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The Development of the Intelsat Global Satellite Communication System

Part 1—The Early Years and the Intelsat III Satellites

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U.D.C. 629.783.001.6

The Intelsat satellite communication system has grown from experimental beginnings in 1965, to become one of the main media for international telecommunications in 1969. This article traces the development of the system in its early years, and describes the new satellites which are just coming into service. Part 2 will examine current earth-station practice, and will review further system developments which are foreseen.

THE EXPERIMENTAL PHASE

Three large-aerial earth stations were built in 1961–62 for tests with the Telstar and Relay satellites; they were at Andover, Maine, USA, at Goonhilly, Cornwall, England and Pleumeur Bodou, Brittany, France. The satellites were launched in 1962–64 and the experiments showed conclusively that high quality facilities could be provided by satellite relay.[1,2,3,4]

These early experimental satellites had fairly low orbits, a few thousand miles high at apogee. Satellites in low orbits move rapidly across the sky and provide communication between two earth stations for only a short period at each transit, up to say one hour. This would not prevent continuous communication being maintained between earth stations; with enough satellites in suitable orbits there would always be another ready to take over when the one in use was passing out of sight, and the problems of circuit interruption at hand-over could be overcome. However, such systems would be complex and expensive. A stationary orbit is preferable, since the same satellite can be used continuously. Unfortunately, it is a high orbit, 35,800 km above the equator, and a much more powerful rocket system, controlled with great precision, is needed to inject a satellite into it. Furthermore, it was feared that the long radio-link transmission delay (270 ms each way) would impede the flow of conversation. Further tests were needed.

The SYNCOM III satellite, launched in 1964, was successfully injected into a stationary orbit. The EARLYBIRD satellite followed it into a stationary orbit over the Atlantic in 1965.[5] EARLYBIRD's primary purpose was a full-scale field trial of the subjective effect of long transmission delay on telephone users. The three original earth-stations were now joined by a fourth big one at Raisting, Bavaria, in the Federal German Republic, and a smaller one at Fucino in Italy. These stations were used to set up, via EARLYBIRD, a network of public telephone circuits linking USA and Canada to many countries in Western Europe. The administrations taking part made careful studies of customer reactions to a large number of calls, other calls on submarine-cable circuits being used as controls.[6] Various echo suppressors were tried, including some specially designed for use on long-delay circuits.[7] The reports on these studies varied somewhat from administration to administration, but the general conclusions were, that although some customers find a cable circuit rather easier to use than a satellite circuit, the latter is an acceptable alternative, provided that the transmission delay is not further increased by a long terrestrial extension or a second satellite hop.

THE INTERNATIONAL TELECOMMUNICATIONS SATELLITE CONSORTIUM

The Organization

At the present stage in its development, satellite communication is particularly suitable for providing international telephone services, and it is the only economic method of providing high-quality telephone circuits in small groups, or television links, over intercontinental distances.

Earth stations can be built at the individual initiative of telecommunications authorities like the Post Office, but an international co-operative organization was needed to provide the satellites and administer their use. On 20 August 1964, eleven nations signed agreements which set up the International Telecommunications Satellite Consortium (Intelsat), for this purpose.[8] These eleven founder-members were:

Australia	Italy	United Kingdom
Canada	Japan	United States of America
Denmark	Netherlands	Vatican City
France	Spain	

By the beginning of 1969, the number of member nations had risen to 63. The members provide the capital needed to finance the satellites, each paying a quota according to their expected amount of usage of the system, although non-members may be allowed to use it also.

The policy-making body of Intelsat is the Interim Communications Satellite Committee (ICSC). This is an interim committee because the 1964 agreements, from which the ICSC draws its authority, are provisional; a permanent agreement is to be negotiated during 1969. Most of the present Intelsat member countries are represented on the ICSC. The day-to-day business of the Consortium is done by the Communication Satellite Corporation (Comsat), which is a United States organization selected by the Consortium to act as the Intelsat manager. Comsat operates, and partly owns, the earth stations in the USA which work to the Intelsat system.

The System

One of the early problems which Intelsat had to resolve was whether to use stationary or moving satellites. The Consortium took charge of the EARLYBIRD project, and decided, on the evidence of customer reactions, that stationary

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orbits should be adopted. Consideration of the earth's geography and the geometry of the satellite orbit then led to the division of the world into three zones, each of which might be served by one satellite. These zones cover all the important land areas of the world. Fig. 1 shows maps of

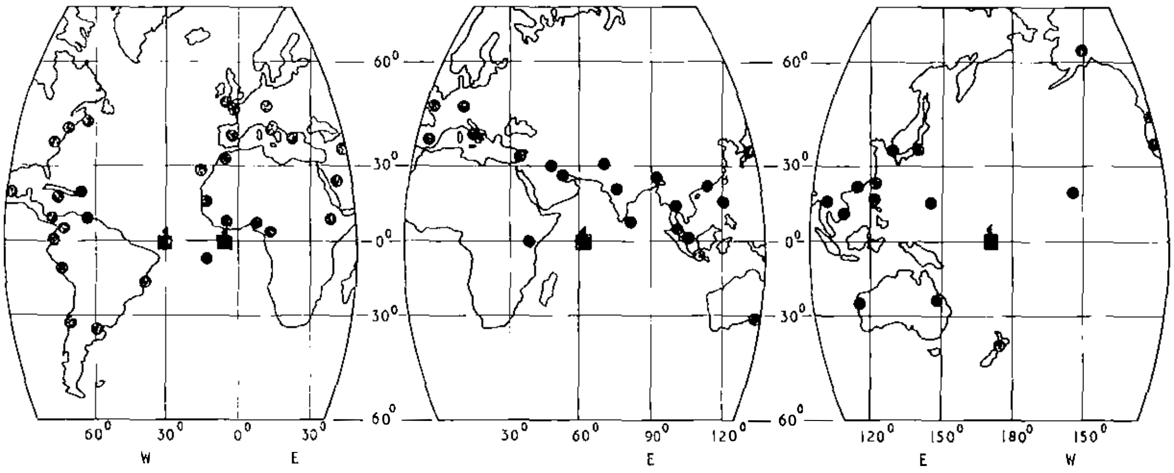

FIG. 1—Earth stations and satellites planned for the three zones of the Intelsat global system in 1970.

these zones, known as the Atlantic-Ocean Zone, Pacific-Ocean zone and Indian-Ocean Zone. Fig. 1 also shows the positions of the 65 earth-stations expected to be in service by the end of 1970. Some countries, including the United Kingdom, are taking advantage of overlapping zonal boundaries by building two earth-stations, in order to gain access to two satellite zones.

There is a demand for telephone service from every country to virtually every other. Some are busy routes needing hundreds of circuits, others are so lightly loaded that it would be uneconomic to provide even one direct circuit. Disregarding the latter, and excluding circuits that are expected to be carried by other media such as submarine cable, Fig. 2 shows the total number of telephone circuits

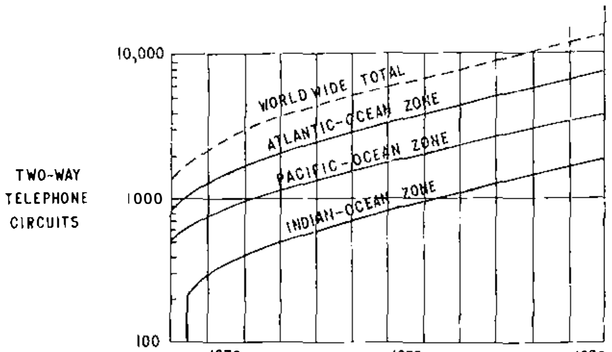

FIG. 2—The total telephone traffic forecast for the Intelsat system, 1969–1980.

that the Intelsat satellite system is expected to carry in the years up to 1980. Table 1 shows Britain's share of this traffic.

Ideally, all the satellite-system traffic within each zone should be carried by a single spacecraft which has "multiple access", i.e. access from all the earth stations in the zone. This combines the maximum of flexibility with the minimum of expenditure on earth stations and satellites. Fig. 2 shows that each Intelsat satellite should preferably be able to carry about 1,600 two-way telephone circuits by 1970, and 4,000 circuits by 1975. These would be divided between two dozen to three dozen earth stations, and serve hundreds of individual earth-station-to-earth-station routes. All but the earliest of the Intelsat satellites have been designed for multiple access, and one satellite will be able to cater for the present forecast needs of each zone, for most of the foreseeable future.

Some of the earliest experiments with TELSTAR I in 1962 demonstrated that a satellite could be used for relaying television signals. The demand for occasional international television links for the transmission, for example, of pictures of major sporting and ceremonial occasions and news events, is catered for by the Intelsat system. This facility more than any other has led the public to appreciate the significance of

TABLE 1

Forecast of Number of Satellite Telephone Circuits Terminating in Britain

Distant Terminal	Atlantic-Ocean Satellite		Indian-Ocean Satellite	
	1970	1975	1970	1975
Argentina	5	14		
Australia			24	48
Bahrain			9	18
Brazil	7	13		
Canada	50	120		
Ceylon			15	30
Chile	4	8		
Colombia	4	8		
East Africa			21	32
Ethiopia	5	10		
Greece	9	20		
Hong Kong			13	26
India			23	46
Iran	4	9		
Japan			6	11
Kuwait			6	11
Lebanon		11		
Malaysia			6	14
Mexico	4	10		
Morocco	3	7		
New Zealand			4	15
Nigeria	12	22		
Pakistan East ..			5	13
Pakistan West ..			6	13
Panama	1	3		
Peru	4	8		
Philippines			2	5
Saudi Arabia	3	7	1	2
Singapore			7	15
Sudan		4		
Turkey		27		
Thailand			3	7
United Arab Republic		21		
USA	180	540		
Venezuela	2	7		
Totals	297	869	151	306

satellites in communications. In the past, the picture quality has been below the standards aimed at for long-distance television links, and availability has had to be limited. This is because of the conflicting needs of the telephone service, but both the quality and availability of television links are being improved.

THE INITIAL INTELSAT COMMERCIAL PHASE

The main task which faced Intelsat when the Consortium was established in 1964, was to set up a global satellite-communication system as soon as possible. This involved having satellites designed and built, getting them put into orbit, defining as far as necessary the characteristics of earth stations and their emissions, and providing a basis for the day-to-day administration of the system.

The basic technical principles of the system were defined in 1965–66 with the help of the EARLYBIRD tests. A specification for satellites was issued in 1965, and a contract for the development and construction of six satellites (INTELSAT III) was placed in 1966. Arrangements for launching were negotiated with the National Aeronautical and Space Administration (NASA) in the USA. The characteristics of earth stations and emissions were defined during 1967 and 1968. Methods of operational control were developed for the satellite system. The system is being put into operational use in the first half of 1969 with many earth stations already built.

While all these preparations were being made, there was a pressing demand for communications services and an urgent need for experience of operating satellite systems. For these purposes Intelsat set up temporary facilities using satellites of two types; INTELSAT I and INTELSAT II.

INTELSAT I

Five earth-stations in Europe and North America were availablefor service after the EARLYBIRD customer-reaction trials had been completed, and the EARLYBIRD satellite, renamed INTELSAT I/FI, was put into use for trans-Atlantic services. It remained in use for $3\frac{1}{2}$ years, the Canadian earth-station at Mill Village, Nova Scotia, replacing Andover, and the small station at Fucino dropping out in 1967. This system provided four telephone supergroups, 240 circuits. This capacity was virtually filled when the first global-system satellite took over in January 1969.

A brief description of the INTELSAT I satellite system follows. The earth-station signals, at 6,301 and 6,390 MHz, were received on a low-gain aerial (4 dB relative to isotropic), and fed to separate frequency changers, where they were down-converted to intermediate frequencies around 60 MHz. The i.f. amplifiers had bandwidths of about 30 MHz. After amplification and amplitude limiting, the two signals were up-converted to the 4 GHz band (centre frequencies 4,081 and 4,161 MHz) and passed together through a travelling wave tube amplifier with 6 watts single-carrier output-power rating. The transmitting aerial had a gain of 9 dB. The maximum equivalent isotropically-radiated power available for each carrier was about + 10 dB relative to 1 watt (+ 10 dBW).

The INTELSAT I satellite had a cylindrical body, like a drum, 29 in diameter and 23 in long, with the microwave aerial system projecting from the centre of one end. It weighed 87 lb. It spun about its axis of symmetry, which was arranged to be parallel to the earth's axis of rotation, so that the earth was always illuminated by the disc-shaped radiation pattern of the directive aerials. The curved outer surface of the drum was covered with silicon photo-voltaic cells, which convert light from the sun into electric power for the communications repeaters (transponders). The solar array also supplied power to the telecommand and telemetering equipment, which allows a ground station to monitor and control the satellite via v.h.f. and s.h.f. radio links.

One transponder received the signal from Europe and transmitted it to America, and the other transponder passed the American signal on to Europe. The transponders had amplitude limiters, so each could amplify only one carrier at a time. Thus multiple access was not possible, and the European earth stations took turns in using the satellite. A network of terrestrial links, between Frankfurt, Paris, Rome and London, was used to connect each circuit to its permanent terminal exchange regardless of which station was working.

INTELSAT II

An urgent need for a private network of circuits for NASA led to the building of a number of earth stations in 1966 and the production of a stretched version of the INTELSAT I satellite—designated INTELSAT II. These new satellites differed from INTELSAT I in various ways. They were bigger and more powerful, they served a larger area and there was more complete duplication of the communications equipment as a protection against failure. But the two most significant differences were:

(*a*) a single transponder of 130 MHz bandwidth replaced the two narrow-band transponders of INTELSAT I, and

(*b*) no amplitude limiters were fitted.

These changes enabled many frequency-modulated carrier waves to be amplified simultaneously in the transponder without excessive mutual-intermodulation interference, thus facilitating multiple access. Two of these satellites were put into use over the Pacific and one over the Atlantic, during 1967. NASA private-circuit requirements did not take up all the available power and bandwidth, and the remainder was used for telephone circuits for the public network by earth stations in USA, Italy, Spain, Panama, Chile, Hawaii, Japan, Australia, Thailand and the Philippines. These stations used frequency-modulated carriers, as in the INTELSAT I system, but the baseband capacities were smaller, in the range 12 to 72 channels.

These satellites, together with INTELSAT I, are still functioning and two of the former are still being used for the NASA private circuits. All the public-network services will be transferred to newly-launched satellites of type INTELSAT III, designed for the global system.

THE GLOBAL-SYSTEM SATELLITES INTELSAT III

Physically the INTELSAT III satellites resemble their predecessors. Fig. 3 shows the general appearance. The drum-shaped body carries an array of solar cells on its curved outer surface, to provide power. The body is made to spin about its axis, which is always parallel to the earth's axis, to provide attitude stabilization for the aerial. These satellites are capable of carrying more circuits than the earlier types, and are bigger and heavier, as shown in Table 2.

TABLE 2

Comparison of Satellites INTELSAT I to INTELSAT III

	INTELSAT I	INTELSAT II	INTELSAT III
Diameter of body (in)	29	56	56
Length of body (in)	23	26·5	41
Mass (lb)	87	192	270
Capacity in two-way telephone circuits between "standard" earth stations	240	240-300	about 1,200

Each satellite may be considered as consisting of a number of sub-systems.

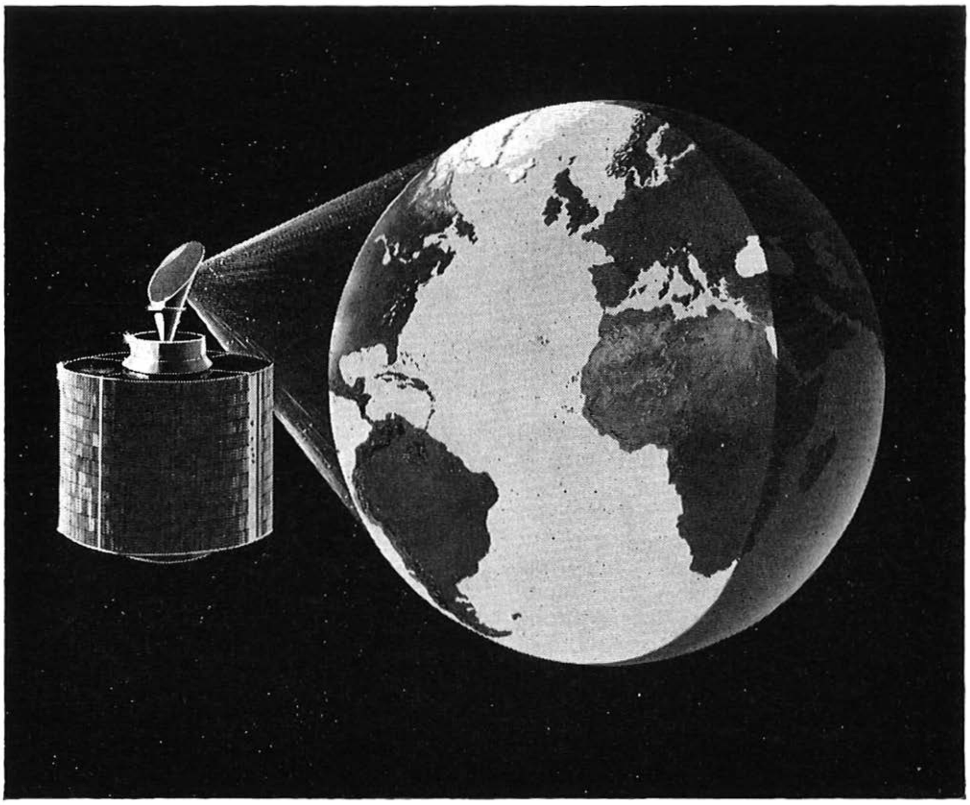

FIG. 3—An artist's impression of an INTELSAT III satellite serving the Atlantic-Ocean zone.

The Power Sub-system

About 10,000 N-on-P silicon photo-voltaic cells form the solar-cell array. These will provide at least 131 watts of d.c., even under the most adverse conditions of solar illumination normally encountered, i.e. at the solstices, and after five-years exposure to the hard radiation of outer space. This is enough for all the electrical equipment, including a surplus to charge the nickel-cadmium secondary batteries that power the satellite when it is eclipsed.

The Aerials

INTELSAT III has no v.h.f. telemetering and telecommand equipment. Consequently a 6 GHz receiving aerial, with substantially omnidirectional properties, has to be provided to receive telecommand signals for the initial setting up in orbit. Under normal conditions a conical horn aerial, with maximum gain of 16·5 dB relative to isotropic and a minimum 6 dB beamwidth of 20°, is used for all purposes, receiving at 6 GHz and transmitting at 4 GHz. Since the satellite body is spinning (about 100 rev/min), it is necessary to rotate the aerial at the same speed in the reverse direction, to keep the earth always within the aerial beam. Infra-red sensors locate the direction of the earth for the automatic control of the direction of the horn aerial. If necessary this control can be taken over by an earth station. The aerial is designed to receive left-handed and transmit right-handed circularly-polarized signals.

This mechanically-despun aerial is the most important innovation in these satellites, and perhaps the most critical. Special lubricants are used for the bearings, which are exposed to the hard vacuum of space, and a wide temperature range must be tolerated. Unhappily the first satellite in service has already exhibited intermittent bearing seizure, apparently due to thermal effects. Satellites launched later have an improved design.

The Transponders

Fig. 4 is a block-schematic diagram of the two transponders and the diplexers that give them access to the common aerials. These transponders amplify the 6 GHz signals received from earth stations and change their frequency to the 4 GHz band. They also receive the telecommand signals and pass them to the command decoder, and transmit the telemetering carriers supplied by the telemetering units.

Each transponder has a bandwidth of 225 MHz. Together they cover most of the 500 MHz bandwidth allocated to the communication-satellite service in the 6 GHz and 4 GHz frequency bands. Multi-stage 6 GHz tunnel-diode amplifiers (t.d.a.) are followed by frequency changers, and two stages of power amplification in travelling wave tubes (t.w.t.). There is no hard limiting, and the amplifiers operate over a fairly linear portion of their input-output amplitude characteristic. The level of intermodulation products, due to the simultaneous presence of many carriers at different frequencies, is high but tolerable. The total r.f. power output from each transponder, when fully loaded with multiple carriers, is about 6 watts.

The gain of the transponders is about 104 dB. This allows the power levels emitted by earth stations to be kept down to acceptable values; higher gain would permit a reduction in earth-station power, but would increase the noise added by the t.d.a. to the relayed signal and would make the system more sensitive to interference. Great care has been taken to minimize crosstalk between the carriers relayed by a transponder.

The Positioning and Orientation Sub-system

Gas jets, controlled from the ground, are used for the fine adjustment of the orbit after the initial injection into an approximate stationary orbit by the launcher (three-stage Long-Tank-Delta system) and the apogee motor, a small solid-fuel rocket. The same system of gas jets is used to set the spin-axis parallel with the earth's axis, and to make maintenance adjustments to satellite position every few weeks, as required. The gas is a mixture of nitrogen and ammonia, produced by admitting liquid hydrazine into a reaction chamber containing a catalyst which causes it to decompose. All hydrazine storage vessels, control valves, reaction chambers and gas-jet thrusters are duplicated for reliability.

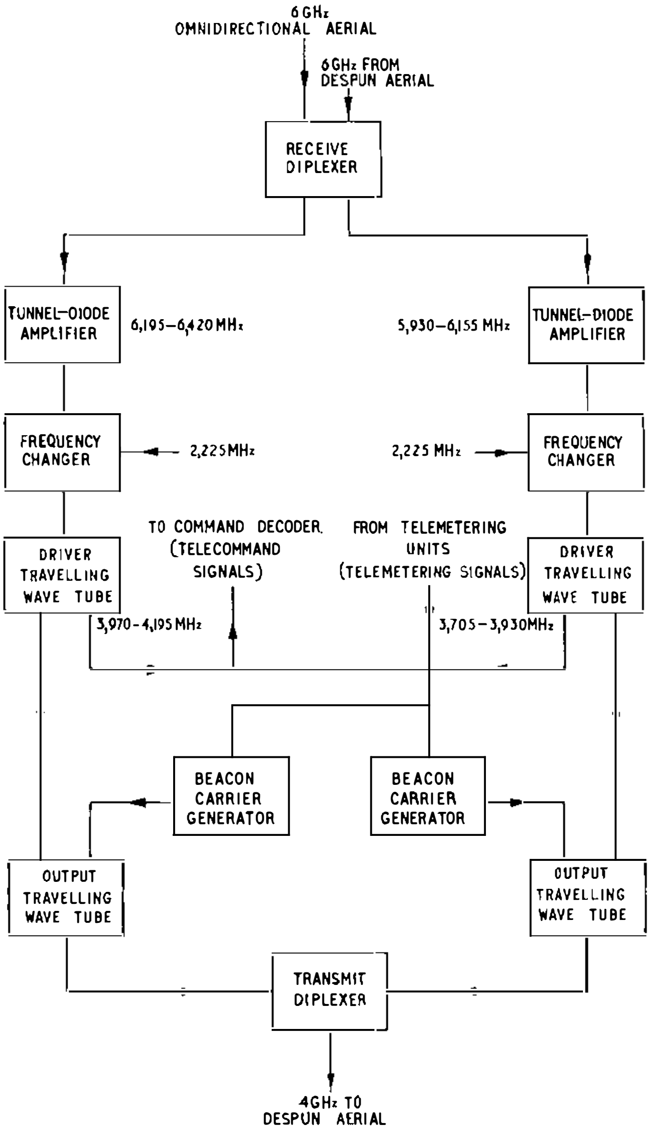

FIG. 4—A simplified block diagram of the INTELSAT III communications equipment.

The Telecommand and Telemetering Sub-system

Four Intelsat satellite-control stations have been set up, at Andover, Maine, USA, at Fucino, Italy, at Carnarvon, Western Australia and Paumala, Hawaii, USA. Their functions will include monitoring the transponders and the power sub-systems of all Intelsat satellites, operating the gas jets of the positioning and orientation sub-systems when required, and making very precise measurements of satellite orbital elements. All of these can be done with the aid of the telecommand and telemetering sub-system. The r.f. carriers used for the telemetering signals from the satellites also serve as tracking beacons for earth stations.

Satellite Deployment

One INTELSAT III satellite is being provided for the Pacific-Ocean Zone and another for the Indian-Ocean Zone located over longitudes 171°E and 62·5°E, respectively. One satellite would not be sufficient for the Atlantic-Ocean Zone even in 1969, so two are to be used, at 6°W and 31°W. This division of the Atlantic-Ocean Zone is unfortunate, since it precludes direct intercommunication between all the earth stations in the zone. For example, Britain will have access to South American stations only via the West German earth station. Situations of this kind will persist until much more powerful satellites are available.

TRANSMISSION CHARACTERISTICS FOR INTELSAT III

The output power of the satellite is low, and the free-space path loss between the satellite and an earth station is approaching 200 dB, i.e. 50 to 60 dB more than that for a typical line-of-sight link. In order to obtain high communication capacity from each satellite, the ICSC has employed four important principles to maximize the efficiency of the system and the performance of earth stations.

Multiple-destination Carriers

Frequency modulation (f.m.) of the earth-station's carrier by telephone carriers in frequency division multiplex (f.d.m.) having been adopted, the first principle is that each station should transmit as few separate carriers as is practicable. Most earth-station links will therefore carry channels intended for reception at several earth stations. Each distant station will receive the carrier transmitted by the satellite, and will extract the channels it wants. Three standard baseband capacities have been adopted, 24, 60 and 132 channels. A station needing more than 132 channels will transmit more than one carrier.

Standard Earth Station Figure-of-Merit

For the present generation of satellites the required satellite carrier power is approximately proportional to the gain of the earth-station aerials in the receiving direction (G_r), and to the inverse of the earth-station system noise-temperature (T_S). These two factors are conveniently combined in the figure-of-merit (G/T) which is numerically equal to $10 \log_{10} G_r/T_S$. The second principle is that all earth stations must reach the high figure of merit of 40·7 dB/°K.

Intermodulation-Noise Dispersal

The various carriers intermodulate in the satellite transponders, and the odd-order intermodulation products could cause severe interference in a proportion of telephone channels. It is not feasible to arrange for the intermodulation products to fall into unused frequency bands. The third principle is to attempt to spread this noise-like energy evenly over the whole bandwidth of the transponder. It is approached in two ways:

(*a*) a low-frequency triangular waveform is used to frequency-modulate television video-carriers all the time, and telephony carriers when the amplitude of traffic signals is low. Thus, the spectrum of all emissions is always well dispersed: in particular no strong carrier-frequency component is ever present. This is called carrier energy dispersal. It follows that the intermodulation-product spectra are also dispersed.

(*b*) carrier-frequency assignments are planned to avoid any build-up of intermodulation noise in particular parts of the transponder frequency spectrum. A typical arrangement is shown in Fig. 5.

Wide Deviation and Small Threshold Margin for Telephony

The signal-to-noise ratio in f.m. basebands varies with the square of the test-tone deviation, provided that the pre-demodulator carrier-to-noise ratio (C/N) exceeds the demodulator threshold. The signal-to-noise ratio falls rapidly as C/N falls below threshold. The fourth principle is to use the widest deviation and the least satellite carrier power consistent with the attainment of both the following objectives:

(*a*) the CCIR recommended channel signal-to-noise ratio to be met under clear-sky propagation conditions, and

(*b*) C/N to be sufficient to exceed the threshold in high-performance extended-threshold demodulators under the

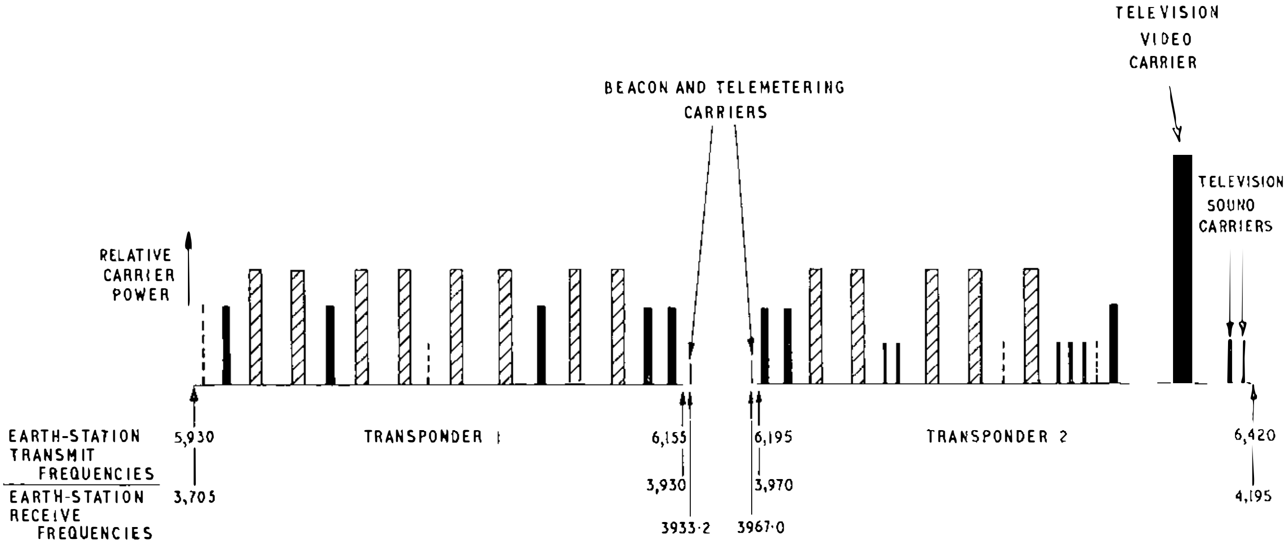

FIG. 5—A typical frequency-assignment plan for an INTELSAT III satellite.

worst propagation conditions commonly arising, i.e. during very heavy rain at the receiving earth-station, assumed to have no radome.

