. To provide adequate protection, the coil assembly is potted in a bronze case, connections being made by a screened cable passing through a compression gland. Fig. 10 shows an exploded view of the head before sealing and potting.

The end-speed recorder is normally mounted in the catapult machinery compartment below the flight deck, and so is subjected to a certain amount of

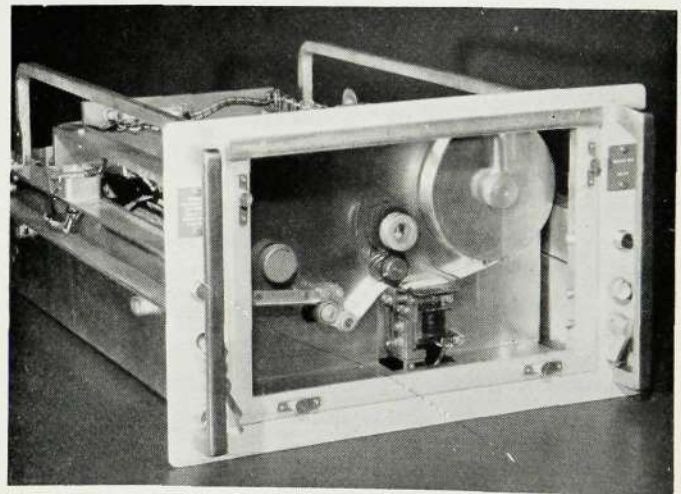


Fig. 8 (c)—Printer relay, helix and tape feed

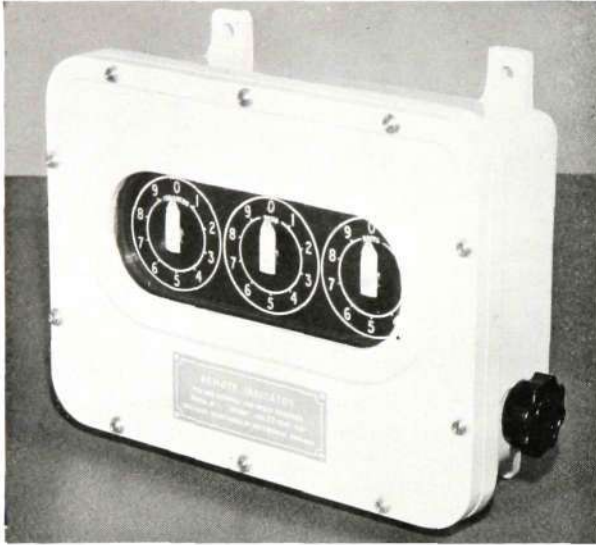


Fig. 9—The remote indicator unit mounted in a standard waterproof case

steam and condensation. In this compartment it may also be subjected to very high ambient temperatures. For this reason it is totally enclosed and ventilated by a separate fan from outside the machinery compartment. Fig. 2 shows the cabinet structure employed. In accordance with normal custom for electrical apparatus in machinery compartments, the recorder case is made drip- and spray-proof and all electrical connexions are made through waterproof glands. It is also necessary to reduce the fire risk associated with electrical faults to a minimum, and for this reason the use of organic insulation has been avoided. The components in the electronic sub-assemblies are mounted on small ceramic insulators which are soldered into a steel chassis plate. In this way even serious over-heating cannot produce inflammable vapours.

Although production of these recorders has only been in hand for a short period, it is already apparent that the models installed are playing a significant part in extending the usefulness and dependability of the steam catapult, and they are to be supplied not only to the Royal Navy but also to the Commonwealth and to certain foreign aircraft carriers.

ACKNOWLEDGMENTS

The steam catapult together with its control mechanisms was developed by Brown Brothers & Company Limited, Rosebank Ironworks, Edinburgh 7, and the end-speed recorder equipment associated with the steam catapult was developed by Ericsson Telephones Limited. Acknowledgments are also due to the Director of Electrical Engineering of the Admiralty and to the Directors of Ericsson Telephones Limited for permission to publish this article. Mention must also be made of Mr. D. M. Taub* and Mr. G. A. Matthews† who were responsible for circuit design, and to Mr. N. Nicholson† and Mr. W. C. Newman*, who were responsible for the mechanical aspects of the recorder. The assistance of all these is gratefully acknowledged for providing much of the information on which this article is based.