Table 3 shows the chief characteristics of the three standard telephony carriers.

TABLE 3

Characteristics of Telephony Carriers

Baseband Capacity	Channels	24	60	132
Assigned bandwidth	MHz	5	10	20
Test-tone deviation (r.m.s.)	MHz	0·25	0·41	0·63
IF bandwidth	MHz	4·0	8·0	14·4
Threshold margin under clear sky conditions for standard earth stations with good low-threshold demodulators	dB	4·0	4·0	4·0

TELEVISION TRANSMISSION

A video channel of CCIR-recommended performance, received at a standard earth-station with a 4 dB demodulator threshold margin, would need about 75 per cent of the power of one INTELSAT III transponder. The system cannot afford to offer such a high standard yet, and in order not to limit telephone capacity to an unacceptable extent, about 40 per cent of the power of one transponder, and frequency assignments with a total bandwidth of 50 MHz, have been set aside for television, to be used by any earth station as the need arises. Most of this power is used for the video carrier, centred on 6,390/4,165 MHz, with an available bandwidth of 40 MHz. The remainder provides for two multi-channel telephone carriers, used to provide the associated audio-program channels, and cue and control circuits. These emissions are standard 24-channel telephone carriers, wide-band program channels being derived by music-in-band equipment. The picture quality obtained is substantially better than that provided by the less-powerful earlier satellites such as INTELSAT I, and is in fact subjectively almost as good as the CCIR standard.

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Wideband Signal-limiters

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U.D.C. 621.396.1/.4:621.374

The application of a high power-level signal to an f.d.m. wideband transmission system (coaxial line or radio system) will cause the system to become overloaded resulting in the loss of all traffic carried by the system. To prevent overloading, wideband signal-limiters are used. This article considers the performance and design of suitable limiters. Consideration is given to the significant performance aspects including the desired input/output level characteristic and the method of monitoring the peak and mean signal power-levels. The block schematic diagram of a complete limiter is described, together with details of some of the electrical circuit elements.

INTRODUCTION

Standard frequency-bands encountered in repeater stations include a basic group and a basic supergroup. The group is formed by modulating 12 audio channels and assembling the resulting lower-sidebands in the frequency range 60–108 kHz. A supergroup is formed by modulating five groups and assembling the resulting lower-sidebands in the frequency range 312–552 kHz. Further modulation stages are used to form the complete baseband for a wideband-transmission system. If, due to a fault or misoperation, the signal level on any one group or supergroup is allowed to greatly exceed the normal traffic-level, overloading of the wideband-transmission system could occur, resulting in the loss of a large number of circuits. To prevent overloading, wideband signal-limiters can be connected into the group or supergroup transmission-paths at points electrically preceding the group and supergroup modulation stages (referred to as group translating-equipment (G.T.E.) and supergroup translating-equipment (S.T.E.).) Fig. 1 shows signal-level limiters connected to all inputs of G.T.E.s and S.T.E.s.

INPUT/OUTPUT LEVEL CHARACTERISTIC

The input/output signal-level characteristic required of a wideband signal-limiter is shown in Fig. 2. This follows the law of a constant-loss device when signals below certain levels are applied (referred to as the peak and mean-power limit-levels). When signals above these levels are applied, additional loss is introduced into the transmission path and a constant output-level is given.

The input/output signal-level characteristic could be obtained by clipping the applied electrical-waveform so that a distorted waveform, having a constant peak-value, is obtained. This technique is used on audio-limiters; it is not, however, a desirable means of reducing the level on high-frequency (h.f.) transmission-paths carrying many channels, because distortion of the applied-waveform results in the generation of intermodulation products. This causes noise to appear in the group or supergroup band concerned and also in adjacent group or supergroup bands. The circuit used to reduce the signal-level on h.f. limiters is shown in Fig. 3. This is arranged so that the base-emitter impedance (Re) of two transistors is shunting the transmission-path. The value of Re depends on the current passing through the transistors and decreases as the current is increased. By controlling the d.c. current taken by the transistors, the shunting-impedance and, therefore, the loss of the network, can be controlled. Because some signal-current is being shunted through the transistors, the value of Re will tend to vary at the signal-frequency causing some distortion of the waveform. Intermodulation can, however, be contained within acceptable

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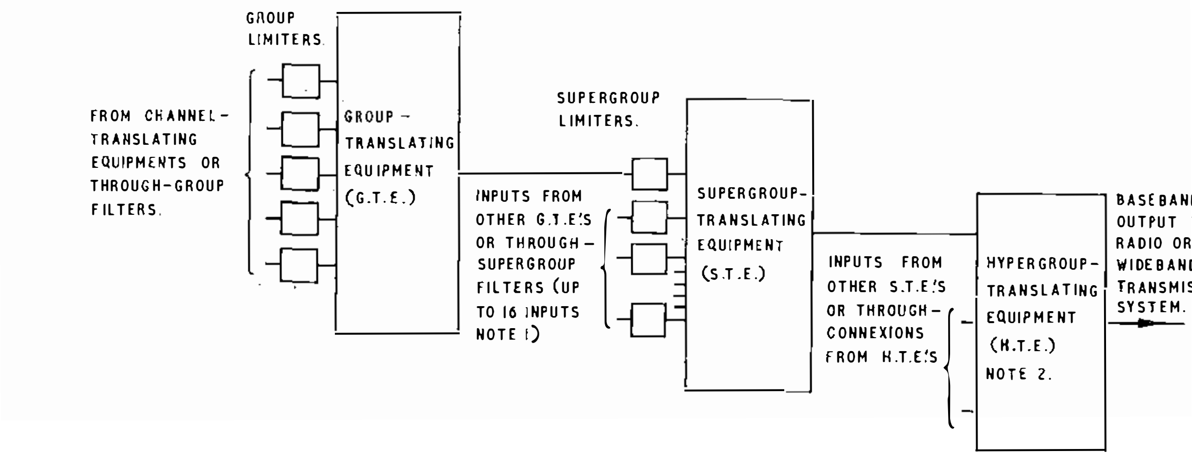


Note:
1. Up to 15 inputs only are used when the S.T.E. output is connected to H.T.E.
2. H.T.E. is used only on transmission systems having a bandwidth greater than 4,028 kHz

FIG. 1—Group and supergroup limiter connexion points

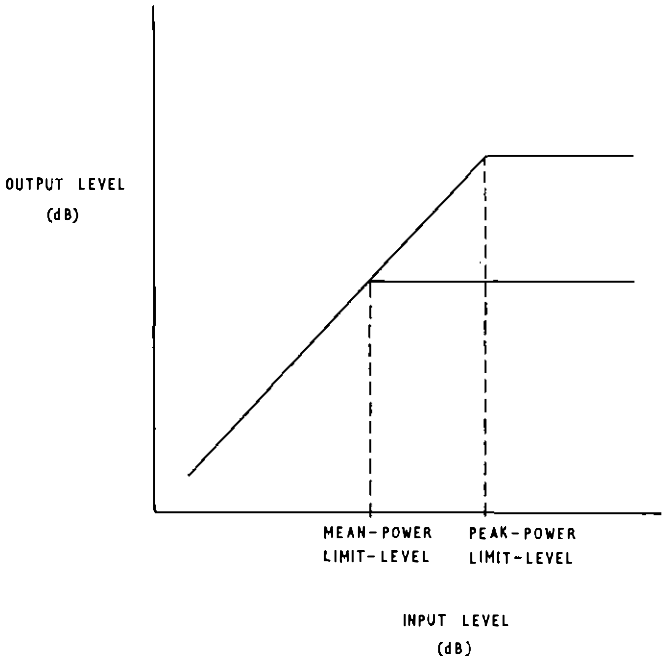


FIG. 2—Input/Output level characteristic of a wideband limiter

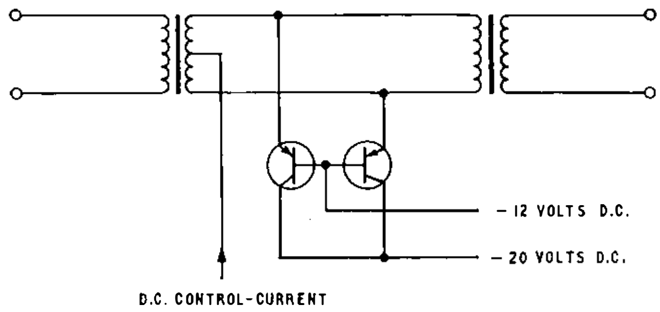


FIG. 3—D.C. controlled variable-loss network

limits by arranging for the d.c. control-current to be large compared with the signal-current. Normally, the network is working in the minimum-loss condition, where the control-current is zero and the shunting effect of the transistors and therefore the intermodulation, is negligible.

MEAN-POWER AND PEAK LIMITING

To fully protect wideband-systems from overload without disturbing genuine traffic it is necessary for wideband-limiters to employ two separate level-monitoring systems which measure the peak and mean values of the applied-signal loading. The instantaneous power loading of the h.f. waveform that exists on a group or supergroup carrying telephone or voice-frequency-telegraph traffic has many short duration, high-level peaks which greatly exceed the long-term average-power loading of the waveform. If genuine traffic is not to be disturbed, these peaks must be allowed to pass through the limiter unrestricted. Wideband-transmission systems are designed to carry these short duration, high-level signals. The application of a signal having a continuous long-term average-power loading close to the normal peak value could, however, result in a transmission-system being overloaded.

The wideband-limiter constantly monitors the peak value of the applied-signal waveform and, if this exceeds a certain power-level, loss is rapidly introduced into the transmission path. Also, the long term mean-power value of the applied waveform is monitored, and if it exceeds a certain power level, which must always be lower than the peak power-level, loss is introduced after a delay period (or recognition-time). This period, which is necessary to recognize that the signal is not genuine traffic, is a function of the applied signal-level. In practice, the peak and mean-power limiting levels are set several decibels higher than those that would normally exist on a group or supergroup carrying traffic. This gives a margin against false operation of the limiter while still giving adequate protection to the transmission system.

DURATION OF RECOGNITION-TIME

To give the maximum protection against overload, it is arranged for the recognition-time of the mean-power limiter to depend upon the applied-signal level. If a signal, with a power level greatly exceeding the mean-power limit-level, is applied to the limiter, the recognition-time is relatively short (Fig. 4). A long recognition-time is applied when the mean-power level of the signal only slightly exceeds the mean-power limit-level. The curve slope ensures that a constant amount of energy is passed to the transmission system during the recognition period, resulting in a recognition-time that is always long enough to prevent false operation of the limiter when genuine traffic is applied, but keeping the energy absorbed by the transmission system below a certain maximum value in a given time.

When signals above a certain level are applied the peak limiter lowers the recognition time to zero. The point at which this occurs is determined by the peak instantaneous-value of the applied signal. The mean-power value at this

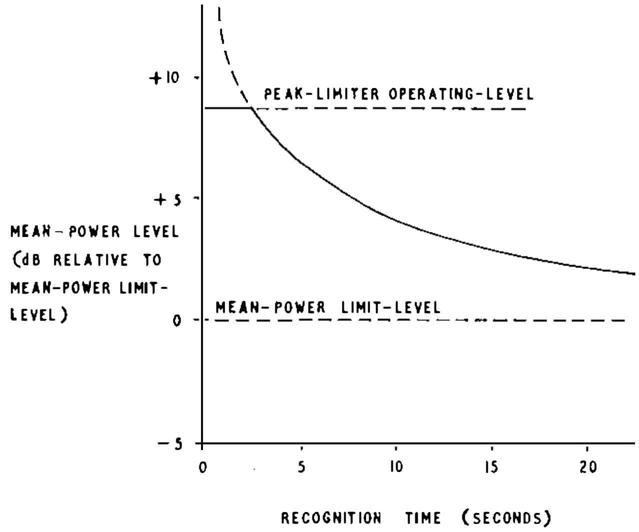


FIG. 4—Curve of signal level against recognition time

point will depend on the waveform shape, and Fig. 4 demonstrates a typical case only. If the applied waveform has high peak and low mean-power levels, it is possible for the peak-limiter to operate at a point which is below the mean-power limit-level.

The mean-power limiter will operate when the mean-power during the recognition period equals certain values. This does not mean that the instantaneous power has to be equal to this value throughout the recognition period. An instantaneous power level that is below the mean-power limit-level for much of the recognition period could still result in a mean-power level that is high enough to operate the limiter.

PEAK-LIMITER OPERATE AND RELEASE TIMES

A periodic waveform having a peak-power value that exceeds the limit level will remain undistorted providing the loss introduced into the transmission path remains constant. If the limiter is able to vary its loss in a time that is comparable with the periodic interval of the applied waveform, the loss will not remain constant and distortion of the waveform shape will result. It is necessary, therefore, to ensure that operation and release of the peak-limiter do not occur too quickly. However, waveforms having a very long periodic-interval will have their shape altered. A high-level sine-wave having low-frequency amplitude-modulation, for example, will appear at the limiter output as a constant-amplitude sine-wave, the modulation being removed by the limiter. Any complex waveform can be shown to consist of a number of sine-waves of different frequencies. The effect of varying the loss in the transmission path is to generate additional sine-waves (sidebands) at frequencies surrounding each of those forming the complex waveform applied to the limiter input. Restricting the response-time of the limiter ensures that sidebands are generated only at frequencies that are close to the frequencies already present at the limiter input and interference to adjacent group or supergroup bands is minimized. The operate and release times selected for a peak-limiter must therefore be a compromise giving reasonably rapid operate and restoration times while ensuring that generation of unwanted sidebands is maintained within acceptable limits. In practice, operate times in the order of 1 ms and restoration times in the order of 5 ms are used.

It is convenient to measure the operate and restoration times of a peak-limiter by applying to the limiter input a high-frequency signal which is amplitude-modulated with a low-frequency square-wave and observing the resultant output-waveform on an oscilloscope. Fig. 5 shows the output waveforms obtained from a supergroup limiter when a 500 kHz sine-wave having 50 Hz square-wave modulation was applied to the input. The level difference between the minimum and maximum values of the input waveform was 20 dB. When the peak value of the applied waveform was made equal to the peak-limit-level, the output (Fig. 5(*a*)), was an h.f. signal that increased in level by 20 dB and then reduced in level by 20 dB, these two conditions being continuously repeated. This is identical to the input. When the peak value of the input waveform was adjusted to be 10 dB above the peak limit level (Fig. 5(*b*)), the 20 dB level increase was followed immediately by a 10 dB level reduction as the limiter operated. Similarly, the 20 dB reduction was followed by a 10 dB increase as the limiter released. With the signal level adjusted to be 30 dB above the limit level (Fig. 5(*c*)), the 20 dB level increase was corrected by the limiter so that the output level remained almost constant (shown enlarged in Fig. 5(*d*)). In this case the 20 dB level reduction was not sufficient to cause the limiter to restore to zero loss and the 20 dB reduction was again corrected by the limiter which was still in the operated state (shown enlarged in Fig. 5(*e*)).

ELECTRICAL DESIGN

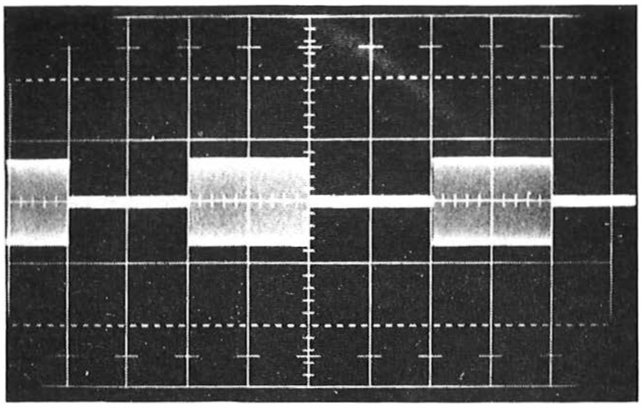
Fig. 6 shows the mechanical details of a supergroup-limiter engineered in 62-type construction practice and a block-schematic diagram of the limiter is shown in Fig. 7. The attenuator preceding the variable-loss network is required to ensure that the input impedance remains reasonably constant over the complete range of transmission loss given by the variable-loss network. This also improves the intermodulation performance by reducing the signal level applied to the variable-loss network. The amplifier, following the variable-loss network, compensates for the loss of the attenuator so that the complete device has an overall gain of unity (0 dB).

The peak-level monitoring circuit comprises an amplifier followed by a rectifier which gives a potential proportional to the peak value of the h.f. waveform present at the limiter output-terminals.

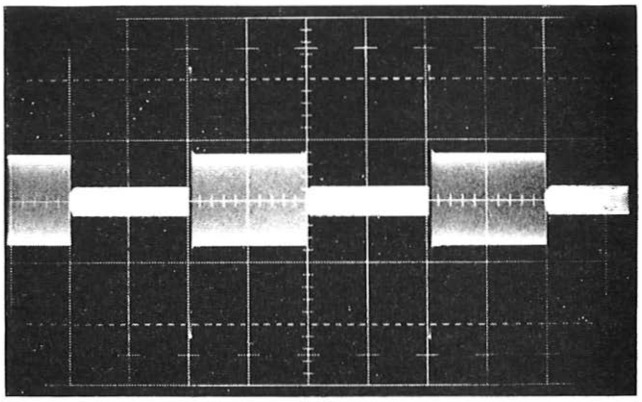
The mean-power monitoring circuit comprises an amplifier followed by a square-law rectifier which gives a d.c. output-voltage proportional to the instantaneous power present at the limiter output-terminals. This voltage is applied to an integrating circuit having a long time-constant resulting in a d.c. voltage being generated that is proportional to the long term mean-power present at the limiter output-terminals. The d.c. outputs from the peak and mean-power monitoring circuits are applied to gates where they are compared with fixed d.c. reference voltages. The gates give no output voltage when the d.c. voltage from the monitoring circuit is less than the reference voltage. An output is, however, given if either of the monitoring circuits generates a d.c. voltage that exceeds the appropriate reference voltage. The outputs from the gates are applied to a d.c. amplifier which controls the variable-loss network.

When the limiter operates, a complete feedback-loop is set up resulting in the variable-loss network being automatically set at the loss required to obtain the input/output signal level characteristic shown in Fig. 2. Since the limiter is a feedback device, careful attention must be given to the design to ensure that a stable condition is reached when the limiter operates.

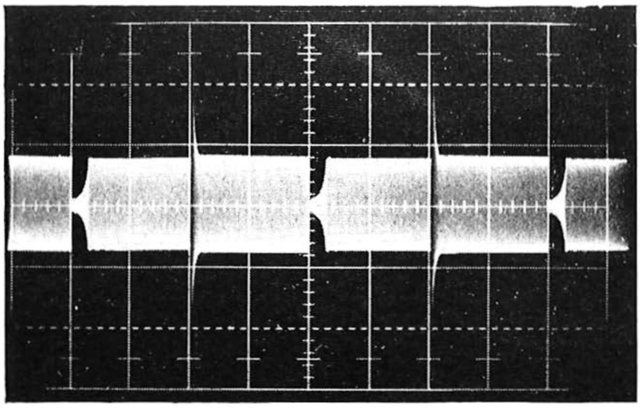
A second output from the d.c. amplifier is used to energize an alarm relay whenever the limiter is operated. This ensures that the repeater-station staff are made aware of the fact that the limiter has operated. A receiving-attention key is provided so that the alarm can be silenced while the source of the high-level signal is being located. There may be occasions when the traffic level on the group or supergroup is higher than normal, perhaps due to a temporary fault condition. When this occurs, it is possible for normal traffic



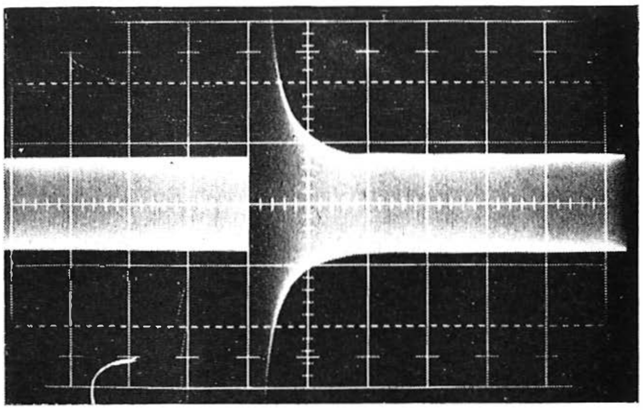
(*a*) Maximum input-signal level equal to the peak-limit level



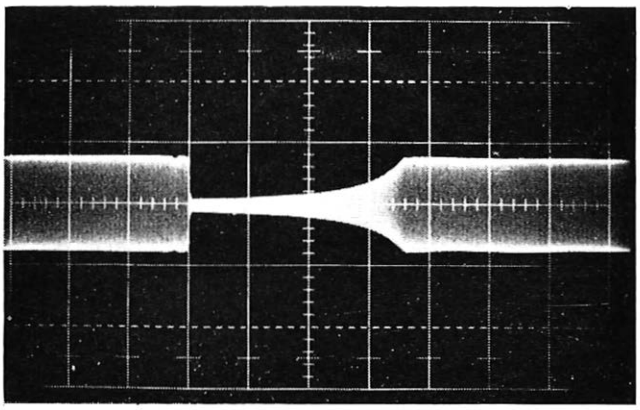
(*b*) Maximum input-signal level exceeds the peak-limit level by 10 db



(*c*) Maximum input-signal level exceeds the peak-limit level by 30 db



(*d*) Part of waveform (*c*) showing the level reduction given by the limiter



(*e*) Part of waveform (*c*) showing the level increase given by the limiter

FIG. 5—Peak-limiter output-waveforms with a h.f. signal input modulated by a low-frequency square-wave

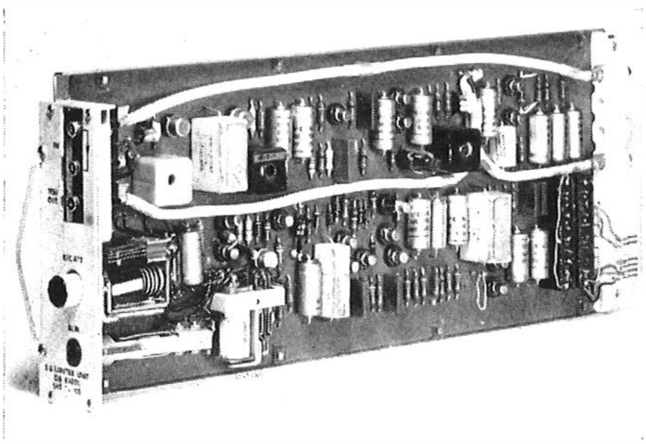


FIG. 6—Mechanical-construction of supergroup-limiter

to cause occasional, short-duration operations of the limiter. A delay-network is therefore included in the alarm circuit to prevent operation of the station alarms when the limiter is momentarily operated.

sinusoidal signal which exceeds the peak limit-level must, after a short recognition-time, cause the mean-power limiter to operate. This makes it difficult to measure the performance of the peak limiter with standard items of repeater-station test equipment which generate sine-waves. A link is, therefore, provided at the output of the mean-power monitoring circuit allowing the mean-power limiting facility to be temporarily disabled so that the performance of the peak limiter can be measured.

USE OF WIDEBAND-LIMITERS ON THE H.F. NETWORK

At the present, the number of wideband transmission-system failures caused by overload are not sufficient to justify the expense of providing wideband-limiters on all inputs to group and supergroup translating equipments. Limiters are provided, therefore, on international supergroup bands only, where the cost of lost circuit-time due to system failures is high.

A possible future use for wideband signal-limiters would be on group and supergroup bands that are fed with wideband signals (e.g. data) from renter's premises.

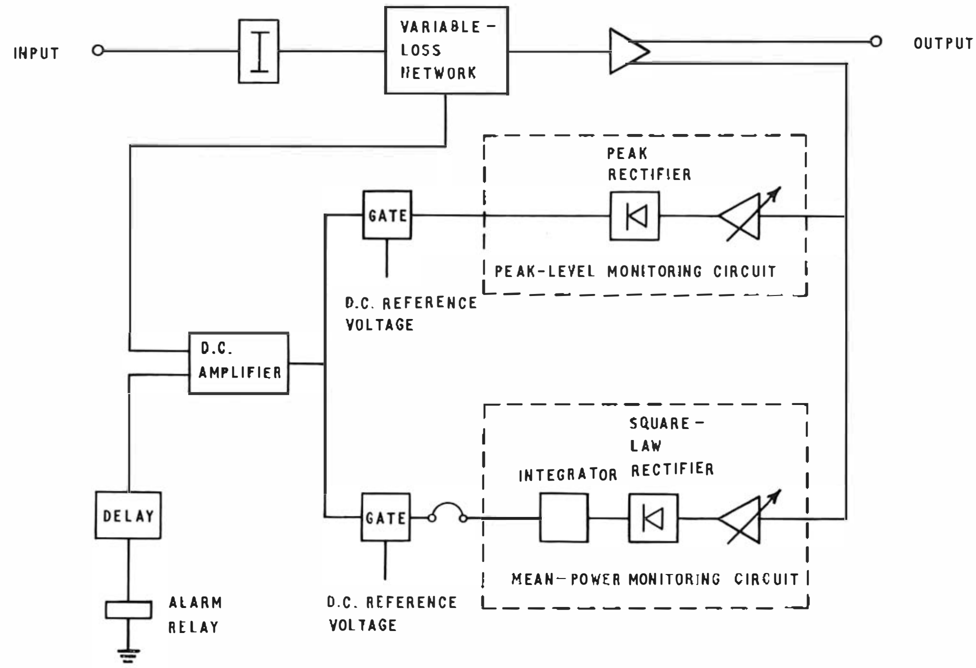


FIG. 7—Block-schematic diagram of wideband-limiter

The peak and mean-power limit-levels required may not be fixed for all occasions. These will be influenced by the nature of the traffic being carried (e.g. telephony, voice-frequency telegraph, data etc.) and the overload margin on the transmission system. The peak and mean-power limit-levels are therefore adjustable over a certain range so that the limiters can be individually set to suit the conditions. The h.f. amplifiers in the monitoring circuit provide a convenient means of adjusting the limit levels and suitable gain-controls are therefore provided on these amplifiers.

When sinusoidal signals are applied, it is not possible to operate the peak limiter, except for short periods, since a

Development of limiters for use on frequency bands wider than the group and supergroup is not being pursued at present because it is considered necessary to apply limiting to bands that contribute a significant portion of the traffic carried by the system being protected. The development of higher bandwidth radio and line transmission systems could, however, create a future demand for limiters suitable for use on wider frequency bands.

ACKNOWLEDGEMENTS

Acknowledgement is made to G.E.C. Ltd. who provided the photographs used in this article.

Flameproof and Intrinsically-Safe Telephone Apparatus

A. F. WEEDON†

U.D.C. 621.395.6: 213.34

In the presence of explosive gas/air mixtures, flameproof telephone apparatus is required. The range of apparatus available has now been extended to include the 700 series telephone.

INTRODUCTION

In situations where there are explosive gas/air mixtures, it is necessary to use flameproof or intrinsically-safe telephone apparatus. This apparatus has existed for many years[1] and has now been brought up to date to include the 700-series type telephone apparatus.

Telephone apparatus contacts (such as the dial, gravity-switch and trembler-bell contacts) which have to break reactive circuits produce sparks during operation and two systems have been developed to prevent these sparks causing damage. The two methods, flameproof and intrinsically-safe, are accepted as normal practice in coal mining, but the need for them in industry is strictly localized.

FLAMEPROOF PROTECTION

This method is applicable to lighting and power installations and depends upon the mechanical design of the apparatus to prevent any explosion inside the case of the apparatus, from igniting the external atmosphere. British Standard 229 defines a flameproof enclosure for electrical apparatus as one that will withstand, without injury, any explosion of the prescribed flammable gas that may occur within it, under practical conditions of operation within the rating of the apparatus (and recognized overloads, if any, associated therewith). It will prevent the transmission of flame such as will ignite the prescribed flammable gas which may be present in the surrounding atmosphere.

These requirements are satisfied by the provision of a substantial case, and by ensuring that joints and other openings provide a sufficiently long and restricted flame-path to prevent external ignition.

A minimum length of joint path and the maximum safe gap between the faces of joints is specified, the latter depending upon the category of gas for which the apparatus is approved, e.g. for group one gases, flanges should be of not less than 1 in breadth and the maximum permitted gap is 0·020 in. Gases and vapours have been classified, in order of their risk, into four main groups. The only gas in group one is methane (fire damp) and group two covers many of the vapours of the oil and paint industries. Group three is split into ethylene gases, (3(*a*)) and the coal-gas group (3(*b*)) and group four contains those gases such as hydrogen for which type approval is not possible, the permissible gap being too small to be practicable.

INTRINSIC SAFETY

This method of protection prevents any ignition, by ensuring that any sparking that may occur in instruments, or on lines, is of such low intensity that it is incapable of igniting the gas or vapour. This protection must be maintained during fault conditions, such as short-circuits and disconnexions as well as under normal working conditions.

† New Exchange Equipment and Customer Station Apparatus Development Branch, Telecommunications Development Department, Telecommunications Headquarters.

The two systems, flameproof protection and intrinsic safety, are quite separate and distinct. Adequate precautions should be taken to prevent contact between the conductors of intrinsically-safe circuits and those of any other system so as to avoid the possibility of arcing occurring at the point of contact or of invasion of the intrinsically-safe circuits by currents arising from contact or induction.

INSTALLATION

The apparatus must be installed carefully to preserve those features on which safety depends. In the case of flameproof apparatus, the wiring has to be in either seamless-conduits, armoured, or other approved cable, properly attached to the terminal-chamber and sealed either by filling with compound or by a cable-sealing gland. The conduit or cable-run needs to be carefully planned to avoid mechanical damage which might break or cut a conductor and thus give rise to a risk of ignition. The system must be regularly inspected and maintained to keep the lines and apparatus fully safe. It is important before opening any apparatus to ensure that the circuit is disconnected from any source of power.

AVAILABLE APPARATUS

There are three flameproof telephones, three bell-sets, a double-pole switch and a mains relay-switch (relay-unit CD 1982) available for use in Post Office installations.

The Telephone 702 (Fig. 1) is a lightweight flameproof

FIG. 1—Telephone 702 with Bell-Set No. 69B and Switch No. 8

desk-telephone and in association with Bell-Set No. 69B and Switch No. 8 (to isolate the line whilst working in the telephone) is for use in offices and laboratories. The instrument is suitable for use on 1,000-ohm lines. A press-button, fitted in the instrument, can be used for operator recall or transfer. The bell-set is for wall mounting adjacent to the telephone. Since it is impractical to make the handset flameproof, the handset with cord is made intrinsically safe by providing isolating transformers fitted within the flameproof enclosure and connected between both transmitter and receiver and the remainder of the circuit. The capsule used for the transmitter is a rocking-armature receiver (Receiver Inset No. 4T), the output being amplified by a two-stage transistor amplifier (Fig. 2). The power for the amplifier is obtained from the line via a non-linear resistor, RX, and rectifier bridge to ensure the correct polarity. The remainder of the circuit is the same as for the Telephone 746.

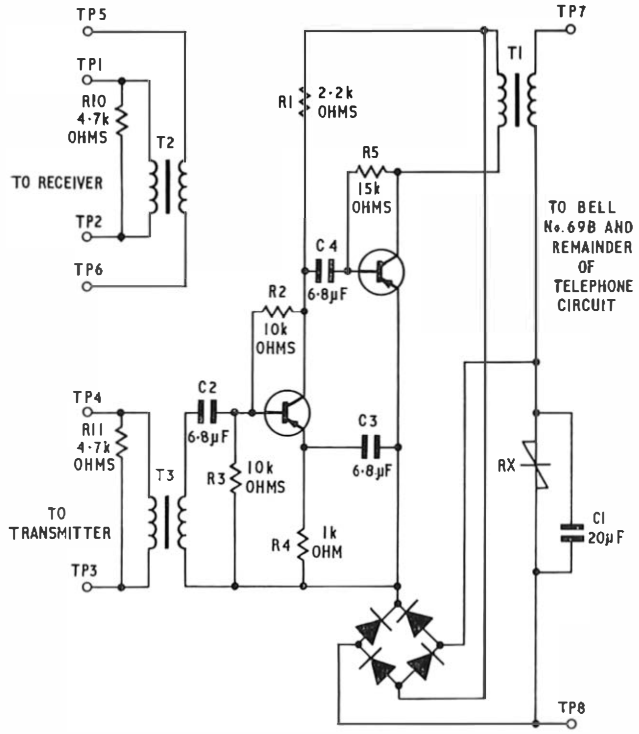


FIG. 2—Part of the circuit diagram of Telephone 702 showing the two-stage transistor amplifier

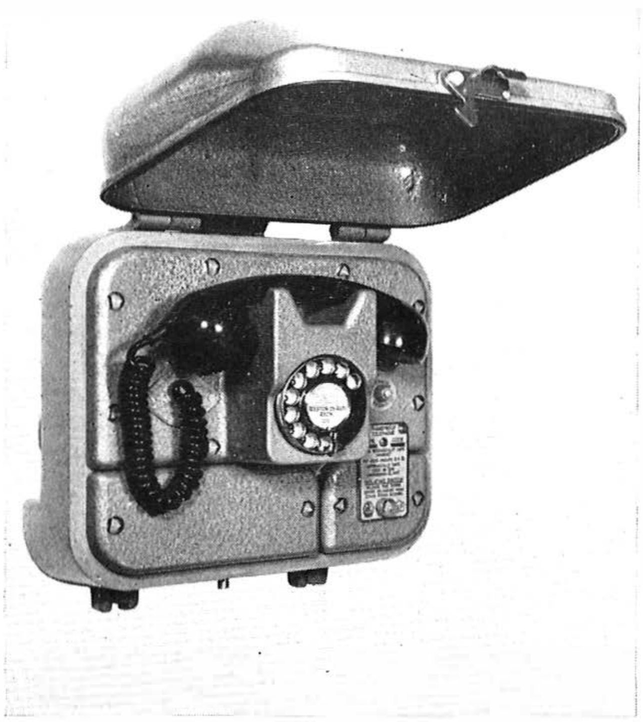


FIG. 3—Telephone 703

The Telephone 703 (Fig. 3) is a wall-mounted telephone with a weatherproof cover for automatic and central battery working. Electrically it is similar to the Telephone 702 with Bell-Set 69A and Switch No. 8. It is a self-contained wall-type telephone and it is so arranged, by interlocking plates, that the line is disconnected by a switch when the telephone cover is removed.

The third instrument (Telephone 723) is a wall-mounted telephone (Fig. 4) with a weatherproof cover for magneto working. It has an intrinsically safe handset and amplifier

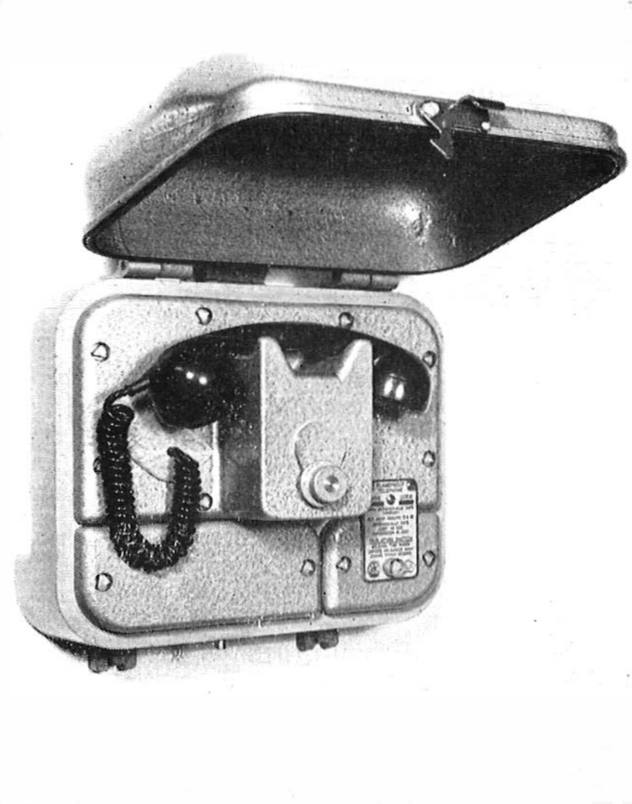


FIG. 4—Telephone 723

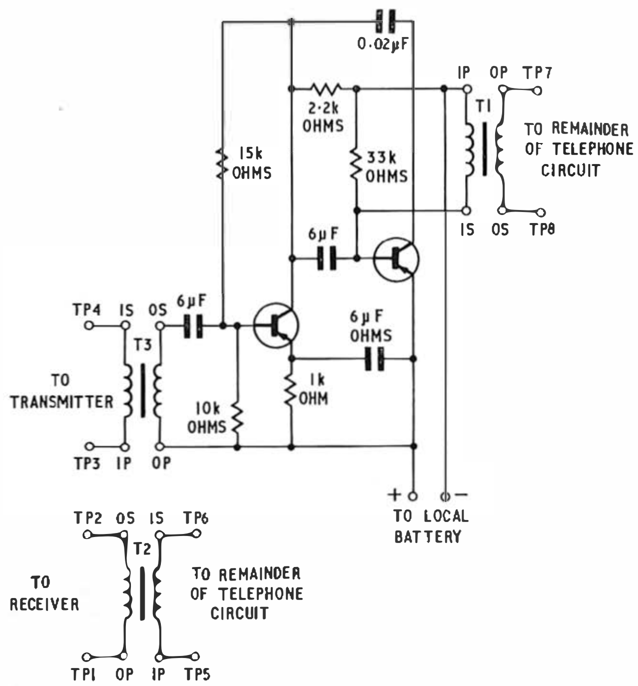


FIG. 5—Part of the circuit diagram of Telephone 723 showing the two-stage transistor amplifier

similar to the Telephone No. 702 (Fig. 5). The amplifier power-supply is obtained from an intrinsically-safe battery fitted inside the telephone. These batteries have a current-limiting resistor fitted inside the case of the battery.

CONCLUSIONS

This new range of flameproof telephone apparatus will extend the line limits, over which service can be given, to 1,000-ohm transmission equivalent resistance (t.e.r.) and also extend the range of 700-type telephones to include this field of application.

Reference

[1] ARNOLD, C. W. Flameproof Telephone Apparatus. *P.O.E.E.J.*, Vol. 37, p. 81, Oct. 1944.

Cable Pulling Eyes

J. P. RICHARDS†

U.D.C. 621.86.06: 621.315.232

Some form of pulling device must be fitted to each length of cable so that it can be pulled into its duct. The development and construction of a new pulling eye to replace the old cable grip is described. The new device can be fitted in the field quickly and is available in different sizes.

INTRODUCTION

Introduction of cabling in longer lengths and the drive for increased productivity by cabling gangs has drawn attention to the undue proportion of cabling time spent fitting cable grips to cable ends. The possibility of asking cable contractors to fit suitable pulling eyes on cable lengths prior to their dispatch from their works was considered. Existing types of factory-fitted cable eye employ a standard "D" shackle for drawing-in and this occupies 2¼ in of free space. As 70 per cent of all lengths installed in the Post Office are drawn over existing cables the use of this type of eye was ruled out. Also, factory-fitted eyes can only be used for the first length of cable pulled from the drum; subsequent lengths must use field fitted eyes. A pulling eye that could be easily and quickly fitted in the field without increasing the cable diameter has therefore been designed.

† Civil and Mechanical Engineering Branch, Telecommunications Development Department, Telecommunications Headquarters.

DESIGN OF THE NEW CABLE PULLING EYE

In the chosen design the cable conductors are trapped in a screw-type compression joint. The eye depends for its successful operation on the sliding action between two cones and increasing the tension increases the compression force on the conductors.

The method of attachment (shown in Fig. 1) is as follows:

(*a*) A reversed taper spike is first driven into the end of the cable using a special drift to protect the screwed shank of the spike. The drift is marked so that the spike is driven in the correct distance.

(*b*) One and a half inches of the cable sheath are removed exposing the conductors.

(*c*) A tapered collar is passed over the exposed conductors and pushed on as far as it will go, thus forcing the conductors down on to the reverse cone of the spike.

(*d*) A washer is fitted over the screwed shank of the spike so that it rests on the shoulder of the tapered collar and a nut is screwed on, forcing the tapered collar down on to the

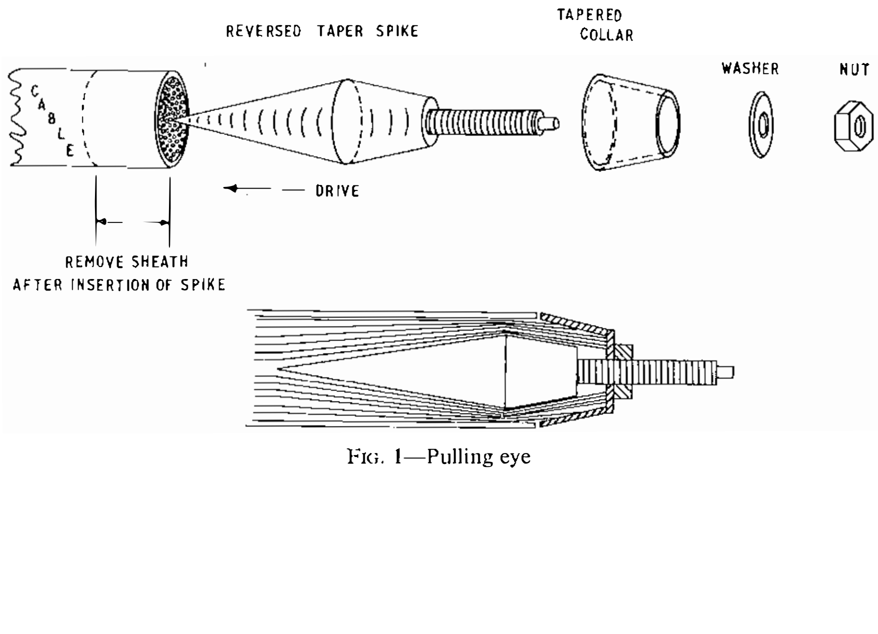


FIG. 1—Pulling eye

conductors and pulling the reverse cone of the spike into the collar. The conductors are thus trapped between the spike and the collar. The dimensions of the spike and collar are such that when all the conductors are trapped it is impossible to withdraw the spike through the collar.

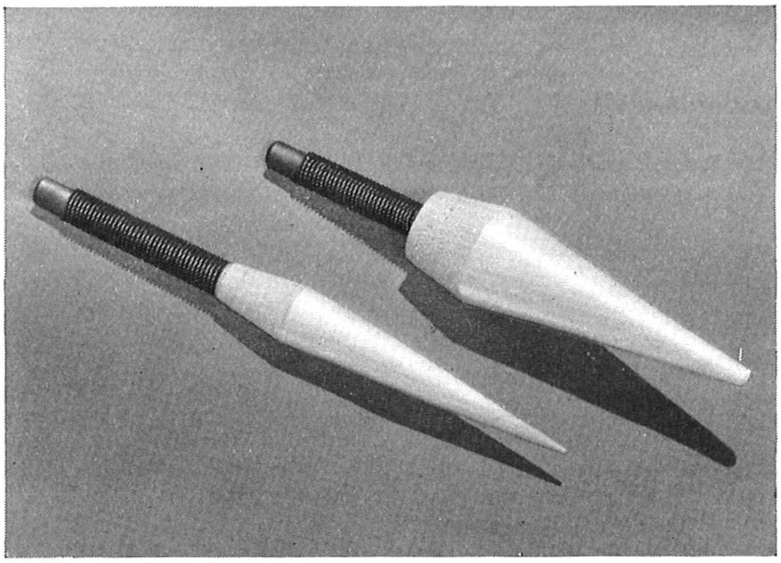


FIG. 2—Experimental pulling eye with plastic spike

(*e*) The collar is taped to the end of the sheath to prevent the entry of water during the cabling operation. A typical complete eye unit can be fitted in approximately eight minutes. This compares with 25–30 minutes for a conventional cable grip.

EXPERIENCE

The new pulling eye has been in general use for 12 months on local cables and field trials have been carried out by cabling contractors on trunk and junction cables.

The 12 months field experience has shown:

(*a*) When rigging a snatch block or a cable sheave in a manhole, it is necessary to have the block or sheave in line with the duct into which the cable is being pulled otherwise the screwed shank of the spike may be bent.

(*b*) The smallest type of pulling eye has to be fitted with extreme care as no shoulder exists to drive it into the cable end using the drift.

(*c*) The present method of connexion of eye to swivel is too rigid and the screwed shank tends to bend on heavy pulls when the duct deviates.

(*d*) The small size spikes have bullet-shaped ends and these tend to punch back the core of the cable unless extreme care is taken.

FURTHER DEVELOPMENTS

As the new pulling eye shows considerable promise experiments are being carried out using a plastic tapered-spike having a screwed shank with an integral driving head (Fig. 2). This will make the drift unnecessary. It is also planned to lengthen and taper the smaller spikes to a point to avoid punching back the core of the cable when the spike is being inserted.

It is intended to experiment with a short wire strap between the pulling eye and swivel to reduce the overall rigidity of the unit, and thus overcome the tendency of the present shank to bend or break.

Improving Underground Maintenance—Part 1—The Investigation

C. C. THAIN and D. R. WELLS†

U.D.C. 624.194.044.5

A description is given of the investigation stage of a work study of local-line underground maintenance, leading to the proposal of a new improved method. The second part of the article will describe how a field trial of this proposed method was conducted.

INTRODUCTION

Most telephone engineers find themselves at some stage of their careers involved in management. It is thought, therefore, that a brief case history of part of an investigation of a specialist technical organization will be of interest to show not only how decisions are taken to change the existing organization, but also how management techniques can highlight areas where technical improvements are desirable. The assignment was given to a Headquarters work-study unit in April 1966 and had the following terms of reference.

"To investigate the control and execution of underground-plant maintenance in both the main-line and local-line fields, and to make recommendations designed to achieve the highest productivity compatible with the required standard of service."

A preliminary survey showed that the assignment could be divided into two parts, main lines and local lines, and that the latter could be further sub-divided into functional activities as shown in Fig. 1. The first activity investigated was the restoration of service due to underground-plant defects in the local-line network, and this article deals with this investigation.

Two work-study techniques were used for the investigation:

(*a*) multiple activity charting (144 days spent in 24 Telephone Areas by 3 Headquarters observers and 20 Area observers), and

(*b*) sampling of fault statistics.

The sampling of fault statistics was facilitated by having a complete record of all underground (UG) faults (79,250) that occurred in nine Areas between 1 April 1964 and 31 March 1965, thus enabling validity checks to be made of the small samples obtained from individual controls and by direct observation.

† Major Projects Division, Management Services Department, Telecommunications Headquarters.

RESULTS FROM DIRECT OBSERVATION

Although the principle of solo jointing on maintenance was accepted before the investigation commenced, it was found that a maintenance jointer rarely worked entirely alone, and when he did his work was usually confined to jobs such as cabinet and pillar maintenance, where his jointing skill was seldom required. In consequence, 31 of the 32 periods of direct observation of UG fault clearance were with two-man jointing parties. Details of the time spent on various activities by such parties is given in Table 1.

Whilst the employment of the senior member of the party was far from good the second man was definitely under employed. Analysis of the multiple activity charts showed that 80 per cent of all faults dealt with by two-man parties could have been completed by one man working alone.

All but one of the nine two-man parties observed by Headquarters staff, were equipped with a bridge Megger, suitable for Varley tests, and a tone set.

Some had, in addition, a small Megger for insulation tests and/or a disconnexion locator. Table 2 shows the percentage of time spent making different tests. It is significant that 83 per cent of testing time was used for tests which did not locate the fault to a particular point. This was because whilst the party had the equipment to make fault locations, they tended to use Varley tests only as a last resort. In conse-

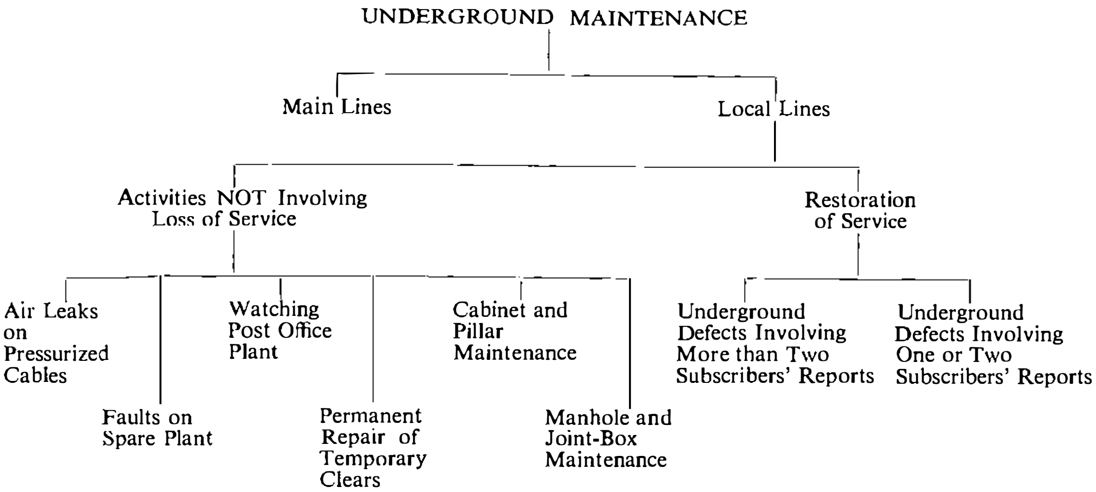


FIG. 1—Division of activities making up underground maintenance

TABLE 1

Activity Analysis for Two-Man Maintenance Jointing Parties

Type of Activity	Percentage of Total Time		
	Man No. 1	Man No. 2	Party
Testing and faulting	14	8	11
Jointing, jumpering, digging etc. ..	16	10	13
Ancillary time (tools, stores, paper work etc.)	27	21	24
Non-productive activities (tea, waiting, travelling etc.)	43	61	52

quence, requests for assistance with Varley tests were common. It was clear, however, that the average maintenance jointer was capable of completing simple Varley tests over distances of up to a mile, provided the method was explained in a non-technical manner, and that calculations were reduced or eliminated by tables or other aids.

The practice of locating faults by the "halving" method involves the opening and closing of joints purely for testing purposes. Direct observation showed that such action reduced the reliability of joints.

Direct observation also showed that many directly-buried polythene cables and some polythene cables in duct were completely filled with water, and that in such conditions the silicon-filled jointing-sleeves did not appear to completely prevent faults occurring.

Although maintenance jointers and most of their first-line supervising officers were emphatic that a 15-cwt vehicle was too small for underground maintenance, the observers were surprised at the very small quantity of tools and stores used each day. They soon formed the opinion that the 15-cwt van is adequate for dealing with most underground defects in the local-line network, provided tools and stores are rationalized and standardized.

Direct observation also showed that the methods used to maintain the older types of underground plant were not always satisfactory and often led to undesirable non-standard practices. This was due primarily to insufficient instruction.

RESULTS OF SAMPLING FAULT STATISTICS

The average out-of-service time caused by an underground plant defect was found to be 50 hours, and a breakdown of this time is given in Table 3. It is significant that 80 per cent of the time is incurred in getting the fault to a party capable of dealing with it.

It is desirable to ascertain if the fault rate is changing significantly; a rising UG fault rate corresponds to an annual loss of productivity measured in underground maintenance manhours per underground line. Such an increase would tend to cancel out any reduction in costs achieved by improved organization of work. Unfortunately, the number of UG faults is dependent upon many factors, some natural (e.g. amount of rain) and some man-made (e.g. amount of underground development work) which tend to have cyclic periods of about a year. It was found difficult, therefore, to obtain reliable data for a sufficient period to draw valid conclusions. It was clear, however, that some Areas do have a rising UG fault rate and an example is illustrated by Fig. 2, where the trend line over a period of six years shows the rise. The need to base such trends over a period of several years is illustrated by the large variation in the fault rate in the December quarters of 1964 and 1965 (i.e. 0·088 and 0·184 UG faults per working underground line per annum).

Table 4 shows the number of faults sustained by different sizes of cable. It is significant that only 3 per cent to 6 per cent of cable defects were on cables of over 100 pairs.

Table 5 shows the way in which UG faults were cleared. The results obtained from direct observation tend to be

TABLE 2

Time Spent on Various Types of Tests by Jointers

		Percentage of Overall Time	Percentage of Testing Time
Tests which Prove Presence of Fault without Indicating Location	Insulation test with Megger	2·6	30
	Test with tone and amplifier	2·3	27
	Test with cell and detector No. 4	1·0	11
	Test from test desk or test set	0·8	10
	Test with telephone	0·4	5
	Total	7·1	83
Tests which Indicate Location of Fault	Varley test (including calculations)	1·1	13
	Test with disconnexion-locator	0·3	4
	Total	1·4	17

TABLE 3

Average Out-of-Service Time Caused by an Underground Defect

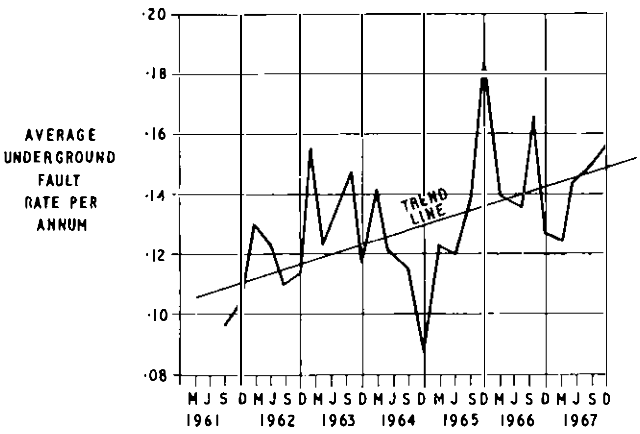
	Time for Repair Service Control Organization to Prove Fault is Underground		Time for Underground Maintenance Organization to Clear Fault		Total Out-of-Service Time in Hours
	Time fault held waiting issue to to lineman	Time taken by lineman to locate fault in underground plant	Time fault held waiting issue to jointer	Time taken by jointer to clear fault	
Average Out-of-Service Time in Hours	12	11	17	10	50
Percentage of Total Out-of-Service Time	24	22	34	20	
	80			20	

TABLE 4
Sizes of Cables Involved in Faults

		Cable Size							
		1 or 2 pairs	3 to 7 pairs	8 to 15 pairs	16 to 30 pairs	31 to 50 pairs	51 to 100 pairs	101 to 300 pairs	Over 300 pairs
Number of Faults	Large sample collected in 1964/65	6,941	1,624	5,306	2,195	1,138	1,255	593	127
	Small sample collected during investigation	14	6	37	22	9	14	6	. .
	Direct observation	11	2	10	13	—	1	1	—
Percentage of Total Faults Recorded Above	Large sample collected in 1964/65	36	8	28	11	6	7	3	1
	Small sample collected during investigation	13	6	34	20	8	13	6	—
	Direct observation	29	5	26	34	—	3	3	—

TABLE 5
Methods of Clearing Faults Reported as being in Underground Plant

		Number of Faults			Percentage of Total Faults				
					Large sample 1964/65				
		Large sample 1964/65	Small sample collected during investigation	Direct observation	Highest Area	Lowest Area	Average	Small sample collected during investigation	Direct observation
Fault Cleared in Underground Plant	Cleared *in situ*	—	88	37	—	—	—	42	49
	Renewed	—	47	7	—	—	—	23	9
	Total	58, 514	135	44	84	59	74	65	58
Restore Service by Changing-out Pair	Changed-out between flexibility points	—	10	8	—	—	—	5	11
	Changed-out in joint	—	42	12	—	—	—	20	16
	Total	11,044	52	20	29	6	14	25	27
Fault not in Underground Plant	Right-when-tested by jointer	—	8	4	—	—	—	4	5
	Cleared while localizing	—	7	1	—	—	—	3	1
	Fault proved out of underground	—	5	6	—	—	—	2	8
	Total	9,692	20	11	15	7	12	9	14
	Total Faults	79,250	207	75	—	—	—	—	—



Note: The trend line shows that the service given by underground plant worsened by 33 per cent in 6 years

FIG. 2—Average UG fault reports per working underground pair per annum plotted quarterly for one area only

biased because the investigation was slanted towards the smaller type of fault, this producing more "fault not found in underground plant" and "restore service by changing-out pair." When a fault exists but is not found in underground plant, a long out-of-service time combined with multiple visits to the subscriber can be expected. Of all faults reported as being due to underground plant defects 7 per cent to 15 per cent were subsequently found to have been incorrectly diagnosed.

SUMMARY OF RESULTS OF INVESTIGATION

(*a*) About 80 per cent of underground-plant defects involve only one or two subscribers' reports of service difficulty.

(*b*) About 80 per cent of these cases can be dealt with by one man.

(*c*) About 80 per cent of out-of-service time due to underground-plant defects is incurred in getting details of the fault to a party capable of restoring service.

(*d*) About 95 per cent of all cable defects occur in cables of 100 pairs or less.

(*e*) Tests which directly locate a fault arc within the capabilities of a maintenance jointer but are insufficiently used.

(*f*) The constant opening and closing of joints, necessitated by the "halving" method of faulting, reduces the reliability of the joints.

(*g*) Some polythene-insulated cables, especially those directly buried, are water-logged and have a high fault liability.

(*h*) There are insufficient instructions showing how the older types of plant should be repaired to reduce their fault liability.

(*i*) The UG fault rate is rising in some Areas.

(*j*) With standardized tool and store kits, a 15-cwt vehicle is adequate for a solo maintenance jointer.

(*k*) No defect could be found in the underground plant in about 10 per cent of the cases reported as requiring the attention of specialist underground-maintenance staff.

DEVELOPMENT OF NEW METHODS

The standard of service given by underground plant, and the cost of maintaining it, are dependent upon the number of defects. The first and best approach to method improvement is to eliminate or reduce the work required to be done. In this case, however, reduction in the number of defects is mainly a technical problem beyond the scope of work study. In consequence it was suggested to the appropriate authorities that the following problems, some of which were already being investigated, should receive special attention.

(*a*) The UG fault rate is rising in some Areas.

(*b*) "Halving" methods of UG faulting increase the fault liability of joints and better testing methods should be used.

(*c*) There are insufficient instructions giving suitable methods of repairing the older types of underground plant.

(*d*) Many existing polythene-insulated cables are water-logged and it is desirable for new cables to be developed to either prevent or restrict the extent to which water can enter the cable due to isolated sheath damage.