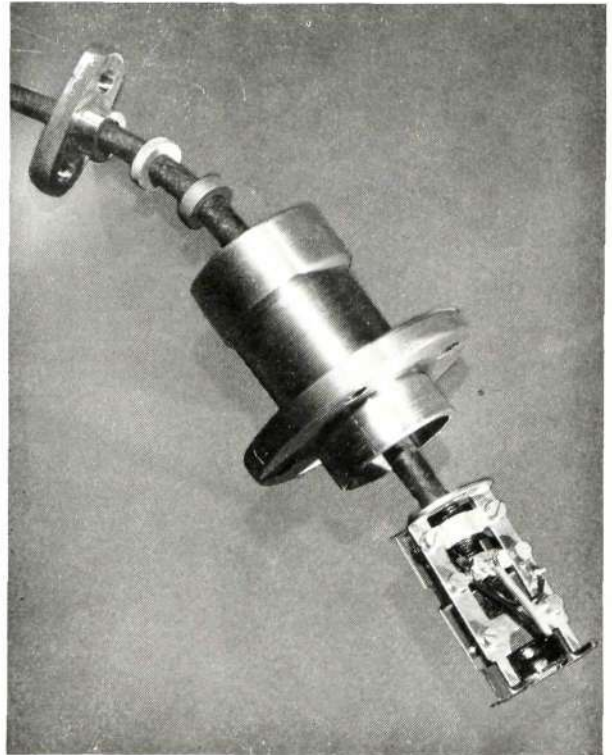


Fig. 10—Exploded view of the detector head

* Formerly with Ericsson Telephones Ltd. † Ericsson Telephones Ltd.

References

- (1) Taub, D. M. The Design of Hard Valve Binary Counters. *Electronic Engineering*, September, 1955.
- (2) Bacon, R. C., and Pollard, J. R. The Dekatron. *Electronic Engineering*, May, 1950.

AN ECHO SUPPRESSOR FOR THE TRANS-ATLANTIC CABLE

W. PROCTOR — Carrier & H.F. Development Department

This article is published by kind permission of the Engineer-in-Chief of the British Post Office.

On long-distance telephone circuits in which four-wire working is adopted, echo suppressors are necessary to prevent reflections at the receiving terminal from giving rise to disturbing echo effects at the transmitting terminal. The equipment described in this article was developed in conjunction with Post Office Engineers, from information supplied by the American Telephone and Telegraph Co., to meet requirements for an echo suppressor to be used at the U.K. and Canadian terminals of the trans-Atlantic telephone cable.

THE first trans-Atlantic telephone cable was brought into service on the 25th September 1956, and has been fully described elsewhere (for example, in the Post Office Electrical Engineers Journal Vol. 49 pt. 4 Jan. 1957). It provides 36 C.C.I.T.T. quality speech channels which, unlike radio circuits, are not subject to interruption by ionospheric disturbances. Although the cable is loosely referred to in the singular, there are in fact two cables, each containing unidirectional circuits, along the major portion of the trans-Atlantic route. All 36 circuits may be used twenty-four hours a day, and the resulting improvement in the service has given rise to a steady increase in the demand for trans-Atlantic calls. Plans for handling further increases in traffic are well advanced, and another cable is due to be put into operation in 1960.

From the brief description above it will be appreciated that a four-wire circuit is provided for each conversation, and conversion from four-wire to two-wire working takes place at the ends of the route. With this arrangement, it is possible for some of the

energy transmitted by the "go" path to be transferred to the "return" path at the four-wire to two-wire conversion point. As a result, an "echo" may appear at the transmitting terminal, the interval between the original sound and the echo being twice the propagation time on one direction along the cable. The trans-Atlantic route is long enough for this interval to reach a value of 70 m.S., which would make the echo very apparent, and the effect would be confusing to the person speaking. Echoes must therefore be suppressed by applying heavy attenuation to the "go" path while the "return" path is in use, and *vice-versa*. In mid-1956 we were asked to develop an echo suppressor for use in the terminal equipment at the U.K. and Canadian ends of the cable. When installed, echo suppression will be carried out partially in the U.K. and partially in the U.S.A. and Canada. At present all suppression is effected at the U.S. and Canadian terminals.