The second approach to method improvement is to eliminate links in the existing work chain, combining this with the elimination of unnecessary labour. This can be done with the aid of flow process charts as illustrated in Fig. 3. This shows the existing method, the best theoretical method and the new method accepted for a field trial. It will be noted that the best theoretical method includes only the essential activities of the

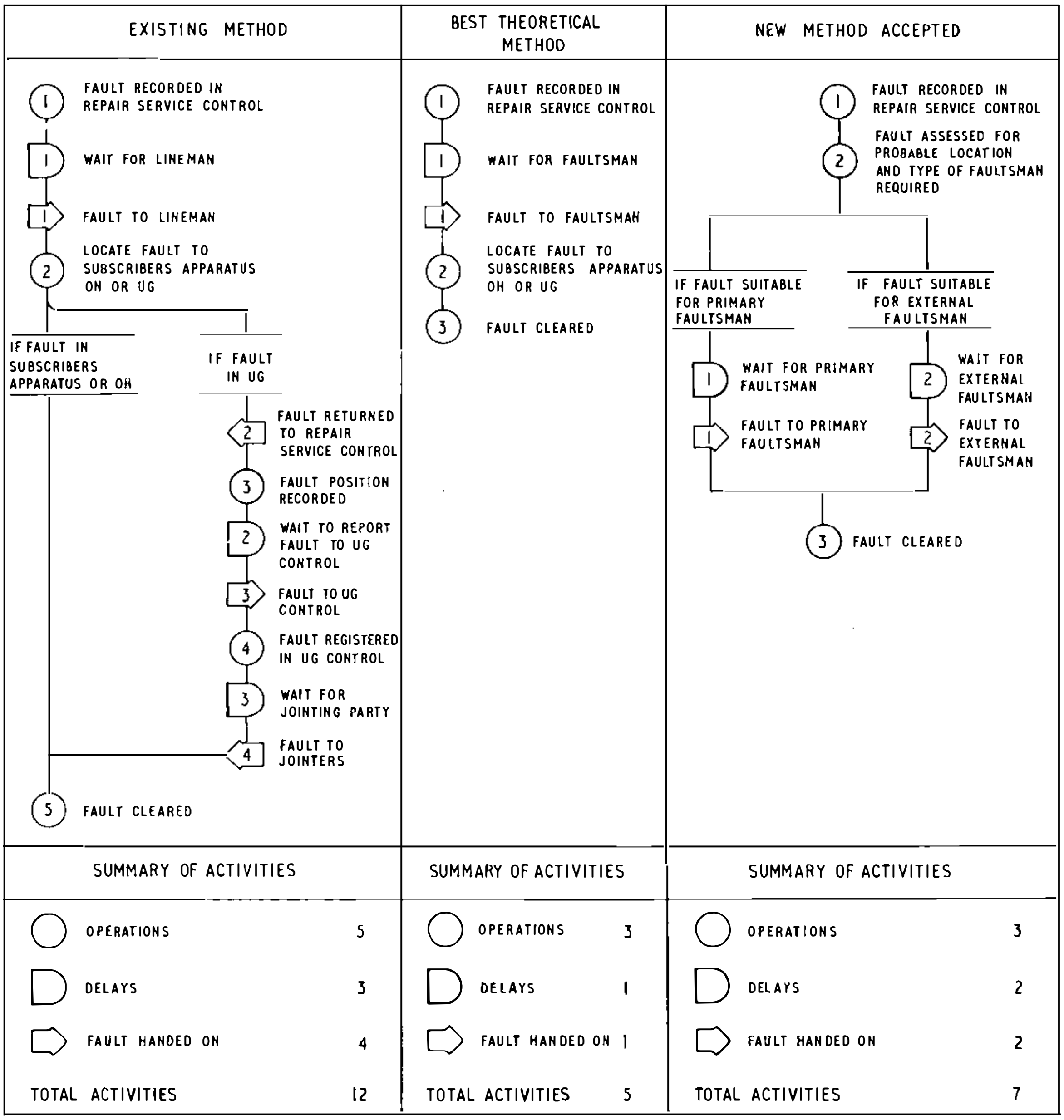


Chart Starts: Fault Recorded in Repair Service Control   Chart Ends: Fault Cleared   UG: Underground   OH: Overhead

FIG. 3—Flow process charts dealing with fault capable of being dealt with by one man working alone

existing method, and the activities involved in clearing a fault have been reduced from 12 to 5, thus reducing both costs and out-of-service time.

At this stage the new method was confined to those faults that could be handled by one man, either alone or with the occasional assistance of a second man, leaving consideration of work beyond this capacity until the results of the first stage had been obtained from a field trial.

The Best Theoretical Method

Critical examination of the facts arising from the investigation indicated that the best theoretical method of improving productivity and service, in the field concerned, would be for:

(*a*) the Repair Service Control (R.S.C.) to assume responsibility for all UG faults that can be cleared by a solo faultsman working alone or with occasional assistance from a second faultsman,

(*b*) a solo faultsman to deal with faults in overhead and underground plant, together with those on simple subscribers' apparatus. Such a man would work on a territorial basis and be termed a comprehensive faultsman.

The advantages of this method would be that the fault distribution procedure in the R.S.C. would remain unchanged, errors in fault allocation to staff would be reduced, and all work within the capabilities of one man dealt with at the first visit. Further, if a comprehensive faultsman could not clear a fault he would be able to assist the report-control officer with a decision as to further action.

The concept of the comprehensive faultsman has its drawbacks. Training and equipment costs would be high and implementation would necessarily be slow. In consequence a less-radical solution was adopted which was more closely in line with existing skills and responsibilities. This is outlined below.

The Proposed Method

The revised method incorporated most of the principles of the best theoretical method except that faulting work would be divided between two faultsmen with overlapping skills and areas of responsibility. These are termed primary faultsmen and external faultsmen and the types of fault they would deal with are given in Table 6.

TABLE 6
Duties of Primary and External Faultsmen

Type of fault handled	Primary Faultsman	External Faultsman
All subscribers' apparatus	Yes	No
All overhead	Yes	Yes
Cabinet and pillar, pin and jumper ..	Yes	Yes
Restoring service by changing to spare plant between flexibility points ..	Yes	Yes
Underground plant	No	Yes

Introducing two types of faultsman would mean that the report-control officer (old-style test clerk) must determine to whom a fault should be given in the first instance, and the effectiveness of the method will be dependent upon his ability to do this correctly. To minimize the effect of an incorrect diagnosis the maximum of overlap in the duties of the two types of faultsman has been recommended. In addition, emphasis would be placed on changing over to spare plant to restore service if the fault could not be cleared.

With the report-control officer playing a key role in the proposed scheme, it is essential that he has responsibility for all faults in a geographical territory and controls a mixed group of primary and external faultsmen. This ensures that the effects of incorrect diagnosis are not transferred elsewhere, giving a motivation towards correct diagnosis and a measure of his effectiveness.

In January 1967 it was agreed that a field trial of the proposed method would be conducted in Bristol Area and Part 2 of this article will describe how this was conducted, and the conclusions reached.

Auxiliary Units for Use with Lamp-Signalling Cordless P.M.B.X.s

F. W. WOOD†

U.D.C. 621.395.23

The connexion of internal extensions to cordless P.M.B.X.s requires four wires. For external extensions and private wires, only two wires are available and hence a series of auxiliary units has been developed to enable these extensions to be connected to the cordless P.M.B.X.s.

INTRODUCTION

The range of lamp-signalling cordless P.M.B.X.s (P.M.B.X.s 2/— and 3/—) has been fully described in previous articles.[1,2,3] A feature of this type of P.M.B.X. is the use of four wires (A, B, C and earth) to connect each internal extension telephone to the switchboard. When the handset of the extension telephone is lifted the switchboard is signalled by a loop applied to the A and B-wires. Supervisory signals are given by the connexion of an earth to the C-wire when the extension user either presses the operator-recall button or replaces the handset on the telephone.

Usually only two external wires are available when it is required to terminate an external extension or private circuit at this type of P.M.B.X. Furthermore different types of line-signalling conditions will be encountered. Therefore, it is necessary to connect a Unit, Auxiliary Apparatus (U.A.A.) between the incoming line and the switchboard, to convert the line-signalling conditions to a form compatible with the switchboard.

Several different types of U.A.A. are available to meet most of the line-signalling conditions likely to be encountered on private circuits and external extensions terminating at this type of P.M.B.X. A list of the available U.A.A. and the signalling conditions which each can provide is given in the table.

U.A.A. Type No.	Signalling Applications
96 96A	External extensions (2-wire)
97	Earth-one-line, Generator a.c., Loop, Automatic balanced-battery — with supervision
98	Generator a.c., Generator balanced-battery — without supervision Automatic balanced-battery in and generator balanced-battery out with incoming supervision only.
99	Loop and earth-dialling to standard P.A.B.X.s
99A	Generator a.c. in, loop dialling out in addition to the facilities offered by the U.A.A. No. 99
100	S.C.D.C. dialling into standard P.A.B.X.s

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PHYSICAL DESIGN

The U.A.A. is encased in a metal box with two mounting brackets fitted to the base of it. These provide a gap of about 1 in between the base plate of the U.A.A. and the surface on which it is mounted to enable interconnecting cables to be routed behind the unit, out of sight. All U.A.A. have standard dimensions of 12 in wide and 7¼ in deep. The height of the unit is 6¾ in for U.A.A.s 96–98 and 8$\frac{11}{16}$ in for U.A.A.s 99–100. All outside surfaces are smooth and finished in elephant grey to match other equipment of this type used at P.M.B.X. installations.

The components are mounted on a flat steel base-plate, Fig. 1, which is provided with a removable protecting cover made of sheet-metal. Relays and other larger components are

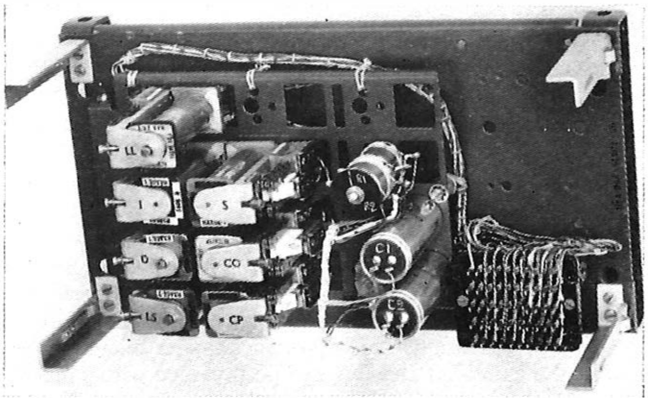
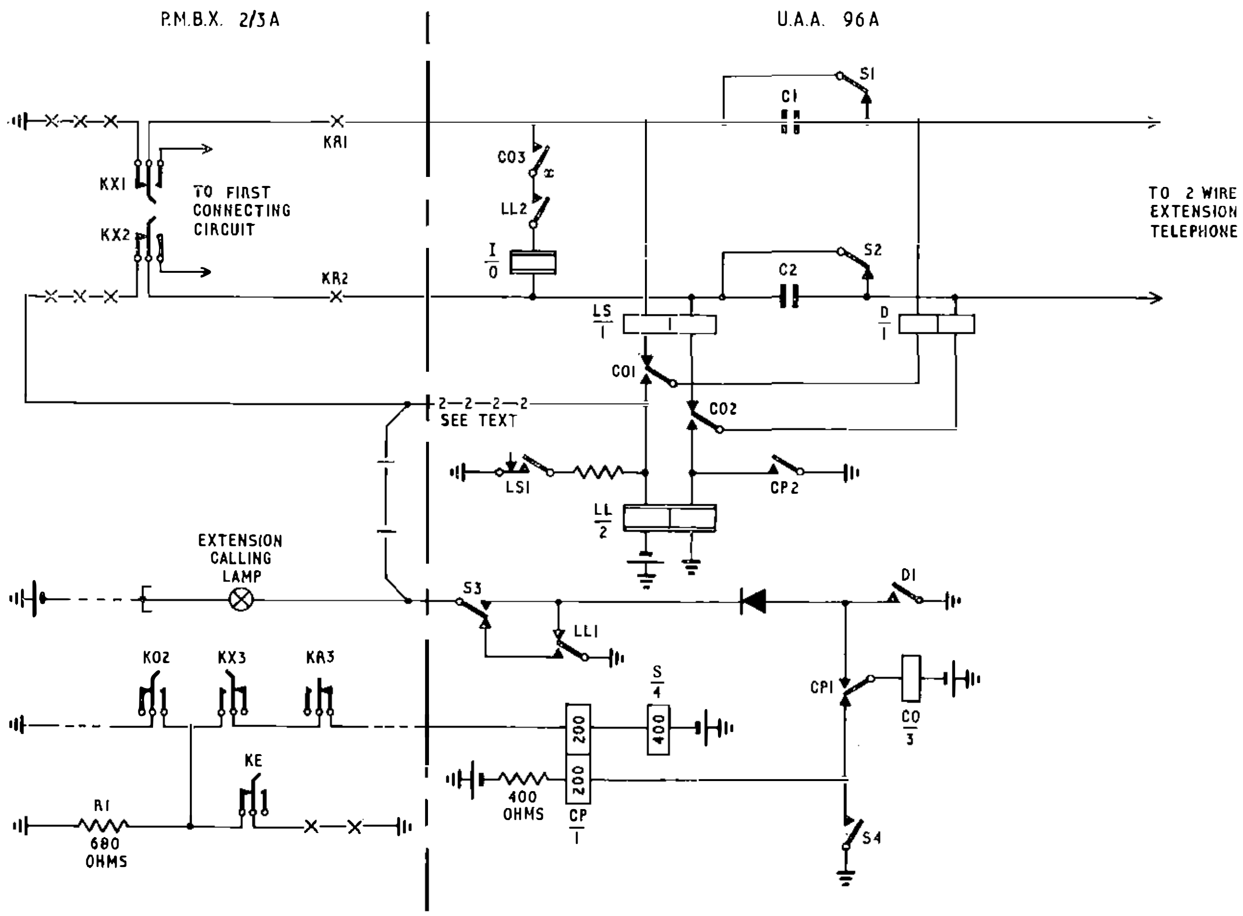


FIG. 1—Unit, Auxiliary Apparatus, No. 96A

mounted on a separate plate which is pivoted to the base-plate so that it can be swung out to allow access to the relay-tag wiring.

A connexion strip is mounted on the base-plate together with the smaller components such as resistors and rectifiers. This connexion strip is used to terminate the interconnecting cable which is routed through an entry hole in the base plate. The strip is also used as a strapping point on those U.A.A. which provide alternative types of signalling.

At P.M.B.X. 2/— installations, U.A.A. are normally bolted to the power-unit and connexion-box to form a single wall-mounted assembly. The U.A.A. are cabled to the appropriate extension terminations inside the connexion-box. Half of the total extension capacity on each type of switchboard (except for the P.M.B.X. 3/5—) can be used for terminating U.A.A. Alternative strapping arrangements provided on tag strips in the switchboard enable each of these extensions to be used for terminating either a 4-wire extension telephone, a 2-wire extension telephone, or a private circuit. These extensions are



Note: Relays CP and D are differentially connected

FIG. 2—Two-wire extension connected to P.M.B.X. 2/3A using a U.A.A. 96A

each provided with two additional wires in the cable between the switchboard and the connexion box. The U.A.A. are wired directly to the equipment on P.M.B.X. 3/—.

U.A.A. 96A

Fig. 2 shows the simplified circuit of a U.A.A. 96A connected to a P.M.B.X. 2/3A. This unit enables a 2-wire extension line to be used in circumstances where it would be uneconomical to provide the additional line plant required by a 4-wire extension. An ordinary 700-type telephone is used at the extension and this can be provided with a press-button for earth-loop recall if required.

If the extension loop resistance is less than 500 ohms the extension calling lamp is operated in series with the telephone calling loop by providing the connexion 1–1 as shown in the diagram. This has the advantage that an additional connexion is not required in the cable between the switchboard and the connexion box. If the loop resistance is 500 ohms or more, the alternative connexion 2–2–2 is used and the calling lamp will be controlled by relay LL.

This unit provides independent transmitter-current feed for the 2-wire extension on calls to another extension or a private circuit. This is because the parallel feed arrangement used in the switchboard connecting circuit is satisfactory only if the two extensions connected to it have similar loop resistances. The condition is usually satisfied by internal extensions, but generally an external extension will have a higher loop resistance and consequently will not receive adequate transmitter-current when it is connected to an internal extension. On extension-to-exchange calls, the transmitter current is received from the main exchange and the extension user can dial through the U.A.A. and P.M.B.X. switchboard.

The differentially-connected relay CP only operates on extension-to-exchange calls when the operator restores her speak key. This relay prevents the extension calling-lamp flashing in response to dial pulses. Press-button recall signals are detected by the differentially-connected relay D and on extension-to-exchange calls ensure that the earth-loop recall signal is not extended to the main exchange.

U.A.A.s 97 AND 98

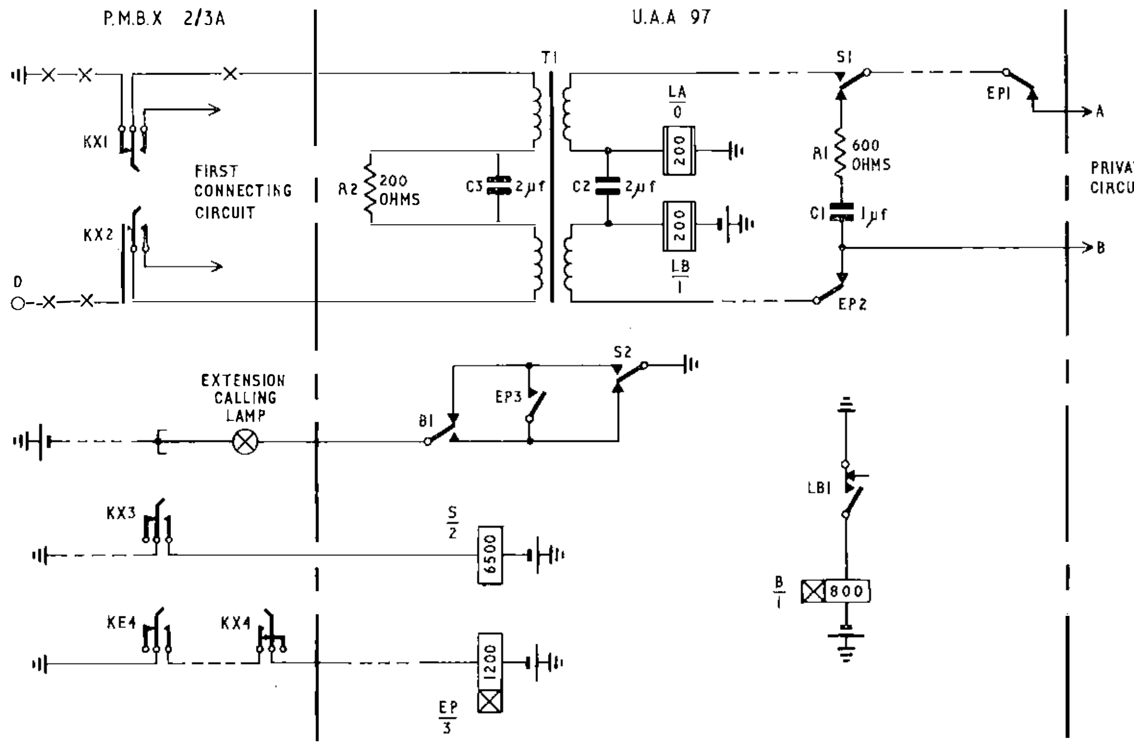
These U.A.A.s provide the various line signalling conditions required on private circuits. The U.A.A. 97 is used for terminating short-distance circuits between P.M.B.X.s when a d.c. signalling path is available. Alternative strapping on the connexion strip inside the U.A.A. enables it to be used for earth-one-line, generator a.c. loop or automatic balanced-battery signalling. A simplified circuit of a U.A.A. 97 connected to a P.M.B.X. 2/3A to provide earth-one-line signalling is shown in Fig. 3.

The transformer isolates the d.c. line-signalling conditions from the connecting circuit in the switchboard and provides a.c. coupling for speech currents. When the circuit is not in use the line is terminated with a 600-ohm resistor (R1) in series with a d.c. blocking-capacitor for line-matching purposes.

If an attempt is made to connect the private circuit to an exchange line, the private circuit is automatically cut off (relay EP).

U.A.A.s 99, 99A AND 100

These units provide the line signalling used for dialling into standard P.A.B.X.s when a d.c. signalling path is available. The transmission bridge in the switchboard connecting-circuit prevents the passage of loop-disconnect pulses so it



Note: Wired for earth-one-line signalling in both directions

FIG. 3—U.A.A. 97 connected to a P.M.B.X. 2/3A

is necessary to provide a separate pulsing lead between the switchboard and the U.A.A. Also, an additional off-normal spring-set has to be provided on the operator's dial.

The U.A.A. 99A provides the same facilities as the U.A.A. 99 and also the additional facility of responding to an incoming a.c. ringing signal. This is required when the private circuit is to be terminated on a normal extension at the distant P.A.B.X. In this case the U.A.A. is wired to provide generator a.c. signalling incoming and loop-disconnect dialling outgoing.

The U.A.A. 100 is used when it is required to provide Single-Commutation Direct Current (S.C.D.C.)[4] dialling into standard P.A.B.X.s. This unit is similar to the U.A.A. 99 except that a high-speed pulsing-relay is used, and the circuit on the line side of the transformer is arranged to provide S.C.D.C. signalling. The high-speed pulsing-relay offers a low impedance to speech currents so a high-impedance coil is connected in series with it to prevent unwanted attenuation of supervisory tones.

The high-impedance coil is short-circuited when the operator's dial is rotated off-normal to prevent it affecting the performance of the pulsing-relay. When the dial has

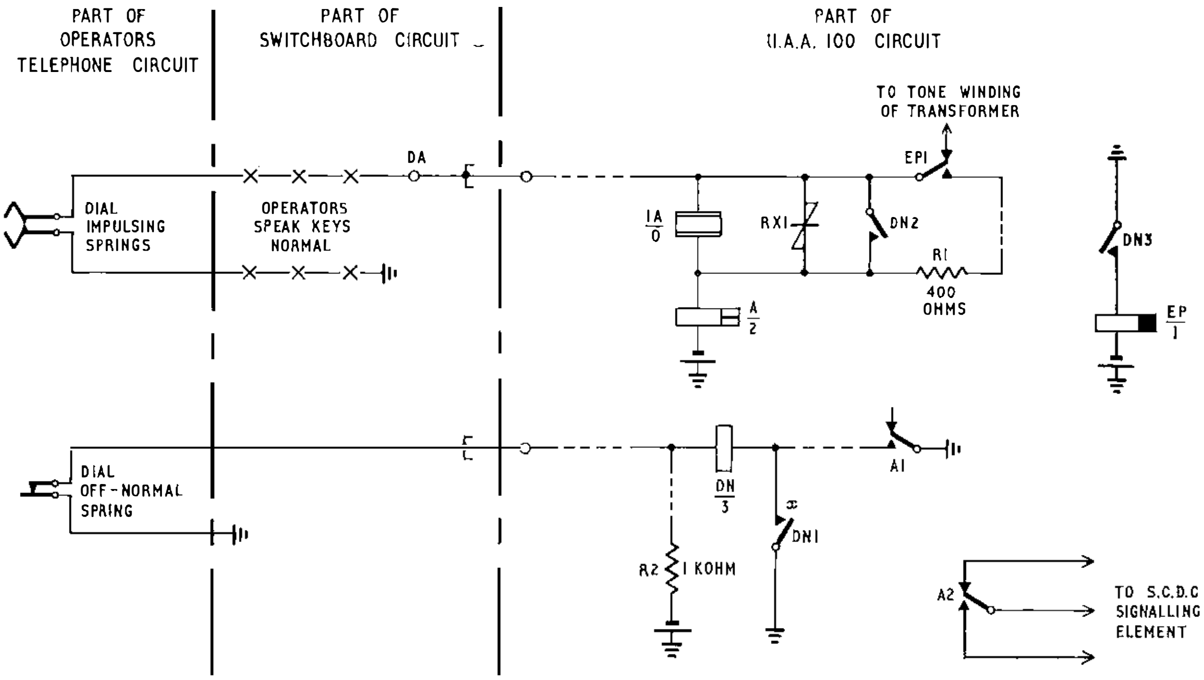


FIG. 4—Two-stage drop-back element from U.A.A. 100

restored to normal it is necessary to remove the short-circuit in two stages to prevent the pulsing relay from momentarily releasing during the build up of flux in the high-impedance coil. The circuit element which provides this feature is shown in Fig. 4.

The voltage dependent resistor (RX1) is included to limit the voltage developed across the high-impedance coil, 1A, as a result of switching-currents induced into the tone winding of the transformer when the answering supervisory-signal is received.

CONCLUSION

Several auxiliary units are available for use with small lamp signalling cordless P.M.B.X.s to meet the various signalling requirements of private circuits and 2-wire extensions connected to these switchboards.

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Testing of Repaired Telephones

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U.D.C. 621.395.001.4: 621.395.004.67

Factories Division repairs more than half a million telephones yearly, and a vital part of the repair process is the proving of the electrical performance of the instrument prior to its issue and subsequent use in the field. The philosophy and design of a telephone-tester used on factory flowlines is described.

INTRODUCTION

Telephones have been repaired in Factories Division since 1913. The instruments have changed, from Telephones No. 1, 2 and 3, through the 100, 200 and 300 series to the 700 series which are repaired today. Repair methods have changed from the time when a telephone mechanic repaired a quantity of instruments using hand tools, and the most primitive testing methods, to the advanced flowline systems used today. Modern repair systems split the work between a number of semi-skilled female factory-technicians, the work-stations being arranged serially in a line. The method of repair is studied closely, holding aids and fixtures being provided, together with testers designed to bring testing within the scope of the female operatives and to meet the performance standards required.

TESTING DURING REPAIR

During the repair process on the flowline, individual components and circuits on the chassis are repaired and tested with a fully-automatic tester, faulty components and circuits being indicated by lamps. After re-assembly, the completed instrument is given a noise-test to show up any high-resistance joints, and the performance of the completed instrument tested for its basic functions of signalling inwards and outwards, and transmission.

Static testing, e.g. d.c. continuity, is only used in the early stages for fault diagnosis.

TESTING TRANSMISSION PERFORMANCE

Originally the transmission tests were limited to the mechanic saying "aah" into the mouthpiece and listening to the sidetone. The results depended solely on the experience of the mechanic and were strictly subjective. An experienced mechanic could detect a low-output transmitter or receiver or a faulty induction coil, but the quality and consistency of this method was questionable.

About 1952, measurements of the transmission circuits were made, using a varying tone applied firstly to the line terminals (and measured as an acoustic output at the earpiece) and then acoustically to the mouthpiece (and measured at the line terminals). The transmitters and receivers were now being tested in circuit, and hence close tolerance testing of these items was not possible. The acoustic coupling was not too efficient and was not really suited to a noisy factory situation. Maintenance costs on the testers were high, lengthy calibration and adjustment having to be done twice daily.

By the time the Telephones 706 came to be repaired in 1962, an acoustic test had been developed for transmitters and receivers in conditions which simulate their use in a handset. A transmitter is placed in a holder that simulates a mouthpiece situated a short distance from an artificial mouth. The mouth is energized by white noise, the acoustic level being carefully controlled. The efficiency of the transmitter in converting the acoustic input to an electrical output, and its dynamic resistance while doing so, are measured over the speech band (300–3,400kHz) and in discrete bands within the speech band. Receivers are tested in a similar manner, the receiver being placed next to an artificial ear, and a probe microphone being used to detect the acoustic signal produced in the ear by the receiver. Thus the efficiency of conversion from electrical input to acoustic output is measured.

The transmission test of the complete telephone was then simplified, to prove the correct connexion of components, and freedom from major component faults.

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THE SIMPLE TRANSMISSION TEST

If the receiver of an energized telephone is placed in front of the transmitter, a howl can be heard from the earpiece. If the loop gain is controlled, a measure of the sensitivity of the instrument is achieved and this is the basis of the new transmission test. Fig. 1 shows the basic transmission test-circuit.

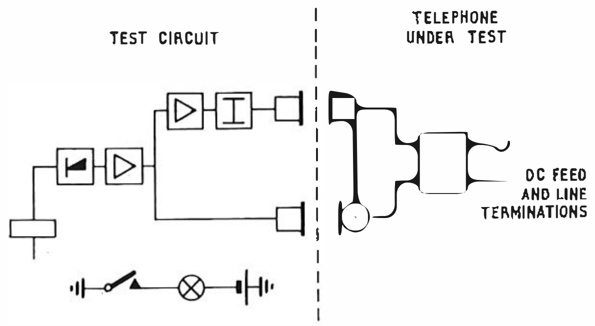


FIG. 1—The basic transmission test circuit

The acoustic path between the telephone receiver and transmitter is replaced by an electronic amplifier path, consisting of a Receiver No. 4T placed directly facing the telephone receiver (and acting as a microphone), an amplifier, and another Receiver No. 4T placed directly facing the transmitter (and acting as a loudspeaker). An attenuator controls loop-gain, and the presence of an oscillation or howl is detected and signalled by the relay and a lamp.

Two tests are carred out; Transmission Test A, with the telephone energized and the line not terminated, and Transmission Test B, with the line terminated. A telephone tested in open-circuit conditions, as in Test A, will have loud side-tone and the attenuator is set to reject a telephone with a transmission efficiency which is lower than the worst allowable.