The East-to-West and the West-to-East paths must include means for applying echo-suppressing attenuation, and a device must be provided to detect the

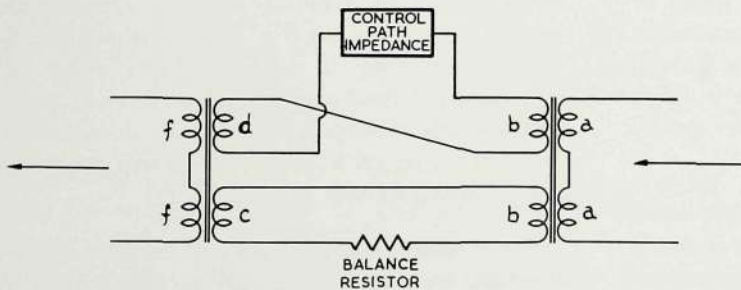


Fig. 1—The Hybrid

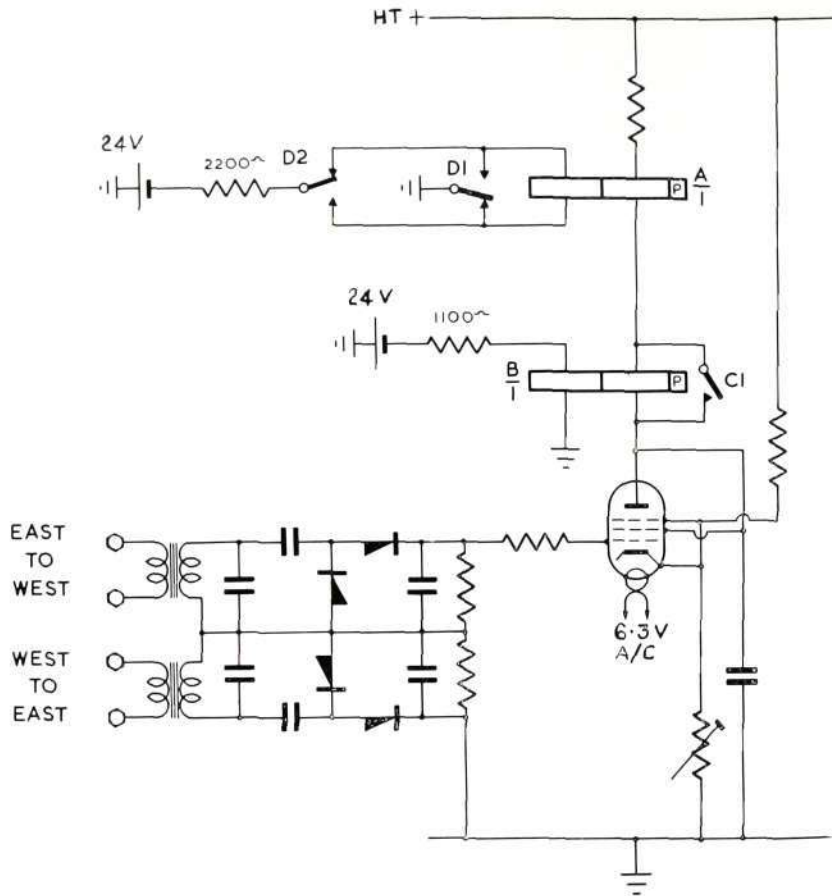


Fig. 2—The Detector

direction in which transmission is taking place and appropriately to control the attenuating networks. The echo suppressor developed for the trans-Atlantic cable employs hybrid transformers as the attenuating elements. The principle of operation is illustrated in Fig. 1. The balance resistor is equal to the control path impedance during the periods when attenuation is required. In this condition the hybrid is balanced; an alternating voltage across the coils *aa* causes equal and opposite voltages to appear across coils *c* and *d*, and with an ideal transformer no voltage would be induced across coils *ff*. In practice, an attenuation of 40 db is obtained. When transmission through the hybrid is required, the balance resistor is short-circuited and the resulting unbalance gives greatly reduced attenuation.

Fig. 2 shows the circuit of the control device which detects the direction in which transmission is taking place. The input transformer is tuned to give maxi-

imum response at 1000 c/s, a frequency which falls within the range of both male and female speech. When an audio-frequency voltage appears at the East-to-West input terminals it is rectified by the diodes and the resulting positive voltage at the grid of the valve causes the anode current to increase. Similarly, the valve grid is driven negative when an audio voltage appears at the West-to-East input terminals, so that the anode current decreases. The standing anode current with no audio voltage at either pair of input terminals is set, by adjusting the cathode resistor, to such a value that relay A is operated and relay B released. These relays are high-speed polarized telegraph relays, and with the D relay contacts in the position shown in the figure, the field due to the bias winding opposes that due to the anode winding in both A and B relays.

When transmission takes place in the West-to-East direction, the valve anode current falls. Relay A

releases, causing the hybrid in the East-to-West path to be set to the balanced or suppressing condition, and at the same time operates a C relay (not shown in Fig. 2). A contact of the C relay locks the B relay in the released condition, by applying a short-circuit to its anode coil, for the duration of the West-to-East transmission. When speech is transmitted in the East-to-West direction, the valve anode current rises and the B relay is operated; its contact sets the hybrid in the West-to-East path to the balanced state and operates a D relay. Contacts of the D relay reverse the bias field of relay A, as can be seen from Fig. 2, so that relay A is locked in the operated condition during transmission from East to West.

A block diagram of the complete echo suppressor is shown in Fig. 3. The West-to-East path divides at hybrid 1; when transmission takes place in this direction, part of the energy passes via attenuator 2 to the East subscriber and part via attenuator 3 and amplifier 2 to the detector. The A relay in the detector releases, as explained above, and contact A1 removes the short-circuit from the balance resistor of hybrid 2, so applying attenuation to the East-to-West path. The A relay releases within 12 milliseconds of the reception of the speech voltage, and the suppressor is therefore said to have a pickup time of 12 milliseconds.

The release of relay A causes the C relay to operate, and contact C2 disconnects the hybrid balance resistor from the A1 contact spring. At the end of the West-to-East transmission, the A relay re-operates, but the release of the C relay is delayed until capacitor CZ

has re-charged. The short-circuit is not re-applied to the balance resistor until contact C2 closes again, and consequently the attenuation in the East-to-West path is maintained for a period, known as the hang-over time, after the end of transmission in the West-to-East direction. The value of CZ is adjusted so that the hangover time is a little greater than the propagation time from the East to the West terminal; this ensures that the West subscriber cannot receive an echo after the end of his transmission. When transmission takes place in the East-to-West direction, the detector receives energy via attenuator 4