If the line is now terminated, sidetone will be at a minimum, as the hybrid circuit of the telephone formed by the induction coil, receiver, transmitter and balance circuit, is balanced by the line. Therefore no howl would occur in a good telephone. However, if, for example, one of the three coils of the induction coil is reversed, the circuit is unbalanced and sidetone is at a maximum, giving approximately 10dB more howl than in the unterminated condition. Test B is necessary, as an efficient telephone with induction-coil reversed, would give a pass if only Test A was applied. A short-line impedance ($0{\cdot}25\mu F$ in series with 300ohms) is used for termination, and as this only normally gives a reduction of 7dB in sidetone when the telephone is energized at 30mA, an additional 10dB is inserted in the amplifying circuit for Test B. Any telephone, will then fail the tests if the induction coil is reversed. Since the regulators are fully tested before assembly into the telephone, the line current is restricted to 30mA.

The tests are performed automatically, each with a PASS and FAIL lamp indication and hence the tests are not subjective.

THE TELEPHONE TESTER

The three functions of the assembled telephone are tested by the complete tester. The transmission is tested by Transmission Tests A and B, the inwards signalling by the bell-ring sensitivity test and the outwards signalling by the platform spring-set test, the dial speed, ratio and off-normal springs tests and a signalling resistance test.

As much as possible of the testing sequence has been made automatic. The transmission tests commence as soon as the block terminal is connected and the handset placed on its holder. The platform spring-set action is tested by first placing a weight on the plungers that should not operate the spring-set and then replacing this weight by one that should operate the spring-set. For a correctly-adjusted spring-set, the bell rings when the second weight is placed on the plungers. Lifting the handset off its holder connects the dial-tester. The dial-tester is preset while the operator dials 0, the release of the dial giving the speed reading. The make-break ratio is dealt with similarly and while the dial releases the operator listens for dial clicks. Operation of a key on the resistance test unit gives a meter indication of the signalling resistance. Using this tester, a telephone can be tested in 25 seconds.

PHYSICAL CONSTRUCTION

In order to provide flexibility for work-bench layout (Fig. 2), the tester is made in six interconnected units.

The handset-holder contains the two Receivers No. 4T, and the block-terminal holder contains the connexions for d.c. feed and line-termination conditions to the telephone. The attenuator, amplifier and various power supplies are situated in the main test-unit whilst the dial-tester is similar to the dial-tester, TRT 28, but with automatic-preset facilities and a stabilized power supply. On top of the dial tester is a lamp display-unit and the resistance-test unit is placed on top of the block-terminal holder.

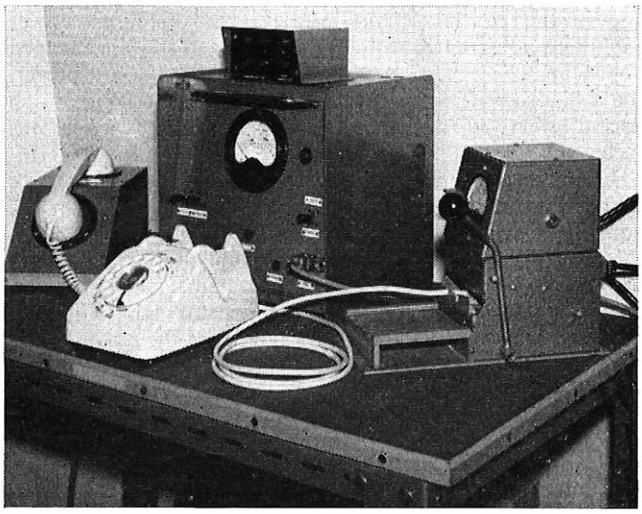


FIG. 2—The telephone tester, showing work-bench layout for testing Telephones No. 706. The main test-unit is below the bench

The separate units are mounted above and below the work bench to give the most economical and best ergonomic layout. The addition of further units, allows a large number of different types of telephone to be tested.

A manually-operated version of this tester is being developed for use in Telephone Area renovation centres.

CONCLUSION

The telephone tester was designed for use on factory flowlines. It is one of the features of the repair process which assists in ensuring a product of consistent quality and of the required performance standards on the repair of telephone instruments which is one of the major activities of Factories Division.

A 10-Line Semi-Electronic Exchange for Remote Areas

A. V. KNIGHT, B.SC., C.ENG., M.I.E.E., and C. J. MACPHERSON, M.B.E.†

U.D.C. 621.395.3: 621.396.65: 621.371

Many remote areas in Scotland are served by one telephone connected to a radio link. This article describes the development of a small exchange giving up to ten subscribers access to the radio link and allowing local calls to be made between subscribers.

INTRODUCTION

In many of the islands and other remote parts of Scotland, the only telephone service was, until 1962, provided by a single call-office connected by a single-channel v.h.f. radio link to the mainland or to the nearest exchange. Directly-heated valves were used in the original radio equipment, which worked in the 76-MHz band in one direction of transmission and in the 86-MHz band in the other direction. Power supplies were obtained from dry batteries which were changed approximately every 3 months. To conserve battery power, the v.h.f. receivers only switched on for a 2-second watch period every 30 seconds, until an incoming carrier was received.

Although the single telephone provided a valuable service to remote communities, there were long periods when the equipment was idle. Potential users often had to travel considerable distances to reach the telephone and, consequently, the link was infrequently used, and operated at a loss. To overcome these problems, a form of line connector giving a number of subscribers access to the radio link from their homes was designed.

DEVELOPMENT OF ORIGINAL UNIT

This unit allowed both local calls between subscribers and junction calls to the main exchange to be set up. The original unit developed was a special line connector which employed cold-cathode valves instead of conventional relays in the count chains. The use of cold-cathode valves reduced the number of contacts required and gave a visual indication of circuit operation. The unit thus became a self-contained, semi-electronic exchange.

The exchange had a single-digit numbering scheme and a single internal connecting-link for local calls, and worked on the line-connector principle for junction calls. The ultimate capacity of 10 subscribers was fixed by the need for simplicity in the count chains and connecting-link. Each subscriber was able to make calls over the radio link to a parent unit in the main exchange and was virtually a parent-exchange subscriber. Individual line circuits were provided at the parent exchange, and the remote unit automatically indicated which subscriber was calling.

The exchange was assembled on a small rack 17 in wide and about 19 in high. This rack contained the line-finder and line selector, or final selector, the cold-cathode counting circuits, and the tone, pulse and transistorized ringing-generator circuits. In addition, the rack housed a new signalling unit which replaced that normally associated with the radio equipment. Fig. 1 shows the 10-line exchange unit, taking the place of the usual signalling unit, placed between the transmitter and receiver of a radio link.

The power supplies provided for the radio equipment were also used for the exchange, these being 90 volts d.c. for the cold-cathode count chains and 24 volts d.c. for relay operation.

The first installation of the exchange was in 1962 on the island of Papa Stour, Shetland and served eight subscribers. The exchange was linked to Sandness U.A.X. on the mainland of Shetland. In 1965, further installations were completed on the islands of Rhum and Canna, working to Mallaig manual exchange, and Soay, working to Arisaig U.A.X. Since that time, all the units have operated satisfactorily without major failure, and have received attention only when routine-maintenance visits were made to replace batteries.

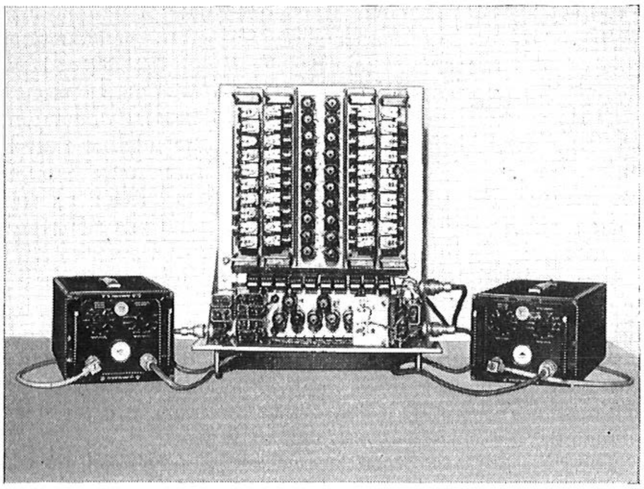


FIG. 1—Original island-exchange unit with v.h.f. radio-link transmitter and receiver

DEVELOPMENT OF SOLID-STATE UNIT

When transistor-type radio equipment came into use, the 90-volt supply, originally obtained from the radio h.t. batteries, was no longer available for the cold-cathode tubes of the small exchange. A new solid-state version of the 10-line unit was, therefore, designed. This used simple earth-pulse signalling over the junction, which could be either a line or a radio link. The switching equipment was connected to the radio equipment by a 4-wire junction, using 2 wires for the audio path and 2 wires for the send and receive signalling paths.

The new 10-line island exchange, shown in Fig. 2, employs only silicon unijunction transistors, low-power silicon thyristors and 3000-type relays. It is constructed on a small steel

† Scotland Telecommunications Headquarters

frame 2 ft 3 in high by 1 ft 7½ in wide, and is hinged within a wall-mounting case or on a rack.

A 24-volt power supply is used. The maximum load occurs during ringing and is approximately 250 mA. The load during local calls is 200 mA, and during radio calls is 100mA.

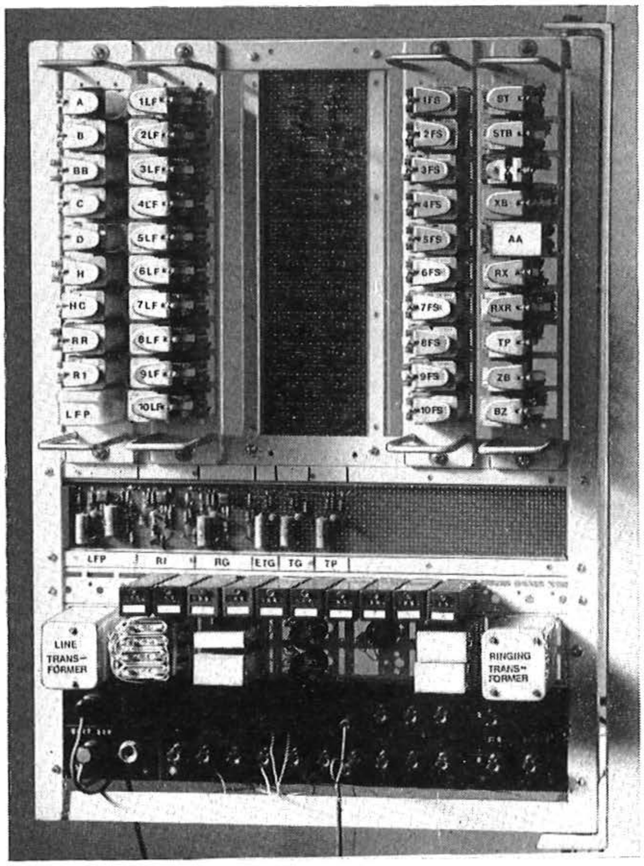


FIG. 2—Solid-state 10-line island-exchange unit

The tones are generated by a unijunction transistor and the ringing current and various pulses are produced by low-power thyristors driven by unijunction transistors.

Line relays and cut-off relays are avoided by suitable use of change-over contacts on the line-finder and line-selector relays. The line-finder and line-selector circuits are identical, both using the same type of relay to switch the speech path under the control of the thyristor count chains.

The parent-exchange signalling unit for the mainland end of the link is shown in Fig. 3. It consists of a uniselector and 12 relays mounted on a small table rack approximately 10 in high by 18 in wide. The uniselector is used as a line-circuit selector on incoming calls to the parent exchange, and as a marker and impulse-storage device on calls outgoing to the island exchange.

On radio calls from the island, the line-connector principle is used. Each of the 10 subscribers has his own line circuit at the parent exchange, and on these calls, he is virtually a parent-exchange subscriber.

Each subscriber has a standard automatic telephone with an earthing push-button. To make a call to the mainland, the island subscriber presses the earthing push-button, removes his receiver from its rest and then releases the push-button. This sets up a connexion via the radio link to his own line circuit in the parent exchange, which, if it is an automatic exchange, returns dial tone. Only the line-finder portion of the 10-line exchange connecting-link is used.

To make a local call, the island subscriber merely removes his receiver and receives local dial tone if the connecting-link is free. He then dials the single-digit number of the required subscriber.

On calls to the island, the parent-exchange signalling unit sends out the requisite single-digit pulse train to call the required subscriber on the island. In this case, only the line-selector portion of the 10-line exchange connecting-link is used.

If a local call is in progress when a radio call is originated from the parent exchange, ringing tone is injected into the local connecting-link advising the subscribers to conclude their call. When the local call has cleared, the number, which has been stored in the parent signalling unit, is pulsed out over the radio link to call the required subscriber. If this facility had not been provided, it would have been necessary to energize the radio link during local calls between any of the 10 subscribers, and this would have been wasteful of battery power.

Only one connecting-link is provided in the 10-line exchange, and consequently P-wires are unnecessary since, if this link is engaged, no other call can be set up. Any subscriber who attempts to make a call when the connecting-link is engaged, receives engaged tone. When the connecting-link becomes free, this tone is replaced by dial tone. If the equipment is seized by a spurious carrier, or other abnormal condition, and pulses are not received within 2 seconds, the equipment automatically releases itself.

Metering is provided on both local and radio calls. Local calls are registered on the 10 meters provided in the 10-line semi-electronic exchange. Radio calls are registered on the subscribers' meters in the corresponding line circuits in the parent exchange, if the parent exchange is an automatic exchange.

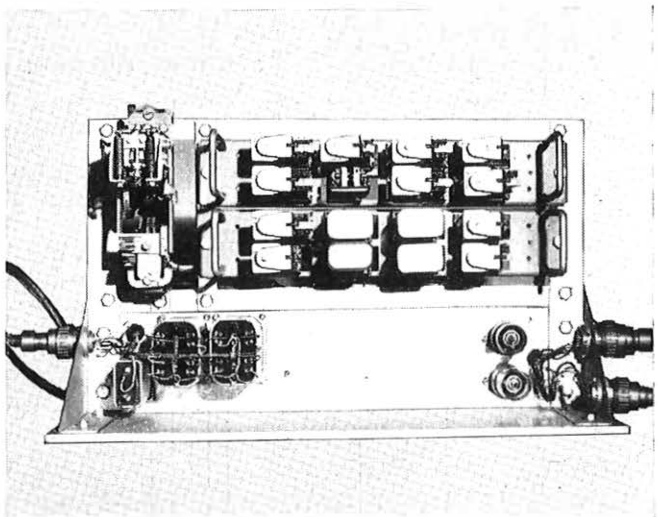


FIG. 3—Parent-exchange signalling unit

Call-office discrimination is inherent in the design, as each subscriber has his own calling equipment in the parent exchange.

The mode of operation is the same if a line is used instead of a radio link.

CIRCUIT OPERATION

Local Call

Fig. 4 is a simplified circuit diagram of the 10-line island exchange. If the connecting-link is in use, relay BB is operated, and engaged tone is received by any other subscriber on the island who lifts his receiver.

If the connecting-link is free, the loop from the calling-

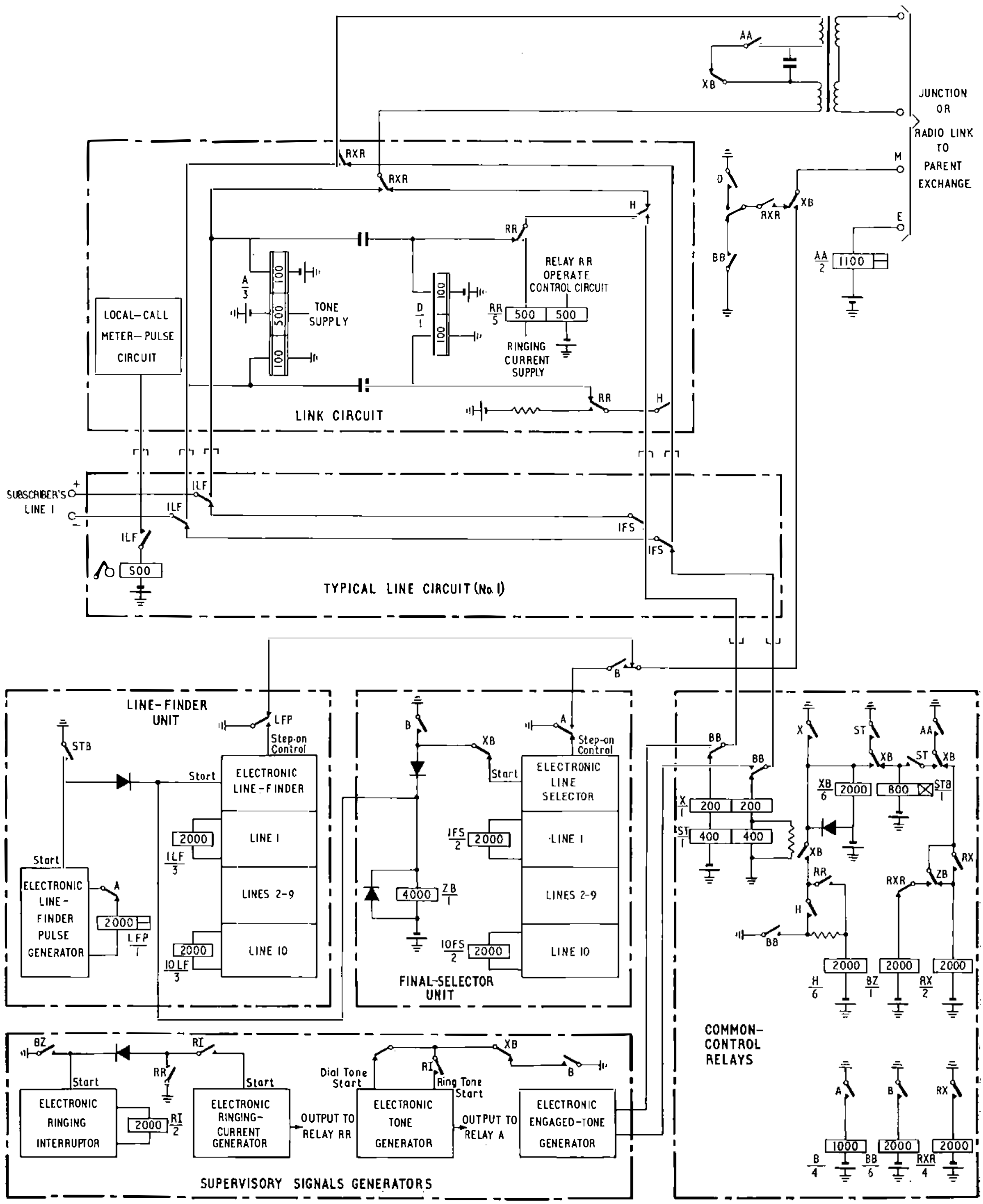


FIG. 4—Simplified circuit diagram of 10-line island-exchange unit.

subscriber's telephone operates relay ST. Relay X is differentially wound and does not operate. Relay ST operates relay STB which operates relay ZB and starts the line-finder pulse generator and line-finder. The line-finder searches for the calling subscriber by applying relay A across each of the 10-subscribers' lines in turn. On encountering the calling line, relay A operates to the calling loop and stops the line-finder pulse generator, thus preventing further searching.

The calling-subscriber's line is now extended via its associated line-finder relay contacts to the connecting-link. Operation of relay A causes relays B and BB to operate and relays ST and STB to release. Relay B holds relay ZB operated, prepares the line selector, and starts the unijunction tone generator which supplies dial tone to the transmission bridge.

The calling subscriber now dials, and relay A steps the line selector. The FS relays operate one at a time to each break pulse. At the end of impulsing, the desired subscriber's FS relay is operated, and relay RR operates.

Operation of relay RR operates relay H and starts the ring-tone and ringing-current generators, the outputs of which pass to the calling subscriber via relay A, and the called subscriber via relay RR, respectively.

The called-subscriber's answering-loop releases the differentially-connected ringing relay RR which disconnects the ringing supplies, and operates the subscriber's local meter. Speech can now take place via the Stone-type transmission bridge.

Release of the call is under the control of the calling subscriber.

Outoing Call to Parent Exchange

In order to make a call to the parent exchange, the subscriber presses the earthing push-button while removing the receiver from its rest. This unbalances the line causing the operation of the differentially-connected relay X as well as operating the start relay ST. Relay X operates relay XB which connects earth to the island-unit M-wire, to energize the v.h.f. radio-link transmitter and signal the parent unit.

On seizure, the incoming section of the parent unit returns an acknowledging signal which operates relay AA. Relay AA operates relay STB which starts the line-finder searching for the calling subscriber. Relay LFP in the pulse generator transmits break pulses to the parent unit as well as stepping the line-finder. When the calling-subscriber's line is found, relay A operates to the calling loop and stops the line-finder pulse generator. The number of break pulses transmitted over the radio link therefore corresponds to the local number of the calling subscriber.

As the island-unit M-wire is connected to the parent-unit E-wire, the transmitted break pulses are received by relay AA in the parent unit, shown in Fig. 5, which steps uniselector FD accordingly. At the end of the pulse train, relay C releases and operates relay H. Relay H extends the circuit to the subscriber's own line and meter circuit via the uniselector wipers, and prevents any further pulse train from stepping the uniselector. Dialling tone is then received from the parent exchange. Further impulses are repeated to the parent exchange by relay AB.

The equipment is under the control of the calling subscriber and releases when he replaces his receiver. If the parent exchange is a manual switchboard, each subscriber has his own calling equipment.

Incoming Call from Parent Exchange

Any parent-exchange number can be allocated to each of the 10 subscribers. The positive and negative wires of the

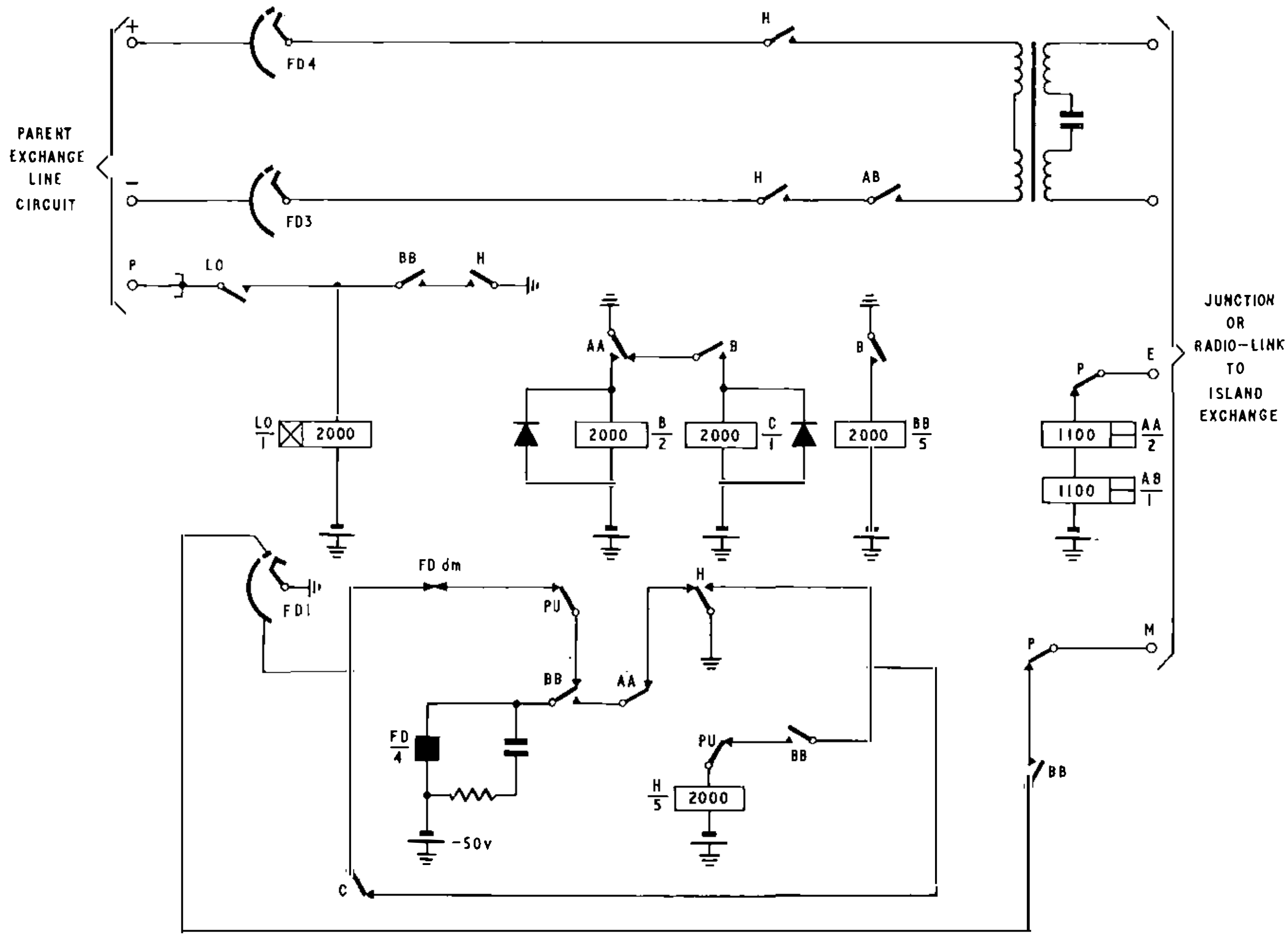


FIG. 5—Simplified parent-exchange control circuitry for call incoming from island exchange

parent-exchange line circuits are jumpered to the parent-unit uniselector bank, and the private wires are commoned and connected to the P-wire terminal on the unit. This puts an engaged condition on all the subscribers' P-wires if the radio junction is in use.

On an outgoing call from the parent exchange, the uniselector in the parent unit functions as a small register-translator, translating the parent-exchange number into the single-digit number of the subscriber on the 10-line exchange at the other end of the radio link. The outgoing section of the parent unit is shown in Fig. 6.

If the radio junction is not in use, the earth extended from the final-selector P-wiper operates relay P in the parent signalling unit which, in turn, extends earth to the parent-unit M-wire to energize the radio transmitter. On seizure, the 10-line island exchange returns an acknowledging signal over its M-wire which is connected to the parent-unit E-wire and operates relays PU and RT. Meanwhile, the ringing-return negative-battery potential from the parent-exchange final-selector positive-wiper marks the uniselector over the positive wire. Relay PU now locks in and completes the circuit for the pulse-generating relay S. The pulses step the uniselector until its positive-wiper encounters the negative marking-potential on the uniselector bank, whereupon the pulse generator circuit is cut by a contact of the high-speed relay K. The same pulsing-contact transmits break pulses to the parent-unit M-wire and hence to the island-unit E-wire. Therefore, the number of break pulses transmitted over the radio link corresponds to the local number of the required island subscriber.

Relay AA in the 10-line island unit receives these pulses and steps the line-selector relay chain to call the required subscriber. During the first break pulse, the acknowledging signal is disconnected from the island-unit M-wire, which releases Relay RT in the parent unit.

At the end of the impulse train, the ringing-relay RR is operated as in the case of a local call, and ringing current is sent over the required subscriber's line. Meanwhile, the calling subscriber receives standard ringing tone from the parent-exchange final selector.

When the called subscriber answers, the supervisory relay D operates, and returns the answering supervisory signal which operates relay RT in the parent unit. A contact of relay RT applies an answering loop across the positive and negative wires from the final-selector wipers, thus tripping the ringing supply and cutting the standard ringing tone which the calling subscriber received. Because the answering loop is extended from the called subscriber back over the radio link to the parent exchange, the subscriber can flash back if required.

Incoming Call when Local Island Call in Progress

When the wipers of the final selector in the parent exchange come to rest on the bank contacts of the required subscriber, relay P operates over the P-wire. This connects earth to the parent-unit M-wire to energize the radio transmitter and to signal the 10-line island exchange over its E-wire. As a local call is in progress on the 10-line exchange, relay ZB is already operated. Relay AA therefore operates relay BZ instead of relay RX, and no acknowledging signal is returned to the parent exchange at this stage. Relay BZ starts the ringing interrupter which causes pulses of ringing tone to be applied to the local connecting-link. This tone indicates to the subscribers who are engaged in conversation, that someone desires access to their 10-line exchange. They therefore conclude their call, causing the release of relays A, B, BB and ZB.