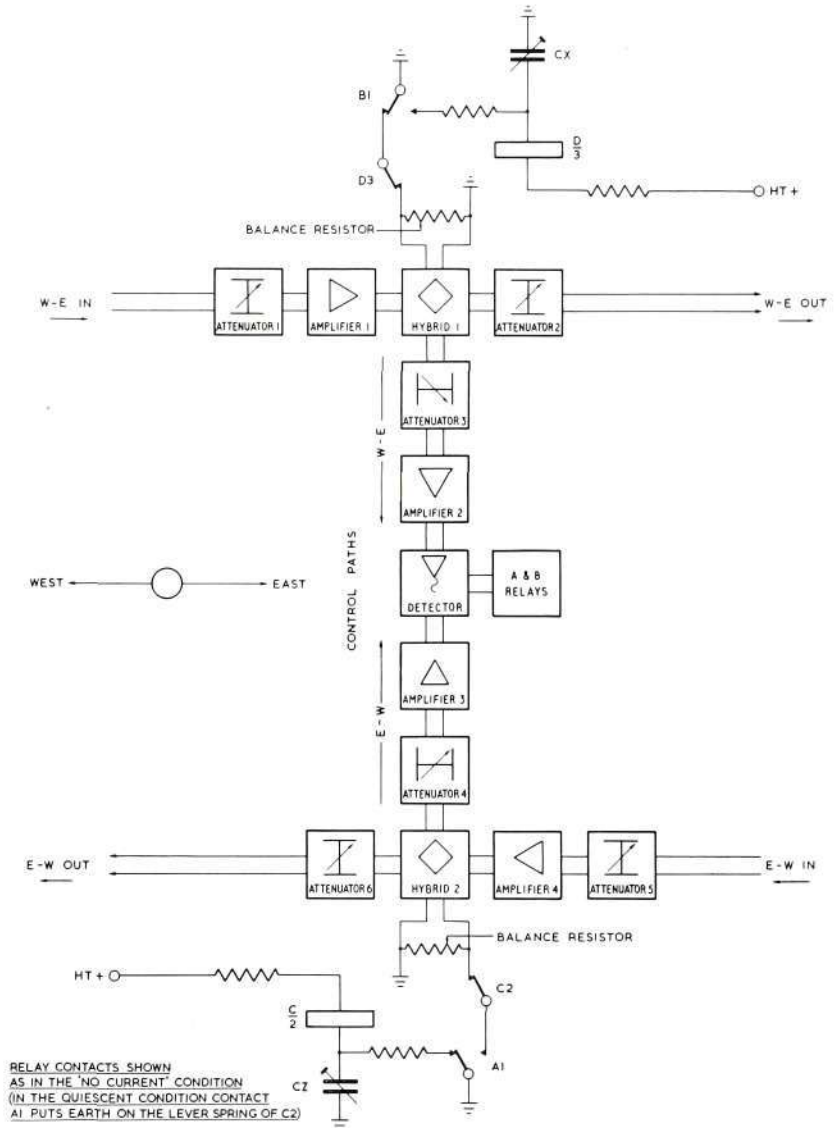


Fig. 3—Block diagram of the complete Echo Suppressor

and amplifier 3, the B and D relays operate, and suppression is applied in the West-to-East path. At the end of the transmission, the attenuation is maintained for the hangover time because the release of relay D is delayed until capacitor CX has recharged.

From Fig. 2 it can be seen that the input transformers and rectifiers in the detector circuit are connected so that if transmissions are made simultaneously by both parties, the valve anode current is controlled by the difference in level between the two transmissions. Hence either party can interrupt the other by speaking more loudly; this causes the direction of transmission indicated by the detector to be reversed, and provided that the interrupting transmission is continued at a sufficiently high level for a period equal to the hangover time, so that the C or D relay can release, the echo-suppressing attenuation is removed from one path and applied to the other.

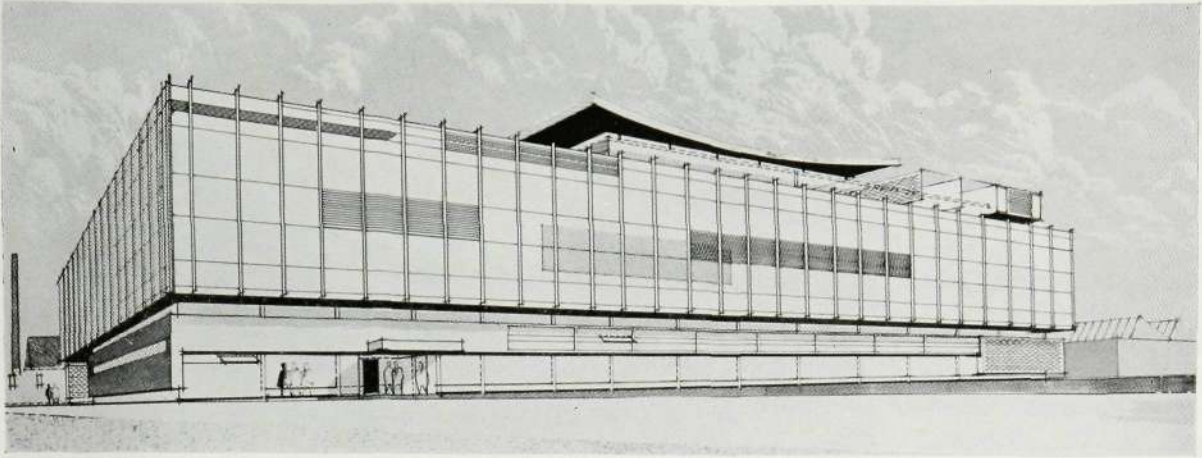
The range of input levels over which the suppressor operates is +2 db to -50 db relative to 1mW in 600

ohms. The mechanical design is based on 51-type construction, and standard units are used wherever possible. The employment of standard British Post Office amplifiers was considered, but occasionally (for example for international meetings of learned societies) it is necessary to employ the echo suppressor on circuits of wider bandwidth than normally provided for telephone traffic. Since the standard amplifier was not intended to deal with frequencies below 300 c/s, a small modification was needed to make it suitable for this application. The suppressor meets all the requirements laid down by the British Post Office.

Comprehensive routine testing can be carried out by means of a test set designed concurrently with the development of the suppressor.

One rack of suppressors and their associated equipment such as power units has been modified to meet the requirements of the Canadian Standards Association and will be installed at Montreal.





Artist's impression of the new building

NEW ELECTRONIC SWITCHING LABORATORIES

ON the 17th July we were visited by the Engineer-in-Chief of the Post Office, Brigadier Sir Lionel H. Harris, who laid the Foundation Stone of our new laboratory building. The ceremony was arranged on the occasion of a

meeting of the Joint Electronic Research Committee, of which Sir Lionel is Chairman. Among the large company present at the ceremony were senior representatives from the Post Office and from other telephone companies, together with Directors and Executives of the Company and staff of Factory, Engineering and Research Laboratory departments.



Mr. J. H. Reed (Managing Director) opening the proceedings
Seated (left to right) :-

Dr. J. H. Mitchell, Ph.D., B.Sc., M.I.E.E., F.Inst.P. (Director of Research). Mr. F. Limb, C.I.G.A., M.I.Prod.E. (Factory Director). Sir Harold A. Wernher, G.C.V.O. (Chairman of the Company).
Brig. Sir Lionel Harris, K.B.E., T.D., M.Sc., F.C.G.I., M.I.E.E. (Engineer-in-Chief of the Post Office).

In welcoming Sir Lionel and inviting him to lay the foundation stone, Mr. J. H. Reed (Managing Director) said : " We see here the early stages of erection of a building which will rehouse and extend part of our Research Laboratories and so enable us to make a still larger contribution towards the activities of the Joint Electronic Research Committee ". Mr. Reed paid tribute to Sir Lionel as the driving force behind the joint developments in electronic telephone exchanges, and continued : " The electronic exchange is a National effort in which many problems still have to be overcome. When a solution is obtained, I think it will be referred to as one of the outstanding engineering achievements of our day ". He gave some details of the building and said the excellent design and layout were due to close co-operation among all those concerned ; particular mention was made of Mr. Booth (Buildings and Plant Engineer) and his staff, Mr. Eales (Company Architect) and the building contractors (A. A. Stuart and Sons).