When relay ZB releases, it disconnects relay BZ and operates relay RX. From this point onwards, the operation is similar to that already described in the case of a call from the

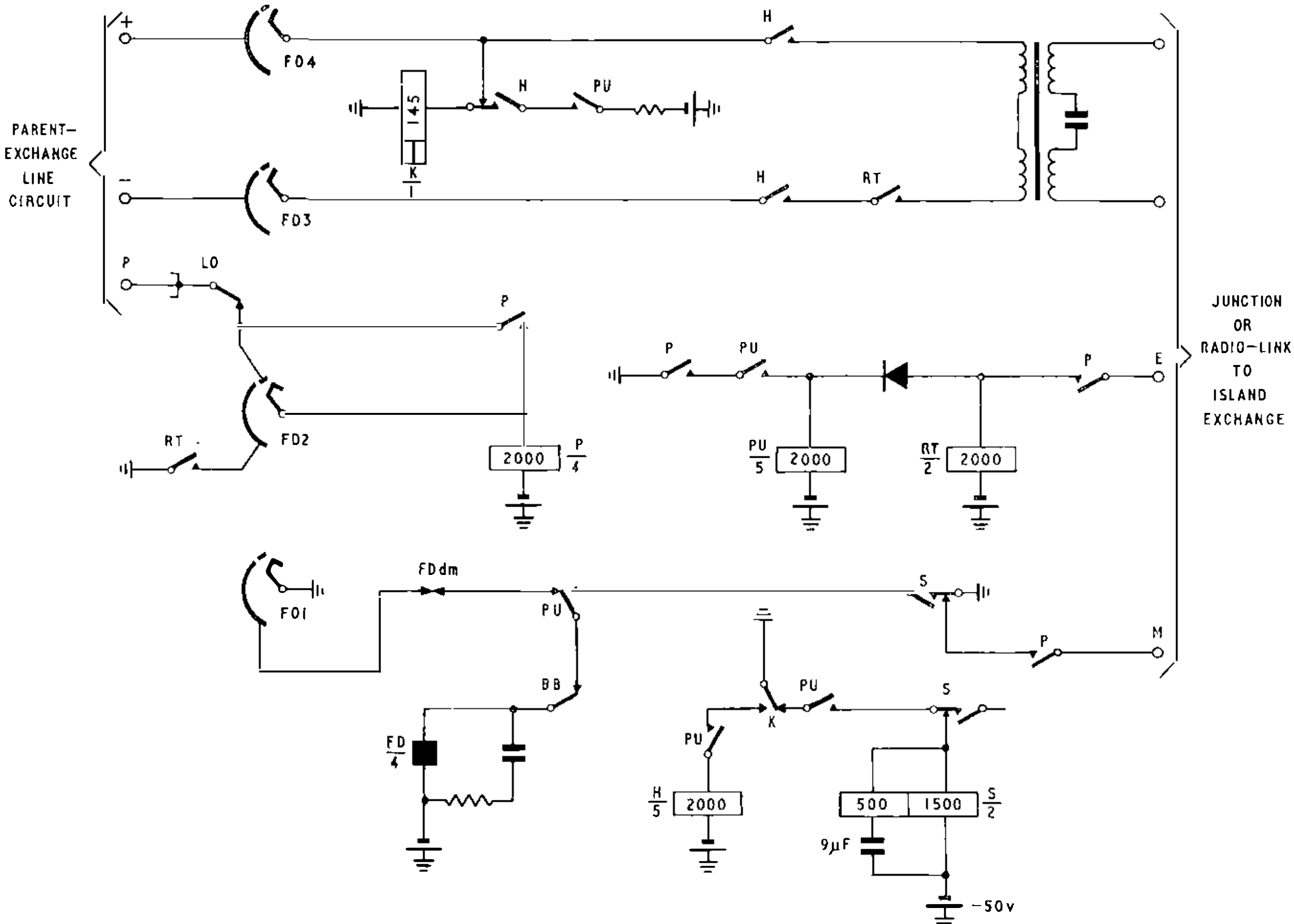
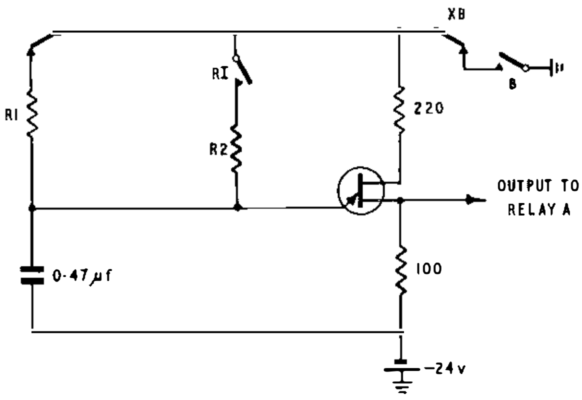


FIG. 6—Simplified parent-exchange control circuitry for call outgoing to island exchange.

parent exchange to one of the 10 subscribers. The number, which has been stored in the parent signalling unit, is now pulsed out over the radio link to call the required subscriber.



Dial tone. R 1 = 47 k ohms
Ring tone. R 2 = 10 k ohms
FIG. 7—Electronic tone generator

Electronic Circuit Elements

The tone generator, shown in Fig. 7, consists of a simple unijunction oscillator, the frequency being determined by the value of the resistor and capacitor in the emitter circuit. Supply-voltage variations have negligible effect on frequency, and the output is relatively rich in harmonics, giving a distinctive tone.

The ringing generator and ringing interrupter are shown in Fig. 8. The line-finder pulse generator is shown in Fig. 9. All three units use a unijunction transistor which alternately fires two silicon thyristors. When a duty ratio other than 1 : 1 is required, it is arranged that one of the two thyristors causes alternate switching of the amount of charging resistance in the unijunction pulse generator, thus alternately changing the pulse length. This arrangement is used in the ringing interrupter and the line-finder pulse generator which have pulse ratios of 1 : 2. The exact pulse ratio is determined by the relative values of the two charging resistors in the unijunction circuits.

The line finder and line selector are identical, and each consists of 10 3,000-type relays driven by a thyristor count

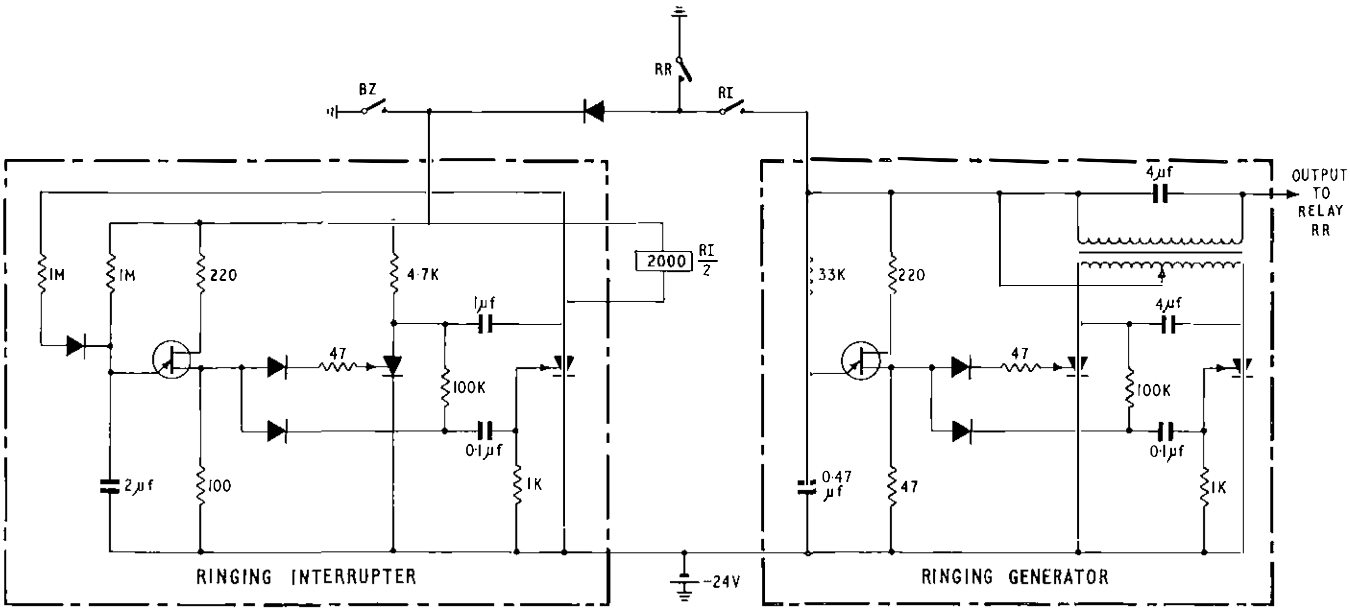


FIG. 8—Electronic ringing interruptor and ringing generator

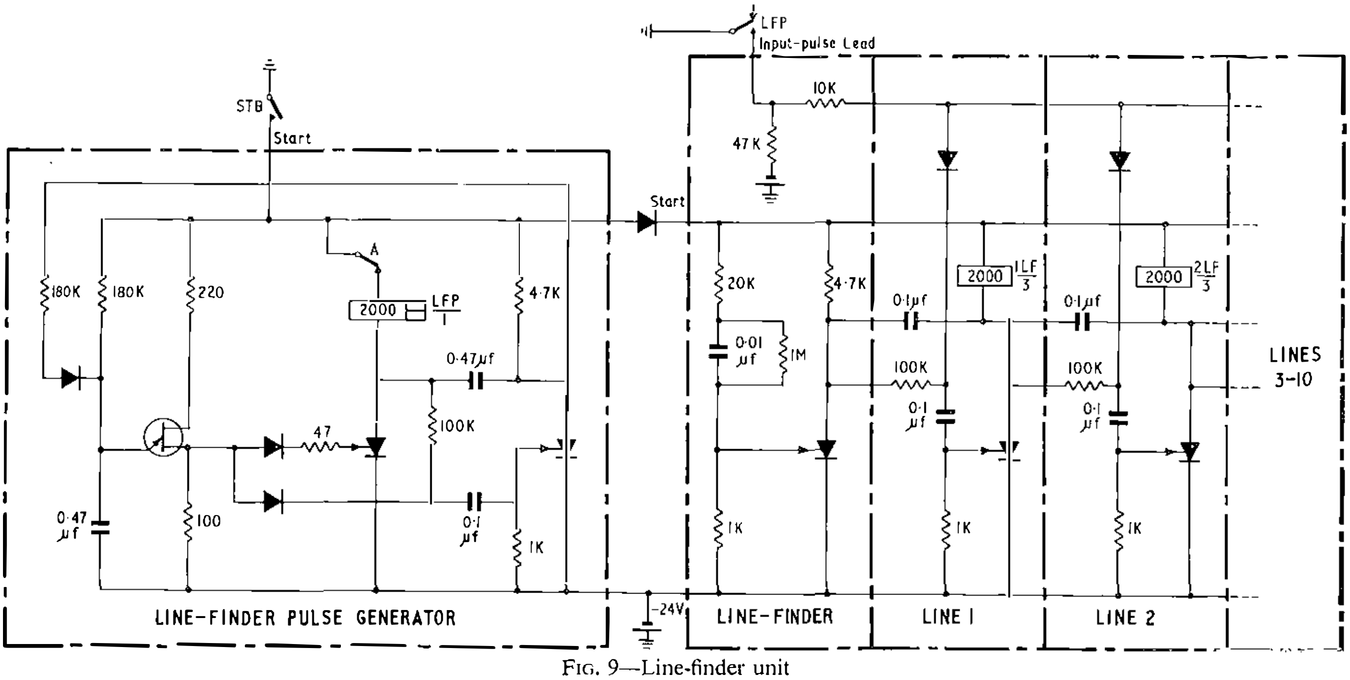


FIG. 9—Line-finder unit

chain. The line-finder count chain is shown in Fig. 9. On seizure, the pre-dialling thyristor stage is fired and this causes the first diode to switch the input-pulse lead to the next stage, in readiness for receipt of pulses. When the train of earth pulses is applied to the input pulse lead, the first earth pulse passes via the first diode gate and fires the thyristor which operates the first relay (1LF). The firing of this thyristor switches the input-pulse lead to the next thyristor, and also switches off the preceding stage by means of a commutating-capacitor coupling the thyristor anodes. This sequence of events continues along the chain, the relays operating one at a time as each pulse is received.

FIRST INSTALLATION

The need to replace the old radio link to the island of Foula, Shetland, with a transistorized transceiver, together with requests from several islanders for individual telephone service, led to the first of the new exchanges being installed on this island. Foula is 28 miles from the radio station at Shurton Hill, near Lerwick, 14 miles from the nearest point of land, and is one of the most remote inhabited islands in Britain. It is also often cut off for long periods by bad weather. Construction of the exchange was undertaken by Aberdeen Area staff and the unit was completed and fully tested only six months after design work had begun.

Preparatory work on Foula involved the laying of cable, directly-buried in peat, from the radio hut to each croft. Each of the subscribers was provided with two pairs to the exchange so that, in the event of a fault occurring on one pair, the subscriber could easily be changed over to the other pair. A rack was erected to carry the exchange, the radio unit and the charging panel, and the rectifier for the car-type batteries. The radio equipment used two 12-volt batteries in parallel, while the exchange operated at 24 volts from two similar batteries in series. Mains power for charging was taken from a small diesel generator at the nurse's house nearby.

Installation of the equipment took only three days, and tests showed that transmission quality over the longest line to the exchange, and thence to the mainland, was excellent. When all the telephones had been fitted in the subscribers' premises, the exchange was open to traffic.

CONCLUSION

The development of a 10-line semi-electronic exchange for working over a single-channel v.h.f. radio link has been a success, and has enabled service to be given to many subscribers in very remote places. The equipment has potential for use in remote areas or in small communities, and can work equally well over line and radio links. Private subscribers can have full s.t.d. facilities with the exception of meters at their own premises. The circuit design is simple and straightforward, and the unit is inherently reliable. In particular, the unit is of low cost and allows more profitable use to be made of hitherto unprofitable radio links.

A new unit, based on the P.A.B.X. No. 5, having 20 local lines, four connecting-links and up to five radio junctions is now under development.

Book Reviews

"Analog-to-Digital Digital-to-Analog Conversion Techniques." D. F. Hoeschele. Wiley and Sons Ltd. xv+ pp. 455 268 ill. 150s.

Analogue circuit design and logic circuit design tend to be treated as separate subjects, so that a book on the design of analogue-to-digital (A/D) and digital-to-analogue (D/A) should provide a useful bridge between the two disciplines. This book deals very clearly with the circuit design techniques used in A/D and D/A converters. However, a number of significant omissions prevent it from being a definitive work on the subject given in the title.

After a brief, but comprehensive, introduction to logic circuits, a chapter on switching analogue voltages gives some useful material which has application outside the immediate A/D and D/A converter field. The chapters on reference voltage comparators are very clearly written and descriptions of some of the more common integrated circuit differential amplifiers are included. Analogue multiplexing techniques are dealt with at some length and there is even some discussion of the effects of electro-mechanical multiplexers (including crossbar switches).

In the chapters on the design of complete A/D and D/A converters, the deficiencies will be immediately obvious to telecommunication engineers. There is virtually no mention of pulse-code modulation as a subject and no indication that speech and television waveforms are analogue signals that can be subjected to many of the A/D techniques mentioned in the book. Although quantising errors are discussed, no mention is made of the effects of non-linear coding and decoding characteristics, such as are used in some pulse-code-modulated speech transmission systems. On the other hand, a complete chapter on shaft-position encoding, reveals that the author's main interests lie in the fields of telemetry and kindred subjects.

This book should prove useful to those engineers who have completed their basic education and wish to gain practical experience in circuit design for telemetry and control applications, but it will have limited value outside these fields.

C. J. H.

"Junction Field-Effect Transistors." C. D. Todd. Wiley & Sons Ltd. xii + 285 pp. 180 ill. 98s.

With so much technical literature presently devoted to the insulated-gate, field-effect transistor (MOST), this book, concerned almost entirely with the simpler junction-gate field-effect transistor, is a timely reminder that the MOST by no means out-dates other field-effect devices.

The book is fairly elementary, though it assumes that the reader has a general knowledge of simple valve and transistor circuits. It opens with a rather sketchy account of the mode of operation of the field-effect transistor (FET) and summarizes its characteristics; thereafter there is no further involvement with solid state physics. The next chapter discusses the device parameters and then, in some depth, their measurement including useful details of practical circuits. In view of the importance of the FET as an a.c. amplifier, however, the chapter on this topic is disappointing and unquantitative with only the briefest attention given to that important attribute of the device, namely, its noise performance. After a somewhat unexpected discussion of active filters, the book returns to d.c. amplifiers, including their temperature stability, and then moves on to the device as a source follower both for a.c. and d.c. signals.

The advantages of bipolar transistor amplifier circuits when driven from an FET input stage are then discussed, after which there is a brief return to the characteristics of the FET now considered as a voltage-controlled resistor. The remaining chapters are devoted to more specialized circuits including choppers, timing circuits, high-frequency applications, negative resistance circuits and photoelectric applications with an appropriately brief discussion of the device in digital circuits.

The book concludes with a very good annotated bibliography and a reference chart by which the content of each reference can be appraised at a glance.

Taken as a whole, the book will be useful to the circuit engineer rather than the solid state physicist and a title such as "Circuit applications of the junction field-effect transistor" would have better reflected its content. The book, unfortunately, contains the inevitable errors; some are, of course, typographical but in the opening chapters they penetrate the argument to an extent which should put the reader on his guard.

F. H. R.

Radio-Wave Propagation as a Factor in the Design of Microwave Relay Links

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U.D.C. 621.391.6:621.37.029.6:621.396.65

Microwave radio-relay links form an important part of the United Kingdom telecommunications network. The performance of such links can be significantly affected by atmospheric conditions, and this article discusses some of the propagation factors that must, as a consequence, be considered in the planning and design of line-of-sight radio-relay links.

INTRODUCTION

Microwave radio-relay links operating in the regions of 2, 4 and 6 GHz now provide an extensive communications network in the United Kingdom. Each radio-relay link which forms part of the network is made up of radio-terminal and repeater stations; highly-directional aerials are employed at each station to direct the radio-frequency signals from one station to the next over line-of-sight paths whose lengths generally fall within the range 30–70 km. Previous papers have dealt with radio-relay links and network planning, together with reliability, performance, maintenance[1, 2, 3] and path testing.[4] This article deals with some of the propagation factors that affect the planning and design of line-of-sight radio-relay links.

Under normal atmospheric conditions, i.e. where the refractive index of the atmosphere at ground level is a little in excess of unity and, in effect, decreases linearly with height, the radio transmission loss for each path, L_R, on a well-designed microwave link can be determined with good accuracy by the formula

$$L_R = 10 \log_{10} \frac{1}{G_S G_R} \left(\frac{4\pi d}{\lambda}\right)^2 \text{ decibels,} \qquad \ldots\ldots (1)$$

where G_S and G_R are the power gains, relative to an isotropic aerial, of the sending and receiving aerials and d is the separation distance measured in the same units as the wavelength, λ. Abnormal atmospheric conditions can arise, however, which will result in quite substantial departures from the normal pattern of refractive index, and these in turn may lead to transmission losses on line-of-sight microwave paths several tens of decibels in excess of the value derived by equation (1). A useful survey of investigations concerning these phenomena is given in a paper by Gough.[5] The pioneering work in this subject by Smith-Rose and Stickland also provides very interesting reading.[6]

The C.C.I.R.* have adopted the following formula for n, the radio refractive index of the lower atmosphere or troposphere:

$$(n - 1) \times 10^6 = \frac{77 \cdot 6}{T}\left(p + \frac{4{,}810e}{T}\right), \qquad \ldots\ldots (2)$$

where T is the absolute temperature in degrees Kelvin, and e and p are the water-vapour pressure and atmospheric pressure, in millibars. Since the temperature and pressure vary with height, h, so also does the refractive index, and this causes the radio waves to follow a curved path through the atmosphere. The radius of curvature of the path followed by a wave launched in a near horizontal plane can be shown to be $\frac{-\mathrm{d}h}{\mathrm{d}n}$. In the British Isles the value of n at a height of 1,000 metres is normally 40 parts in 10^6 lower than at ground level, so that $\frac{-\mathrm{d}h}{\mathrm{d}n} = 2 \cdot 5 \times 10^7$ metres, which gives a radius of curvature four times the true value for the earth.

The planning of line-of-sight links is generally facilitated by drawing the radio path as a straight line; where this is done it is necessary to adjust the earth's radius by a multiplying factor, K, to allow for normal refraction effects. For the British Isles the effective earth radius for the normal atmosphere described above is 4/3 of the actual radius.

Departures from normal atmospheric conditions are generally insufficient to produce appreciable signal-fading on line-of-sight microwave paths but, occasionally, quite abnormal patterns of refractive index arise, resulting in propagation modes conducive to fading. For example, in the early hours of a summer morning, the presence of clear skies could well result in an air temperature several degrees higher than the ground temperature, and this is contrary to the normal condition when the temperature decreases with increase in height from ground level. Such a temperature inversion would mean that the refractive index, n, would decrease more rapidly with increase in height than is normal. This condition might apply to the first 100 metres or so above the ground, while at greater heights the refractive index pattern would gradually re-adjust itself to normality. This effect is illustrated in Fig. 1, where a normal pattern of refractive index is compared with an abnormal pattern. Where appreciable spatial changes in the refractive index gradient occur over a path, several modes of propagation can take place simultaneously, so that the resultant of signals following paths of slightly different length varies in amplitude. Deep fading due to this cause is often referred to as Rayleigh fading, since the probability distribution of the received signal amplitude can be approximated by the Rayleigh Law. As well as causing fading, and hence increasing the thermal noise of a link, multi-path propagation can give rise to intermodulation noise in a frequency-modulated radio-telephony system.

In addition, in the region of AB of Fig. 1, the radio waves could be expected to spread out more than would normally be experienced under free-space propagation conditions. This defocussing effect could give rise to transmission losses appreciably in excess of those derived from equation (1).

If the direct path between successive relay points is too near the surface of the earth, then transmission losses can be expected due to earth diffraction effects. To avoid this, the clearance above ground of the direct ray should be such that

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* C.C.I.R.—International Radio Consultative Committee.

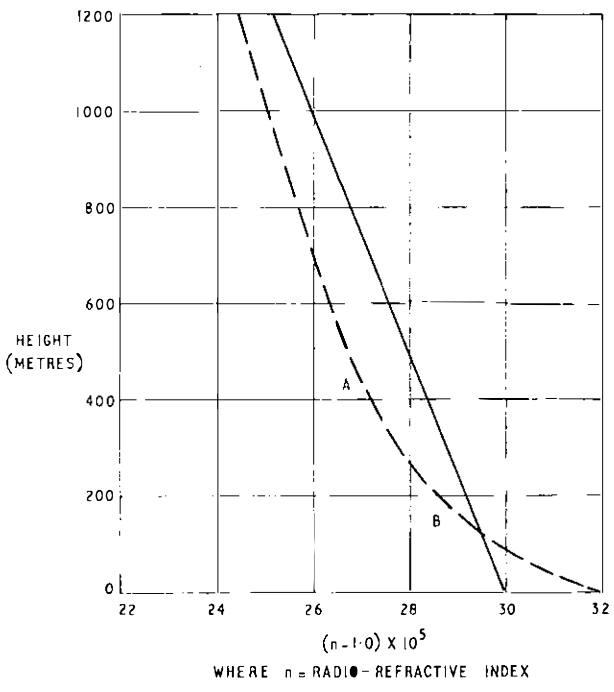


FIG. 1—Examples of normal and abnormal height patterns of radio-refractive index

the difference in path-length between the direct ray and any ground-reflected ray is at least one third of a wavelength (this corresponds to a clearance of about 0·6 of the first Fresnel zone*). The allowance made must also take into account the effect of severe atmospheric sub-refraction, when the effective earth-radius factor K becomes very much less than 1·33. The available meteorological information indicates that in the British Isles the value of K is likely to fall below 0·7 for only a small percentage of time, and this value of K is assumed when determining how high above the ground the direct path between relay points should be. So far, on Post Office radio-relay links, no appreciable transmission losses have been observed that could be attributed to earth-diffraction effects.

Under extreme conditions of refraction, the direction of the radio beam in the vertical plane may be bent to such an extent that the angle of arrival of the wave is significantly changed from normal. The effect of too narrow an aerial beamwidth under these conditions would be fading of the signal, and, consequently, a limit is placed on the maximum aerial size and gain which should be used.

The extreme super-refractive conditions in the atmosphere that give rise to signal fading are closely associated with anti-cyclones and, in general, in the British Isles, appear to be more prevalent in March, June, September and December than in other months. These conditions are often accompanied by fog, but it would be erroneous to attribute to fog itself the kind of fading already referred to, although it is true that the water droplets suspended in fog and cloud produce attenuation due to absorption at frequencies greater than about 10 GHz. Absorption due to rain, hail and snow and to the water vapour and oxygen in the atmosphere will also be appreciable at higher frequencies.

When fading occurs on a radio-relay path the received carrier power falls, while the thermal noise power at the receiver input remains constant. The a.g.c. action of the receiver, however, by increasing the gain to maintain the output carrier at a constant level, increases the level of the thermal noise. In effect, therefore, during fading the carrier level at the output of the receiver remains constant while the thermal noise varies. Locally-generated noise at a constant level is also added at the receiver or repeater station, and the carrier, together with the steady and varying noise contributions, is amplified and, at a repeater, transmitted to the next station. The overall effect of fading on individual paths of a radio-relay link is a variation of the signal-to-noise ratio at the output of the system.

To provide a sound basis for the planning and design of radio-relay links, it is necessary to build up over a long period of time a reliable statistical picture of the behaviour of signals over radio-relay paths. To this end, measurements need to be made of received carrier levels and their variations over paths of different length, over different types of terrain, with different values of clearance over the terrain, at different frequencies, and under different climatic conditions.

Ideally it is desirable to be able to draw on extensive propagation information appropriate to a particular frequency band before the band is put into general use to provide radio-relay links. Where this is not available, and where new propagation factors are becoming significant (such as, for example, attenuation due to precipitation in the 11 GHz band), it is most desirable that some fore-knowledge of the propagation characteristics be gathered from links specially set up for the purpose.

NOISE OBJECTIVES OF RADIO-RELAY SYSTEMS

As a guide to designers of actual radio-relay systems, noise objectives are set out in C.C.I.R. Recommendations. It is recognized that all radio-relay links will to some extent be affected by fading, and the objectives are chosen to take account of this.

The C.C.I.R. sets out its noise objectives based on a Hypothetical Reference Circuit deemed to be 2,500 km long. It recommends[7] that at a point of zero relative level in any telephone channel of such a circuit the following values of total noise power should not be exceeded for a radio-relay system for telephony using frequency-division multiplex:

- 7,500 pW psophometrically-weighted mean power in any hour,
- 7,500 pW psophometrically-weighted 1-minute mean power for more than 20 per cent of any month,
- 47,500 pW psophometrically-weighted 1-minute mean power for more than 0·1 per cent of any month,
- 1,000,000 pW unweighted (with an integrating time of 5 ms) for more than 0·01 per cent of any month.

These allowances apply to noise contributions within the radio portion of the system; they do not include noise contributed by multiplexing equipment, for which a separate allowance of 2,500 pW is made. In addition, having regard to the fact that circuits sometimes differ in composition from the hypothetical reference circuit, as a guide to the planning of real radio-relay links, slightly relaxed noise objectives are set out in a complementary C.C.I.R. Recommendation.[8] Noise objectives appropriate to radio-relay systems for television are also given in another recommendation.[9]

The noise objectives recommended by the C.C.I.R. are not in a form which can be used directly to specify the performance of a radio-relay link. In order to do this, it is necessary to interpret the C.C.I.R. objectives so that the performance of the link can be specified in a more suitable manner. Such an interpretation requires a knowledge of the amount of noise contributed from various sources, which, for telephony links, can be broadly stated as interference noise, intermodulation noise, fixed-level thermal noise, and thermal noise, the level of which is dependent on fading.

A knowledge of typical equipments permits specific allow-

* Fresnel zone.—A Fresnel zone may be defined as a zone, on a specified surface, such that the sum of the distances from the transmitting aerial and from the receiving point, to any point in the zone, does not vary by more than half a wavelength throughout the zone.

ances to be made for intermodulation noise and fixed thermal noise, and a fixed allowance can be made for noise attributable to interference. The allowance to be made for thermal noise subject to fading will, however, be dependent on propagation factors and it is from analysed propagation data that the allowance to be made can be assessed. A method of making the assessment is described by K. W. Pearson.[10]

It should be mentioned that, while propagation data are necessary in order to assess the fading allowances that should be made on line-of-sight radio-relay links, data of a similar kind for distances of up to several hundred kilometres are also required where, for example, estimates need to be made of possible mutual interference between satellite Earth stations and terrestrial radio-relay links. A great deal of useful data for dealing with this problem is contained in C.C.I.R. Reports.

PROPAGATION MEASUREMENTS

An extensive program of measurements has been carried out in the United Kingdom over a number of years to provide information on the fading characteristics of line-of-sight radio-relay links. The information has been collected by employing pen recorders to record the strength of the received microwave carrier, and the data so collected have been analysed to provide statistical information on the depth of fading experienced on each path. To date, recordings made on 25 paths have been analysed, the recordings for each path covering continuous periods of about one year. This is probably the minimum useful period of time that can be employed to provide reliable statistical information, since all the seasons of the year are covered.

Fig. 2 shows the locations of the 25 paths, and Table 1 gives the salient features of each path, together with the fading depths exceeded for 0·1 per cent and 0·01 per cent of the worst month. The paths over which measurements were made ranged in length from about 25 km to 75 km, and covered a variety of terrain conditions and included several oversea paths. In all, upwards of 300,000 chart hours were analysed. The 11 GHz measurements and analyses have been described in detail by Turner, Easterbrook and Golding.[11]

ATMOSPHERIC FADING

An example of the signal-fading occasionally experienced on overland radio links is given in Fig. 3, which shows part of the signal-level chart-record for the morning of 20 June, 1960 for Path 20 (see Fig. 2 and Table 1). The signal levels recorded in both Fig. 3 and 4 are relative to the free-space value.

The nature of this fading suggests a predominantly multipath propagation effect, although the signal-level depressions around 0400 and 0550 G.M.T. could have been due partly to atmospheric defocussing. Simultaneous refractive-index measurements obtained by the Meteorological Office at a nearby site indicated a vertical pattern somewhat similar to that shown by the broken line in Fig. 1.

Fig. 4 is a record of the signal levels received on the overwater section (Path 10) of the United Kingdom–France radio-relay link during 7 September 1959, an abnormally bad day for fading. On this occasion there was fading due to multipath propagation from midnight onwards, while between about 1300 and 2230 G.M.T. the average signal level was depressed—apparently due to defocussing—by up to 20 dB. The weather at this time was fine, with a light breeze from the Continent during the day. Nearby meteorological measurements indicated even more extensive variations in the refractive index pattern than that given by the broken line in Fig. 1.

Many other interesting examples of fading could be given,

TABLE 1

Salient Features and Fading Depths of Paths shown in Fig. 2

Path No. on Fig. 2	Path Terminals	Approximate Carrier Frequency (GHz)	Path Length (km)	Period of Measurement (Inclusive Months or Years)	Transmission Loss in Decibels in Excess of Free-Space Transmission Loss for Indicated Percentage of Time During Worst Month. (Losses due to Precipitation have been Excluded)	
					0·1	0·01
1	Olrig Hill, Thrumster	4·0	26	1960 and 1961	—	13
2	Hook, Wotton	11·1	29·5	May 1961–Apr. 1962	12	20
3	Whitestone, Stockland Hill	3·9	36	1962	16	26·5
4	Kirk O'Shotts, Blackford Hill	4·0	39·3	1955	18·5	26
5	Mendlesham, Stoke Holy Cross	1·9	40·1	1960	23·5	33·5
6	Blackcastle Hill, Blackford Hill	4·0	47	1953–1956	16·5	22
7	Wideford Hill, Olrig Hill	3·9	50·7	1960 and 1961	11	21·5
8	Birmingham, Charwelton	1·8	54	1962	19	27·5
9	Pontop Pike, Corby's Crags	4·0	56	1953–1956	24	32
10	Fiennes, Tolsford Hill	3·9	60	1961	>30	>30
11	Ballygomartin, Portpatrick	4·0	60·8	Oct. 1951–Aug. 1952	24·5	29*
12	Arncliffe Wood, Pontop Pike	4·0	61·3	1953	17	29
13	East Harptree, Goosemoor	4·0	55	1962	18	25·5
14	Ballygomartin, Enoch Hill	4·0	62·3	May 1951–Aug. 1952	26	29·5*
15	Rowridge, Golden Pot	4·0	62·3	1959 and 1961	19·5	27·5
16	Dunstable, Charwelton	2·0	63·1	1962	29	36·5
17	Tinshill, Arncliffe Wood	4·0	64	1952	21	31·5
18	Museum, Golden Pot	3·9	68·5	1959–1961	23	34
19	Golden Pot, Museum	3·9	68·5	1960	24	35·5
20	Peterborough, Wickhambrook	1·9	69·7	1960	32·5	42
21	Corby's Crags, Blackcastle Hill	4·0	74·4	1953–1956	23	34
22	Cranfield, Everton	11·0	24·4	Mar. 1964–Dec. 1965	8	16
23	Sibleys, Kelvedon Hatch	11·5	31	1964	20	>26
24	Greenmore Hill, Dollis Hill	11·5	57	1964	>26	>26
25	Alton, Greenmore Hill	11·5	38·6	1964	14	25

* These values apply to the whole of the period recorded.

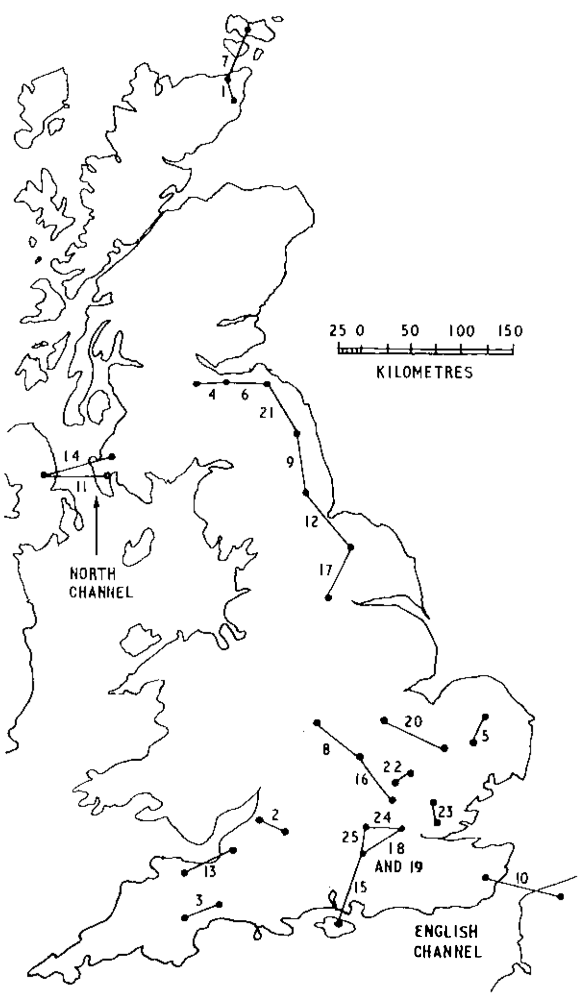


FIG. 2—Locations of radio-link paths referred to in Table 1

but those above will serve to illustrate the effect that fading can have for a small percentage of time on the received signal level.

To provide information from which appropriate allowances can be made for fading, however, fading statistics of the kind contained in Table 1 are required. The 2 GHz and 4 GHz results can be regarded as typical of paths over the moderately rolling terrain of Eastern and Southern England, and the associated best-fit lines shown in Fig. 5 can be used, therefore, as a reference for planning purposes. For paths over more irregular terrain the fading would be expected, on average, to be somewhat less, while for paths over smoother terrain, such as East Anglia, the fading would generally be greater than indicated by the best-fit lines in Fig. 5. Furthermore, it will be noticed that fading on the oversea section between Tolsford Hill and Fiennes (Path 10) was very severe compared with over-land paths.

Comparison of simultaneous recordings at 2 and 11 GHz over two separate years on Path 23[11] showed surprisingly little difference in the amount of signal fading. As will be seen from Fig. 5, however, from the relatively few points which could be plotted from the 11 GHz measurements, more atmospheric fading is indicated at 11 GHz than at lower frequencies, although there is as yet insufficient data on propagation at 11 GHz to establish clearly the extent of the difference.

Parts of the radio-frequency spectrum above 11 GHz are also available for use by radio links. Because of the shorter wavelengths involved, atmospheric fading is expected to be greater at these higher frequencies, but to what extent remains to be seen. The reader is reminded that the atmospheric fading so far discussed is due to atmospheric irregularities brought about largely by abnormal local variations in the temperature and humidity of the atmosphere. The effects of precipitation and of suspended particles such as in cloud and fog will be discussed later.

The results above, together with information supplied by other administrations, have been drawn on in the preparation of a C.C.I.R. Report.[12] Fig. 6 is a reproduction of the diagram in this report, and shows the fading to be expected at 4 GHz on line-of-sight paths ranging in length from 50 to 250 kilometres. It is important to remember that these fading values relate to well-planned links designed to avoid earth-diffraction losses during periods of abnormal atmospheric sub-refraction.

The fading levels shown in Fig. 5 and 6 are, in effect, statistical values of the instantaneous levels of signal, and would differ little from corresponding values derived from the distribution of levels averaged over 1 minute.

Work undertaken by Meadows, Lindgreen and Samuel[13] and by Turner, Easterbrook and Golding[11] indicates that the intermodulation noise arising on multi-channel telephone radio links due to multi-path propagation is unlikely to restrict the use of frequencies up to 11 GHz. It is also comforting to know that on overland paths these effects together with signal fading are confined largely to the early hours of the morning, when normal traffic is light.

DIVERSITY RECEPTION

Facilities for diversity reception were provided on the over-water Fiennes–Tolsford Hill (Path 10, Fig. 2) of the United Kingdom–France telephony radio-link to reduce the effect of multi-path fading. At Tolsford Hill two diversity aerials were spaced vertically by 9 metres and their outputs combined. Fig. 7 compares for 15 March 1961, the reduced fading resulting from the use of two diversity aerials as against one non-diversity aerial; it should be noted here that the two signal-level scales are different. Although this form of diversity reception reduced the effects of multi-path propagation, it will be seen that it did little to reduce the effects of sustained fading due to defocussing. It was realised from earlier records that the only hope of reducing the effects of signal defocussing was to have diversity aerials spaced vertically by 100 metres or more. Accordingly, an experimental receiver was installed at

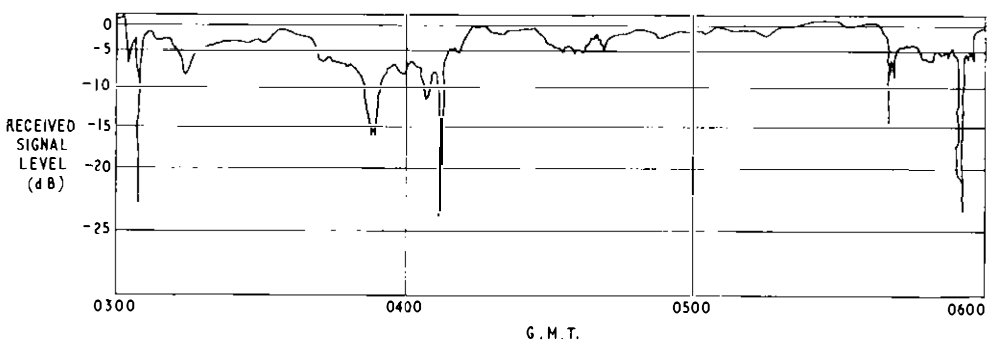


FIG. 3—Example of signal-level fading experienced on Path 20 of Fig. 2

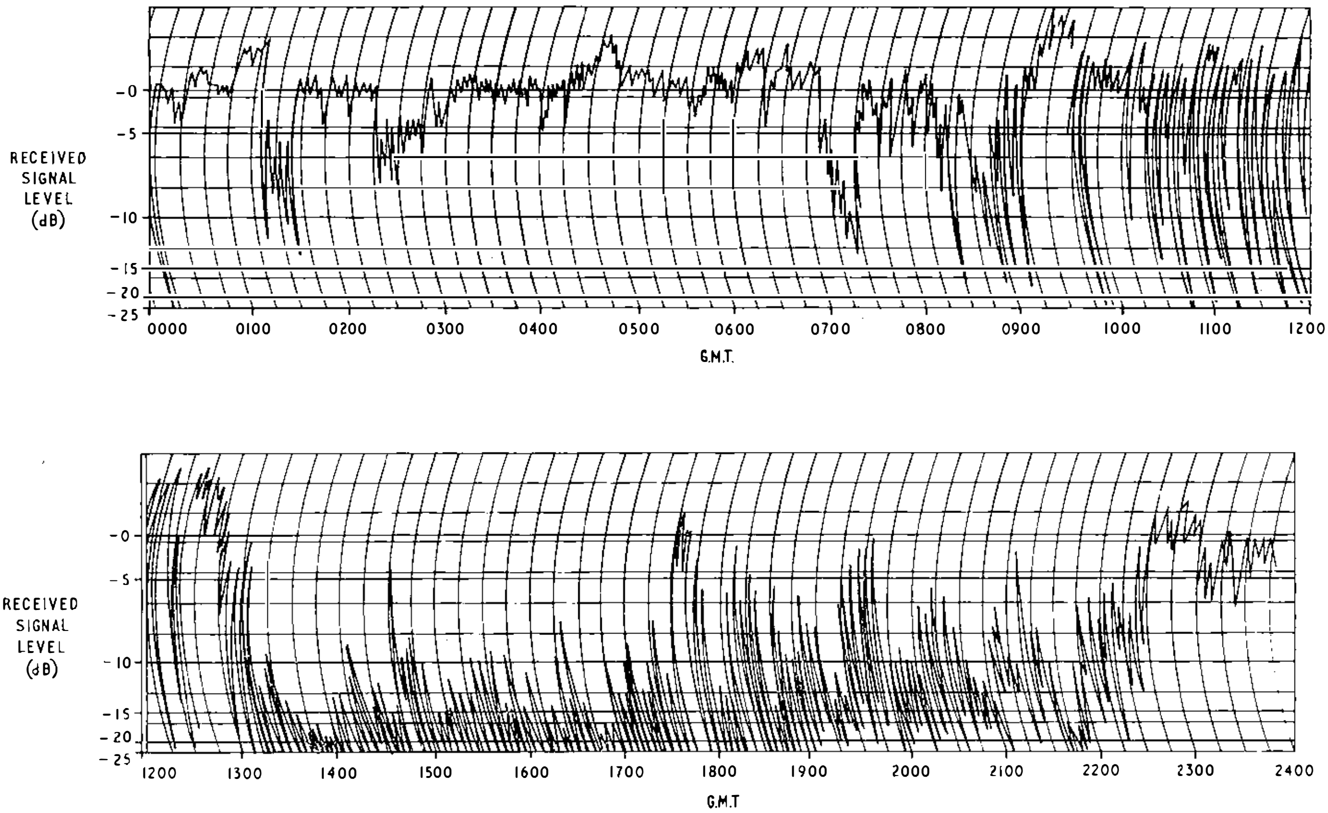
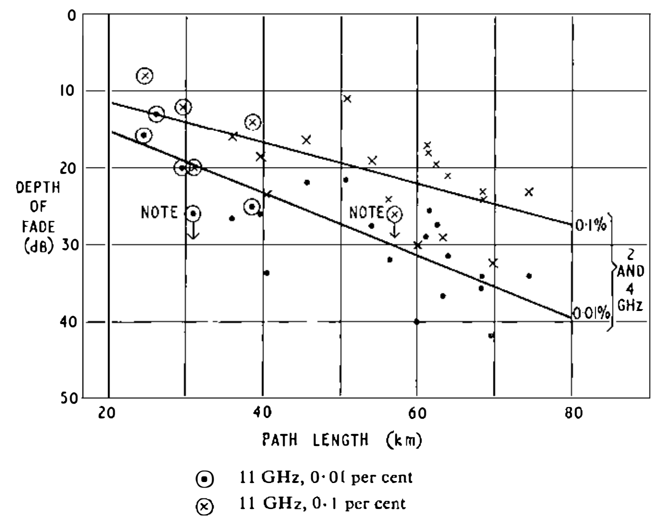
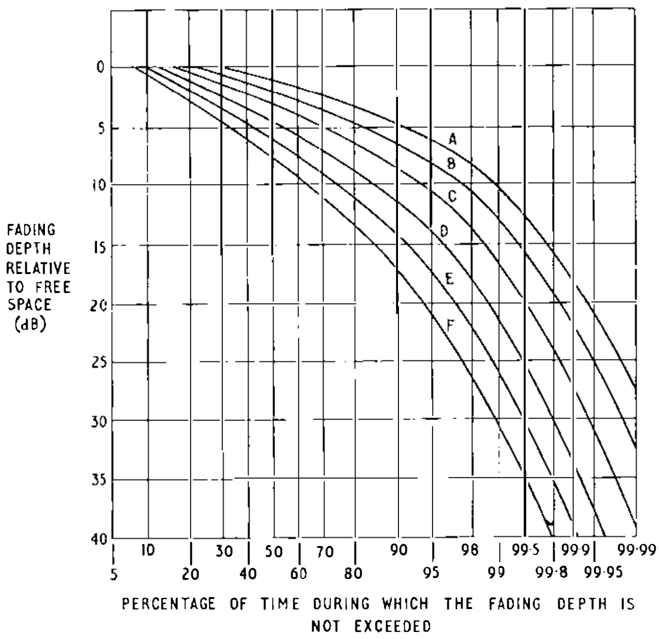


FIG. 4—Signal-level fading on Path 10 of Fig. 2



Note: Reading below sensitivity of instrument

FIG. 5—Depth of fade exceeded for 0·1 per cent and 0·01 per cent of time during worst month



A–50 km, B–75 km, C–100 km.
D–150 km, E–200 km, F–250 km.

FIG. 6—Provisional curves of fading depth not exceeded for a given percentage of the worst month of the year for a 4 GHz link over rolling terrain in North West Europe

Folkestone Head Post Office in order to receive the Fiennes signals at a much lower altitude. The height of the Folkestone aerial, above sea level, was 60 metres, while that at Tolsford was 220 metres above sea level.

Comparison of the signals recorded simultaneously at Tolsford Hill and at Folkestone showed that their combination could substantially reduce the fading due to defocussing. The results of signal level-analysis and various diversity combinations for the period June 1960–March 1961 are summarized in Table 2.

TABLE 2

Percentage of Time Signals Received at Tolsford Hill and Folkestone from Fiennes Faded by 20 dB or More

Period	Folkestone (Single Aerial)	Tolsford Hill (Single Aerial)	Tolsford Hill Diversity Aerials Spaced Vertically by 9 Metres	Diversity Combination of Single Aerials at Tolsford Hill and Folkestone
June 1960 ..	0·400	0·340	0·190	0·008
July ..	0·095	0·040	0·006	0·002
August ..	0·200	0·155	0·047	0·003
September ..	0·140	0·019	0	0·001
October ..	–	0·001	0	–
November ..	0	0	0	0
December ..	0·002	0	0	0
January 1961	0	0	0	0
February ..	0·029	0·008	0·001	0
March ..	1·260	0·800	0·280	0·005
April ..	0·190	0·110	0·036	0·003
May ..	0·350	0·230	0·103	0·002
June ..	1·250	0·780	0·295	0·070
July ..	0·690	0·170	0·041	0·005
August ..	0·140	0·180	0·017	0·002
September ..	0·278	0·250	0·074	0·009
15 March 1961* ..	6·3	3·5	1·1	0·14
15 June 1961* ..	6·3	19·2	13·9	3·6

* 0600–1800 GMT only

For the results given in Table 2 it will be seen that

(*a*) the period of fading on the single aerial at Tolsford Hill was generally less than that of the single aerial at Folkestone,

(*b*) the period of fading using diversity aerials at Tolsford Hill spaced vertically by 9 metres was about one-third of that experienced by the single aerial at Tolsford Hill, and

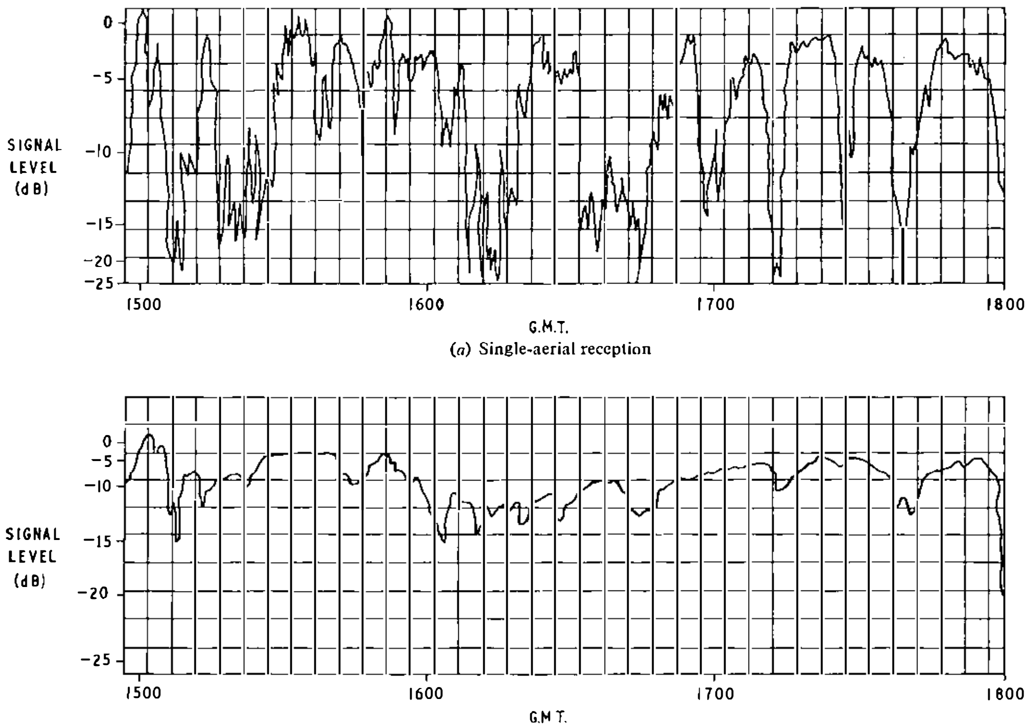
(*c*) diversity combination of single aerials at Folkestone and Tolsford Hill reduced the fading period to an average of about one-eighth that experienced by the diversity pair spaced vertically by 9 metres at Tolsford Hill.

RAY-BENDING

As intimated in the introduction, ray-bending under extreme atmospheric conditions can impose limitations on the size of aerials used for terrestrial microwave links. Calculations based on data contained in a C.C.I.R. Report[14] show that, for a 50-kilometre near-horizontal path, the vertical-wave arrival angle relative to the straight line between transmitter and receiver varies no more than about 16 minutes of arc for 99·98 per cent of the time. The very limited information available suggests that variations in azimuthal arrival angle would not be more than 20 per cent of the vertical-angle variations, and that both vertical and azimuthal angle variations would increase with increase in path length. This indicates that aerial beamwidths, at least in the vertical plane, should not be less than about $\frac{1}{4}$°, which imposes an upper limit of about 56 dB on the realizable aerial gain.

LOSSES DUE TO PRECIPITATION

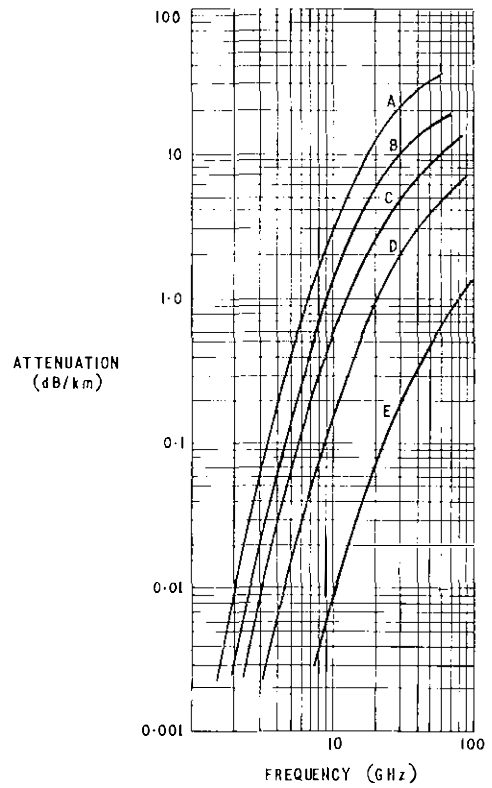
Rain, hail and snow give rise to attenuation at microwave frequencies, although in the British Isles the effects of hail and snow can usually be neglected because of the relative infrequency of these forms of precipitation. Fig. 8, which is taken from a C.C.I.R. Report,[15] indicates the absorption in decibels per kilometre for various rainfall rates and for frequencies between 1 and 100 GHz. Precipitation rates exceeding 10 millimetres/hour are generally associated with summer storms, and rates in excess of 25 millimetres/hour are rare and of comparatively short duration. In the British Isles, the effects of rain are negligible for frequencies below about 10 GHz.



(*a*) Single-aerial reception

(*b*) Diversity reception, vertical spacing 9 metres

FIG. 7—Example of reduced fading due to aerial-diversity reception on Path 10 of Fig. 2



A–100 mm/h, B–50 mm/h, C–25 mm/h
D–10 mm/h, E–1 mm/h

FIG. 8—Attenuation due to rain

A few years ago the information in Fig. 8 and rainfall statistics compiled by Bilham[16] were used to estimate the attenuation that could be expected at 11 GHz due to rain. In doing this, it was assumed that the centre cores of storms giving rise to high precipitation rates moved over the radio link at a typical speed of 30 kilometres/hour. Using Bilham's material, it was then possible to integrate over the complete path the rainfall attenuation corresponding to any phase in the passage of the storm.

The estimated rain attenuation at 11 GHz resulting from an extension of this method is shown in Fig. 9 as a function of path length and time. Recent rain-attenuation measurements at 11 GHz,[11] show surprisingly good agreement wth these estimates. In fact, bearing in mind the fickleness of the British climate, any closer agreement could well be open to suspicion. There is, therefore, some justification for further extending this method for estimating rainfall attenuation to the 18 and 36 GHz bands, and the results are reproduced in Fig. 10 (for regions where the total annual rainfall is 100 cm). For regions where the annual rainfall departs significantly from 100 cm, then the abscissa values in Fig. 10 in excess of 1 per cent would need to be modified accordingly, e.g. for a region with 50 cm annual rainfall, the 1 per cent values shown will now be for 0·5 per cent of the time. Rainfall rates occurring for much less than 1 per cent of the time are largely independent of the region in the British Isles.

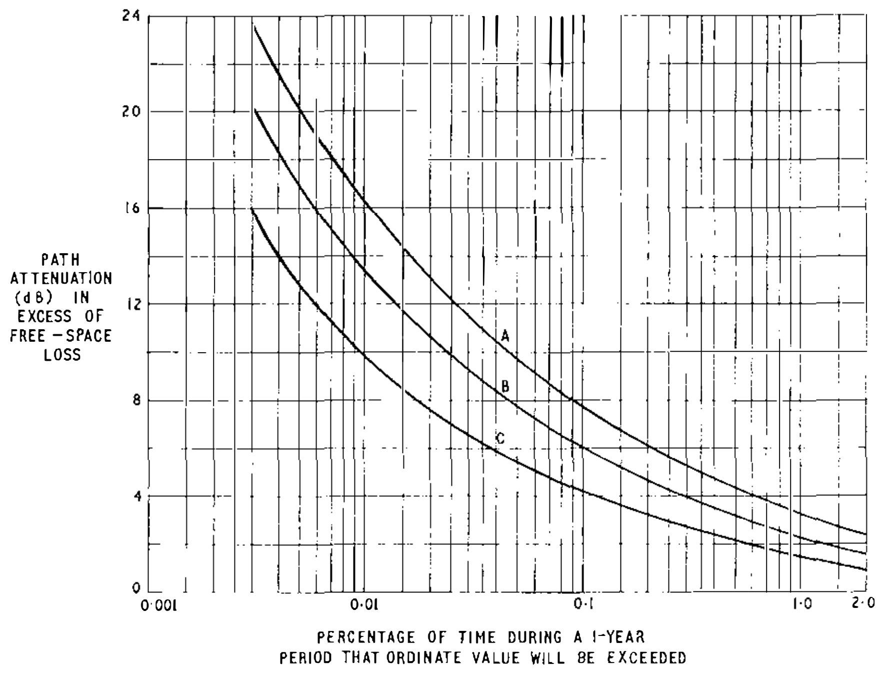
OTHER ATMOSPHERIC LOSSES

Other losses in the atmosphere arise due to absorption by the small droplets of moisture suspended in fog and clouds, and to resonance effects of oxygen and water-vapour molecules. Ryde[17] showed that losses in fog and cloud could be related to visibility. Thus, at 20 GHz, fog consisting entirely of water droplets, and allowing a visibility of 60 metres, would give rise to an attenuation of about 0·2 dB/km. The attenuation would be approximately four times this at 40 GHz and a quarter at 10 GHz.

The absorption due to oxygen and water vapour in the atmosphere at frequencies lying between 1 and 100 GHz is shown in Fig. 11. This is further evidence of the increasing absorption to be expected at the higher frequencies.

CONCLUSIONS

Spatial and temporal variations in the refractive-index gradient of the lower atmosphere can have a considerable effect on the noise performance of radio-relay links. Over a



A–Path length 70 km
B–Path length 50 km
C–Path length 30 km

FIG. 9—Estimated probability of occurrence of attenuation due to rain at 11 GHz as a function of path length

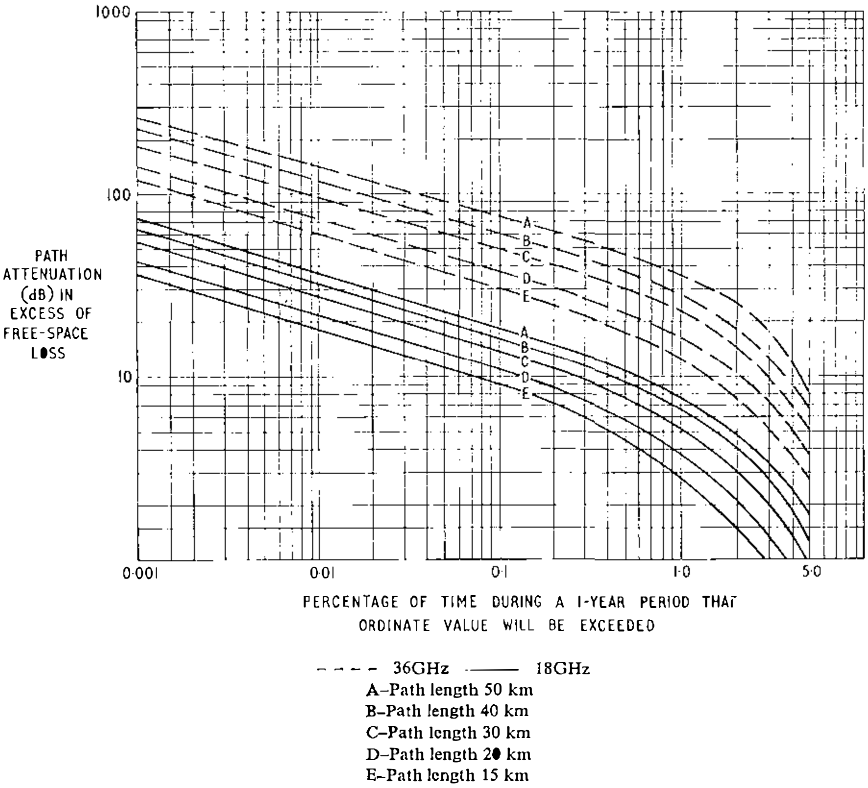


FIG. 10—Estimated probability of occurrence of attenuation, due to rain, at 18 GHz and 36 GHz

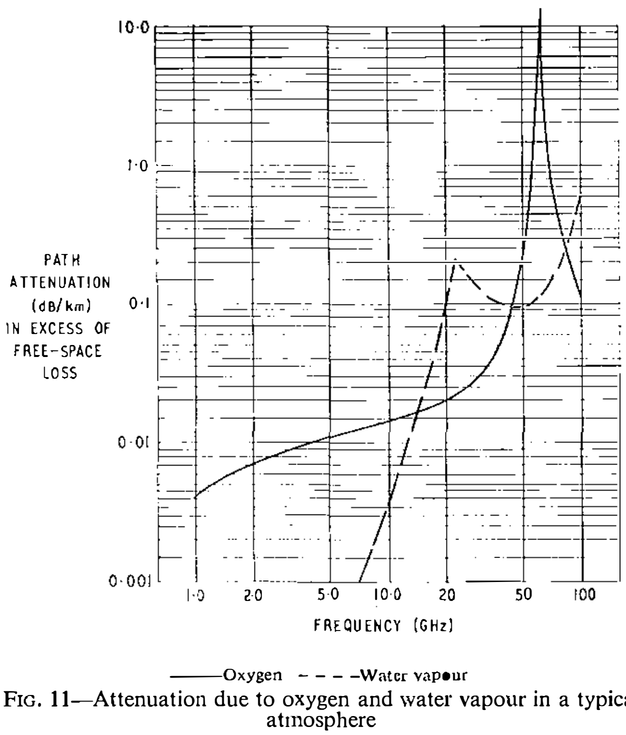


FIG. 11—Attenuation due to oxygen and water vapour in a typical atmosphere

number of years statistical data on the occurrence and depth of fading of the signals received over radio-relay-link paths have been built up, which can be used in the planning and design of further radio-relay links. Above about 10 GHz the combined attenuation due to precipitation and the water vapour and oxygen in the atmosphere increases considerably with frequency and is a further factor which will have to be taken into account when planning links to operate at such frequencies.