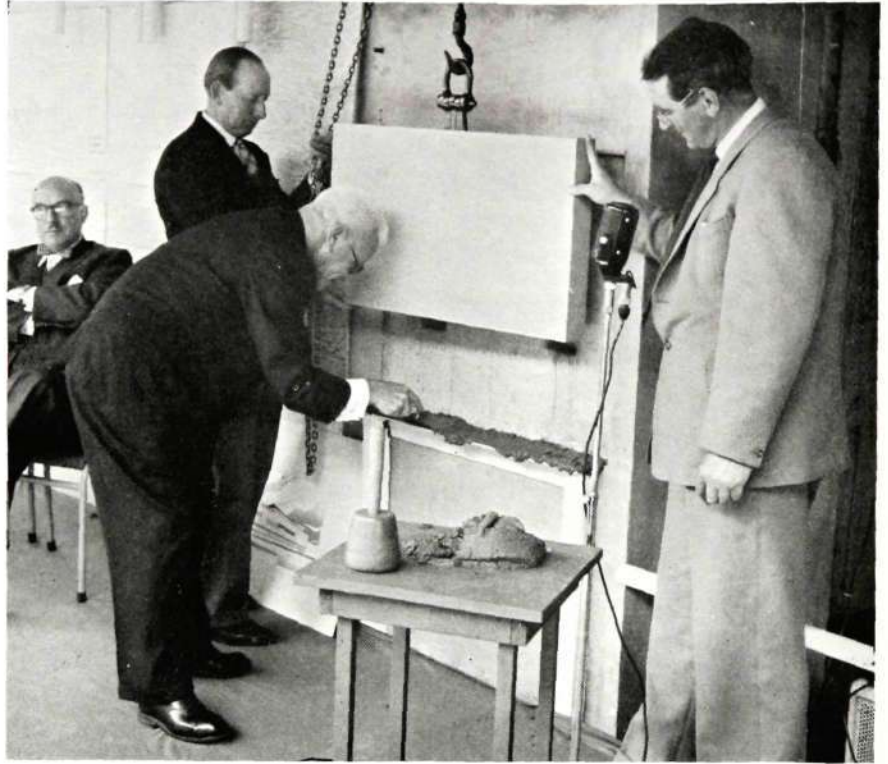
After laying the stone, Sir Lionel Harris expressed pleasure that the building under construction demonstrated in a very substantial way the Company's belief in the developments arising from the Joint Electronic Research Committee and said he hoped the building and the work in it would prosper. Sir Harold Wernher (Chairman of the Company) thanked Sir Lionel and presented him with a silver tray as a souvenir of the occasion.

SOME DETAILS OF THE NEW BUILDING

The new building is of reinforced concrete construction and has three floors. It will provide some 44,000 square feet of accommodation and, to allow the best use to be made of the working space, great care has been taken in the design to provide the maximum clear span between columns. In this way, sections of the ground floor 32 feet by 180 feet are entirely free from columns, with corresponding free areas on the upper floors. To allow the greatest flexibility in layout, a modular plan has been adopted, and as far as possible all partitions, fittings and services are based on this module.

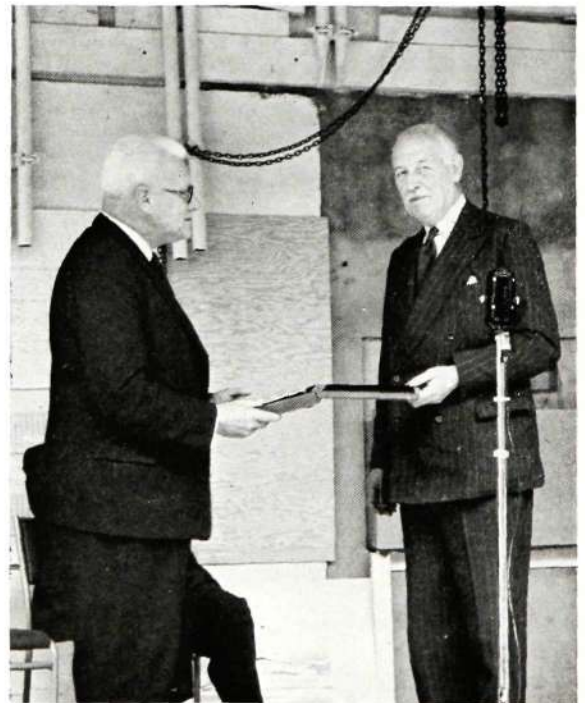
The top floor will provide offices and laboratory space devoted in the main to advanced development work and investigations into new techniques in electronic telephone exchanges and related fields. The middle floor will include workshop and laboratory space where larger experimental equipments and prototypes can be constructed and tested, while the ground floor will provide pre-production space.

Although the increasing use of transistors is tending to reduce the power demands of electronic apparatus, there is also a tendency to design equipment in the smallest possible dimensions and this makes it seem that some localized cooling will continue to be required. For this reason, provision has been made for apparatus ventilation on either open or closed circuit arrangements; these facilities, together with the installation of general air-conditioning throughout the building, will enable heat generated in equipment to be removed without undue

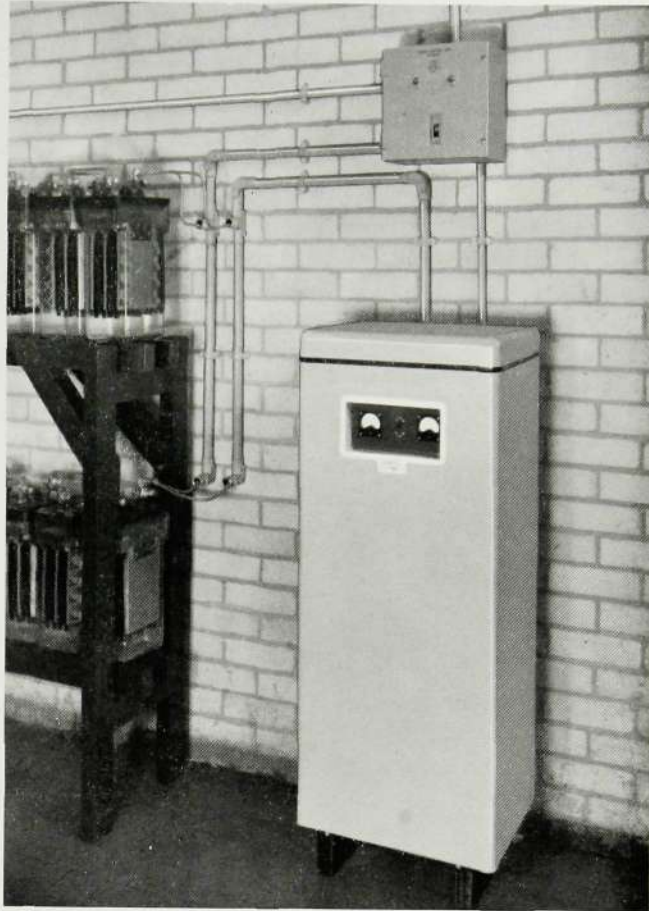


The Stone-laying ceremony

local rise of temperature. To reduce the cooling load involved, the curtain wall of the building is designed to minimize solar radiation effects.



Sir Harold Wernher making the presentation to Sir Lionel Harris



Part of a typical power plant showing the Power Control Unit above the Battery Charging Unit

SIMPLIFIED POWER CABLING IN SMALL EXCHANGES

THE introduction of Power Control Unit Type N23045A1 allows considerable simplification to be achieved in the layout of single battery float schemes as usually supplied for small telephone exchanges.

The photograph shows this very clearly. Only three inter-connected components are needed viz :— battery, autocharger and power control unit. The unit is a wall mounted, sheet steel cabinet $10\frac{1}{2}$ " x $10\frac{1}{2}$ " x 6" (267mm. x 267mm. x 152mm.) finished in either opaline green or grey.

It contains a double pole a.c. mains switch feeding the autocharger, a battery discharge fuse, alarm fuses and relays, low volt alarm equipment and terminal assemblies. Single battery float schemes up to 30

amperes capacity can be covered by the one unit with suitably rated fuses for each application.

The alarm equipment gives a local visual and an extended audible alarm approximately 20 minutes after a supply mains or charging unit failure, thus giving early warning that the exchange load is being taken from the battery. Exchange voltages of 25, 40 and 50 are covered by standard designs, but other voltages could be accommodated by special request.

Since the power control unit incorporates all miscellaneous items assembled and connected together under one cover, installation work is reduced and simplified. All components are readily accessible for maintenance by opening the front cover which is hinged.