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A New Assembly for Flexibility Units

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U.D.C. 621.315.687.2

The introduction of plastic conductor-insulation for underground cables and reliable solderless, crimped, connexions has permitted a radical re-design of cabinet assemblies. The new assembly is simpler, more compact and cheaper than the older ones and is expected to have a lower fault rate.

INTRODUCTION

Cross-connexion assemblies housed in weatherproof cabinets were introduced in 1946 as a standard part of the local cable network.[1] In 1946, distribution cables had paper insulation and the standard conductor joint was the dry twist, insulated by a paper sleeve. Joints, therefore, had to be protected from damp, which would cause low insulation, and from handling, which would damage the paper, displace the sleeve, or disturb the conductor of twist and cause a high-resistance joint. Hence, the cross-connexion assemblies had a sealed cable-entry, which enclosed the cables completely, and connexion points on which the wires were terminated. Cross connexions were made by bridging pins and jumpers. There have been improvements in detail during the 20 years since cross-connexion assemblies were introduced, but the principle has remained the same.

The introduction of plastic-insulated cable during the 1950s[2] removed one of the major obstacles to the use of partial flexibility schemes employing auxiliary joints. The new insulation withstood handling, and the development in the early 1960s in America of the B-wire connector[3] had produced a robust joint. Jointing heads, therefore, became more attractive again and in 1965 the Midland Region introduced a shelf-type cabinet having no screw connexions or jumpers, but consisting of a large joint accommodated in a cabinet having plastic shelves to locate and support the pairs. (Fig. 1.) These assemblies have proved very successful and large numbers have been installed.

THE NEW ASSEMBLY

The Midland Region design was examined in 1967 with a view to national adoption. One drawback of the design was that each distribution-side (D-side) pair had a fixed position on the shelf and the appropriate exchange-side (E-side) pair was brought to that position for jointing. Due to the layout of the shelves and cables, the E-side pairs had different lengths and, if rearrangements necessitated moving E-side pairs to positions requiring longer skinners, piecing out was necessary. Attempts to build in slack in the E-side cable forms proved unsuccessful and a circular layout for the D-side was proposed with E-side pairs of approximately the same length coming from the centre of the circle. A development contract was placed with a plastics moulding firm, and work in co-operation with them produced the moulded prototype shown in Fig. 2. Orders have been placed for 1,000 assemblies of this pattern for field trial in 1969.

The new assembly accommodates 800 E-side and 800 D-side pairs and can be fitted in a small cross-connexion cabinet. Only one size is available since the material cost is too small to give an economic advantage in producing a smaller size. The new assembly is not suitable for pillars.

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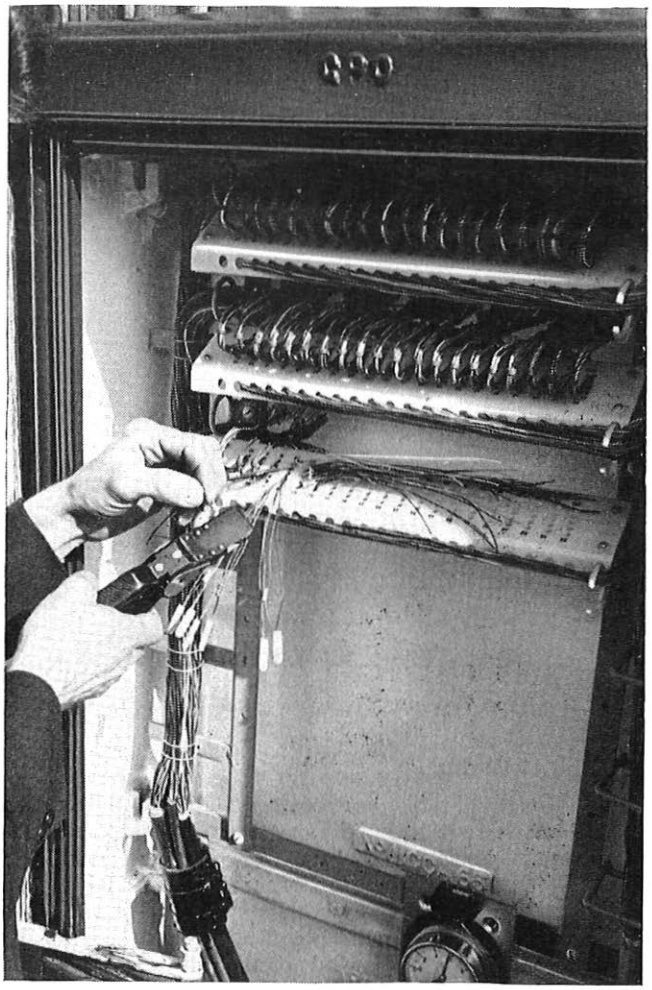

FIG. 1—Midland Region jointing cabinet showing the pairs supported on the plastic shelves

The assembly consists of four mouldings.

(*a*) The main moulding which forms the back plate, supporting the E-side and D-side designation plates, and includes guides for the cable pairs. No lacing of cable forms is necessary, the wires passing through the guides like jumpers. The back plate is moulded in acrilonitrile butadiene styrene (ABS) and is fastened to the assembly support bars by clamping plates to avoid drilling.

(*b*) The E-side designation plate, which is a rectangular plate moulded in clear plastic with 800 holes, each large enough to take one pair of wires. The holes are numbered and grouped to aid identification and the plate is fixed to the top of the back plate by set screws.

(*c*) Two D-side designation plates, forming an annulus with a space at the top for entry of the E-side pairs, and at the bottom for entry of the D-side cables. Each of the 800 D-side holes is large enough to take two pairs of wires.

When an assembly is fitted into a cabinet there is space at the left-hand side for air blocks on the E-side cables and, below, for pressure gauges.

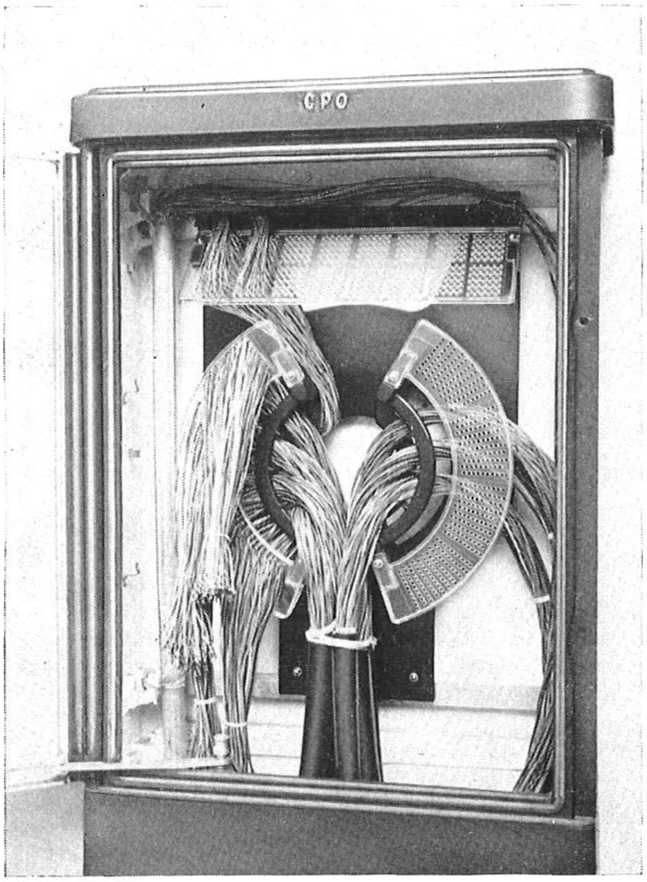

FIG. 2—Prototype assembly (wiring incomplete)

Method of Wiring

No cabinet tail-cables are provided and joints adjacent to the cabinet will normally be unnecessary. All cables terminating on the cabinet must be polythene insulated, and E-side cables will generally be polythene unit-twin and D-side polythene twin, with copper or aluminium conductors.

The E-side cables are led up the left-hand side of the cabinet and an air block is made on the vertical cable. About 60 in of cable is then stripped and the wires taken through the guide rings in the back-plate moulding and down through the holes in the E-side designation plate. The numbers of these holes, in which the cable pairs stay permanently, designate the E-side pair numbers.

The D-side cables enter through the bottom gap between the D-side designation plates and are fastened to the back plate by a strap. Since these cables are not normally pressurized, no provision is made for air blocks. The cables are stripped for a length of about 30 in and the pairs led around the centre moulding and through the D-side holes from the back. These holes designate the D-side pair numbers.

To make a cross connexion, the long end of the E-side pair is taken through the guides and the centre ring, threaded through the appropriate hole with the D-side pair and pulled tight like a jumper. The E-side and D-side pairs are then jointed using two grease-filled crimps, leaving about 8 in of wire in front of the designation plate. For rearrangements, the crimps are cut off, the E-side pairs moved to the new D-side holes and the wires jointed as before. Under the most unfavourable conditions five or six changes can be made before most of the 8 in of spare wire is used up. Any further changes would necessitate piecing in a new length of wire.

Advantages of the New Assembly

Because of its simplicity the assembly is very much cheaper than the present version, even though it must be supplied complete at the outset whatever capacity is required.

The new assembly increases the capacity of small cabinets and so reduces costs and wayleave difficulties. The maximum number which can be economically distributed through one flexibility point is 800 pairs, so there will be no economic case for installing larger cabinets with two assemblies.

The long leakage paths and the very small areas of exposed conductors in the mouths of the crimps make the assembly very resistant to moisture. This has been strikingly demonstrated by several of the Midland Region type cabinets which were completely submerged by floods but gave service again as soon as the water subsided.

The connexion given by the connector used is very reliable—equivalent to a soldered joint and better than a screw terminal. Also, the new assembly involves only one connexion per wire cross-connected, whereas the old assembly with its jumper and tail cables involves two screw connections, two soldered connexions and two underground dry twists. This should reduce the number of intermittent disconnexions in cabinets and produce a substantial reduction in labour costs.

Limitations of the New Assembly

The main limitation of the new assembly is the restriction of the number of times a pair can be disconnected and reconnected. There should be no difficulty over rearrangements for circuit provision and development purposes, but maintenance disconnexions for fault tracing on lines with a high fault liability could cause trouble. Many such disconnexions could be avoided, either by precision testing methods, or by disconnecting elsewhere, and only extensive experience will show how serious this problem is. For maintenance tests which do not require a disconnexion, probes are available which will make contact with the inner metal parts of a connector without damaging the plastic outer part. It may be necessary to retain the older type of assembly for use in special places where frequent disconnexions are required.

The capacity of a cabinet will in future be limited more by congestion of cables than by terminating space, and although it is possible to accommodate 800 D-side pairs of 0·8 mm aluminium or 20 lb/mile copper conductors on one of the new assemblies, considerable care is needed to achieve this. This is an unlikely requirement and one which could be avoided by providing one or two tail cables with smaller conductors.

CONCLUSIONS

A change in design since the prototype shown in Fig. 2 has improved the separation between E and D side pairs and made wiring easier. This has delayed production and field trials will not start before 1970. It has also been decided to continue using large (No. 3 size) cabinets so that space will not be available for other equipment which may be required in future. It is hoped that the new assembly will prove more efficient and much cheaper than present units.

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The Development of Polyvinylchloride (P.V.C.) Duct

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Long-length cabling techniques have focused attention on the need to improve the ductlines used by the British Post Office. This article details the properties of p.v.c. duct, briefly describes the method of manufacture, and discusses its development as an alternative to the traditional earthenware duct.

INTRODUCTION

Since the early days of telecommunications the British Post Office has used ducts to provide a flexible cabling system which allows prior provision for development and facilitates the renewal and recovery of faulty lengths of cable. For the past half century the majority of ducts laid have been manufactured from earthenware, which has well-known characteristics of long life and stability. Other materials have been used, notably cast iron, asbestos cement, pitch fibre and, by the National Telephone Company, precast concrete, but none has proved as satisfactory as earthenware.

The introduction of light-weight, polythene-sheathed cable with a low coefficient of friction, together with light-weight improved rodding systems, has made possible the use of longer cable lengths between jointing points. These new techniques can only be used to maximum advantage if improvements in the air and water tightness, frictional properties, and concentricity of the sockets of duct lines can be achieved. Recent improvements in the jointing of single-way earthenware ducts (Duct No. 15) have met the requirements to some extent, but it has not been possible to extend the same improvements to multiway earthenware ducts. Ducts made from unplasticized polyvinylchloride (p.v.c.) have shown promise of meeting the requirements of a satisfactory all-purpose duct during an extended trial.

MANUFACTURE

P.V.C. polymer, of either suspension or emulsion type, is mixed with stabilizers, lubricants and pigments under controlled conditions to produce a powder designed to meet a particular application or specification. Traditionally, the powder mix was compounded into a pellet form of approximately $\frac{1}{8}$ in mesh. Although this technique is still used, the preferred method is to extrude straight from the powder form which is known as "premix", or "powder compound".

The powder is fed into an extruder via a hopper, mounted on top of the machine, which automatically feeds a predetermined quantity of material into the extruder according to the rated output. The material is thoroughly heated and mixed by the action of the extruder screws, and a fully plasticized material is delivered to a die assembly which forms the compound into duct. Cold water supplied to a calibrating former at the die head (Fig. 1) sizes and cools the material into the rigid state. Cooling to ambient temperature is achieved by passing the duct through an in-line water bath, positioned immediately in front of the die calibrating-unit.

The linear movement of the duct as it leaves the water bath is critically maintained by a caterpillar-type haul-off, after which the duct is marked with an identification code and finally cut to unit length by an automatic cross-cut saw unit. A typical layout is illustrated in Fig. 2. Sockets are formed on the cut lengths by reheating one end to a predetermined temperature, then cooling over a suitably-shaped mandrel or, alternatively, by cooling inside a shaped mould whilst maintaining a suitable air pressure inside the duct.

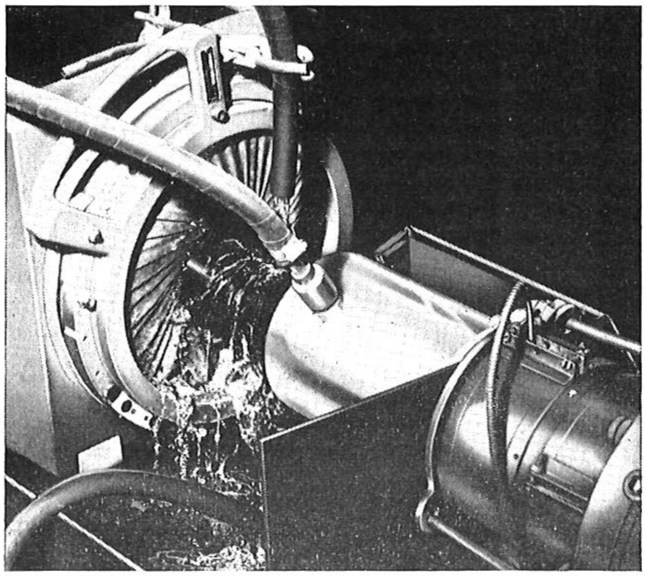

FIG. 1—Die head, extrusion in progress

Bends can be made by heating a suitable length of duct to approximately 130°C. The duct softens under heat and permits the desired radius and angle to be formed. Because of the inherent rubber-like characteristics of the material when heated, it is necessary to prevent the bore from collapsing during the bending operation. This is achieved by compaction with sand, the use of internal flexible cores, or air pressure. The radius and angle of the bend is controlled by moulds, or profiled forming-jigs, around which the bend is pulled and held in position until fully cooled. (Fig. 3).

Sockets may be formed after or during the bending operation.

PROPERTIES OF P.V.C. DUCT

The main requirements of an underground cable duct and the corresponding properties of p.v.c. duct are as follows:

(*a*) The bore should be smooth and have a low coefficient of friction. P.V.C. duct is extruded to limits of $\pm 0{\cdot}008$ in and the resulting bore is extremely smooth. The coefficient of friction is low compared with earthenware.

(*b*) The duct should be airtight and watertight. P.V.C. ducts can be made both airtight and watertight. They are ideal for pneumatic rodding and gastight and watertight duct lines for leading into telephone buildings can be easily provided. The

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silting problems frequently associated with self-aligning earthenware ducts do not occur with p.v.c. ducts.

(c) The duct must be inert to the cable it contains and to its environment. P.V.C. is inert to all organic material and has excellent insulating properties which assist in preventing the electrolytic corrosion of lead-sheathed cables.

(d) The duct must have adequate strength and durability. The mechanical strength of p.v.c. duct is relatively low and it is susceptible to fracture under impact with a sharp object such as a pick, especially at low temperatures. The presence of a notch in the surface of the material reduces the impact strength.

P.V.C. duct is likely to distort under a constant load, a property known as the creep or cold flow. At ambient temperatures in the British Isles the degree of creep is small and the rate decreases logarithmically with time. Creep can be reduced by ensuring good compaction of the backfill around the duct. (Fig. 4).

(e) The cost of the duct must be competitive. With the increased demand for p.v.c. duct and a general decrease in polymer prices resulting from improved manufacturing techniques, the cost of p.v.c. duct should become directly competitive with earthenware duct in the near future. Additionally, it is possible that the cost of laying p.v.c. duct

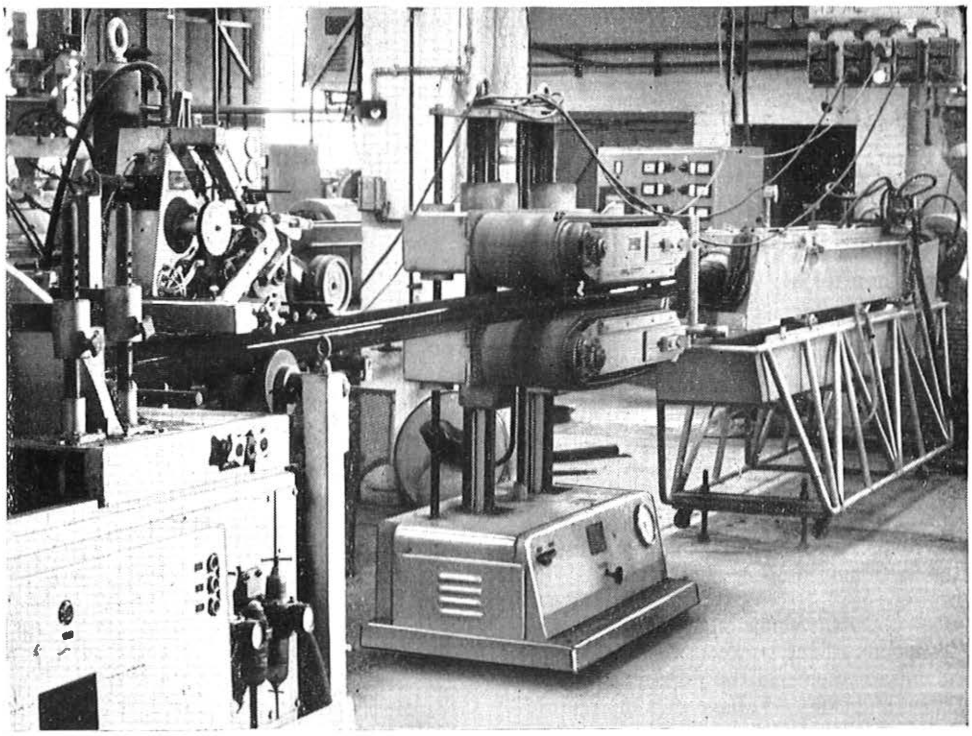
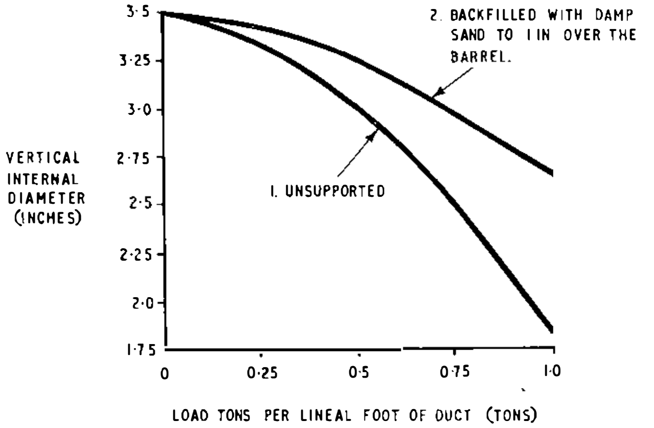


FIG. 2—Typical layout of extruder

FIG. 3—Mould for production of bends



(1) Unsupported (2) Supported

Fig. 4—Distortion/Load characteristics for pipe under load

will eventually prove cheaper than for earthenware, and there are already indications of this for single and two-way formations.

CONSTRUCTION METHODS

The first application in this country of p.v.c. duct was a derivation of the French "B" system in which thin-walled p.v.c. pipes separated by concrete spacers were laid on a reinforced-concrete base and completely surrounded by a wet concrete mix. Although the results obtained from these early trials were satisfactory, experience showed that a thicker wall was necessary to withstand the rigours of placing even a wet concrete mix between and around the assembled ducts, and Duct No. 55 was introduced with a wall thickness of 0·06 in to provide a standard system for exchange leads-in and large multiway formations.

Formations up to Nine Ways

The success of Duct No. 55 lead to the development of a still thicker walled p.v.c. duct for moleploughing or direct burial in the ground. Duct No. 54 was then introduced with a wall 0·150 in thick, and a tapered socket at one end of each length into which the plain end of the adjacent length is driven. The taper, although only slight, ensures a watertight joint. At about the same time, a similar 2 in diameter duct with a wall thickness of 0·060 in was introduced for housing estates and situations where a larger duct is not justified.

Before introducing Duct No. 54 an investigation of probable behaviour under traffic loadings when laid at standard depths was needed.

For traffic conditions in Great Britain the maximum wheel loading per foot run on duct buried at a depth of 24 in in carriageways is 1,000 lb. To meet this, earthenware ducts, which are unable to flex and will break if overloaded, are tested to withstand 30 cwt per foot run. Laboratory tests have shown that, given adequate side support, p.v.c. ducts with a wall thickness of 0·15 in will withstand a test load of 1,000 lb per foot run with a degree of ovality not exceeding 7 per cent. Distortion of this order would allow a $3\frac{1}{4}$ in test-mandrel to pass through a nominal $3\frac{1}{2}$ in diameter duct and is regarded as acceptable, since this degree of distortion is well within the elastic limit of the duct wall and there is no danger of fracture.

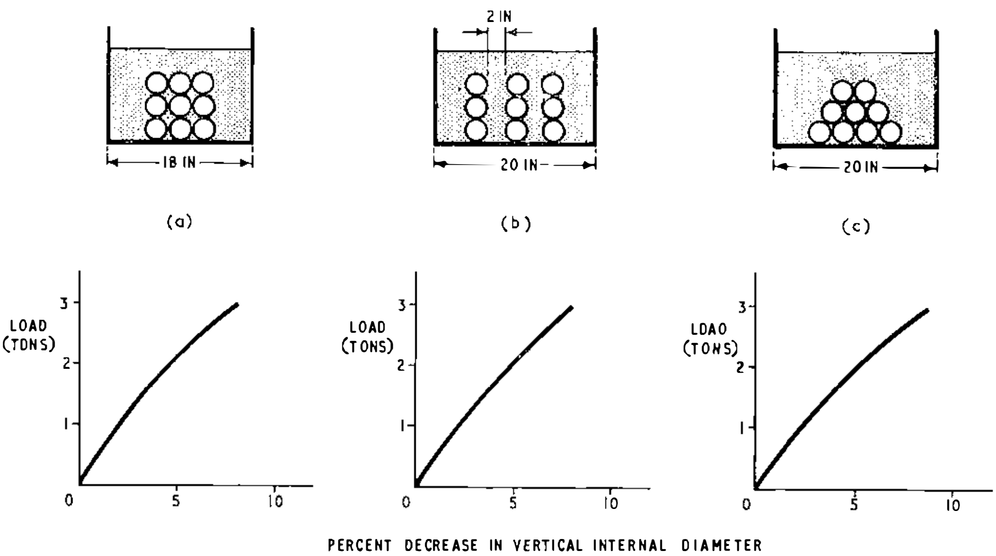
Practical experience has shown that it may be possible to reduce the wall thickness of 0·15 in with a consequent saving in raw material. This is important because the cost of p.v.c. duct is roughly proportional to the thickness of the wall, and a reduction of one third, from 0·15 in to 0·10 in, would reduce the cost by about the same ratio.

The first use of Duct No. 54 buried directly in the ground was in single-way formation both under footway and under carriageway. Mandrel tests taken periodically to check for any reduction in bore size confirmed that the duct was satisfactory, and laboratory tests were undertaken to determine which multiway formations would give comparable results. Experiments showed the most economical and effective forms to be as shown in Fig. 5(*a*), (*b*) and (*c*). The associated graphs indicate the reaction of these formations to a similar applied load. It will be appreciated that methods (*b*) and (*c*) require a relatively wide trench and method (*a*) is the preferred method and the most economical to lay.

Following the laboratory tests, some practical trials were carried out with preferred formations laid in a carriageway. Mandrel tests to check for reduction in bore diameter were made at the completion of laying and subsequently at six-monthly intervals. To date none of the trial formations has shown any significant change, and a decision has been taken to lay up to six ways of these ducts directly in the ground with a possible extension to nine ways as further experience is gained.

Multiway Formations Exceeding Nine-Ways

Because an unsupported p.v.c. duct will flex under load,



(*a*) Rectangular Close Formation
(*b*) Rectangular Horizontally Spaced Formation
(*c*) Pyramid Formation

Note: Graphs show Distortion/Load characteristics for each formation.

Fig. 5—P.V.C. ductnest

restraint of the duct wall is essential if reduction in vertical bore diameter is to be avoided. The laboratory tests made on Duct No. 54 showed that external support is not necessary around every duct, provided that the ducts are in mutual contact along their vertical and horizontal diameters, and that the outer ducts of any layer are unable to flex. It was therefore concluded that for nests exceeding nine-ways it should be possible to lay the ducts in close formation (touching) and to restrain the nest as a whole by placing concrete in the space between the ducts and the trough wall without attempting to work it between the ducts (Fig. 6).

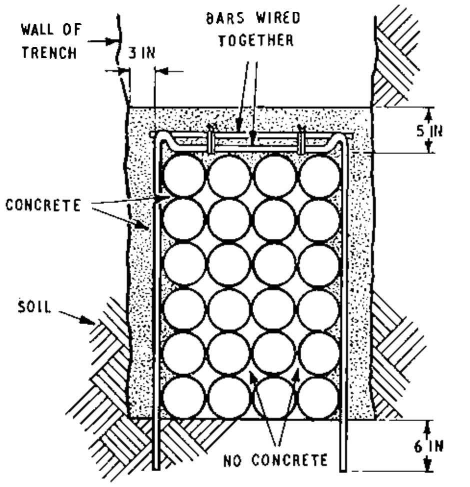


FIG. 6—P.V.C. ductnest: 18-way rectangular close formation in concrete

Field trials of this method are in progress with encouraging results, and it is possible that this form of construction may replace the thin walled duct No. 55, set in concrete, at present used for exchange leads-in.

In view of the relatively wide trench needed for the larger nests, a concrete roof was provided in order to spread traffic loadings. It is possible that this may not always be necessary thus saving on laying costs. The final result depends upon the outcome of experiments now being made with an intermediate wall thickness of about 0·01 in and the possibility of stiffer material becoming available, both of which affect surrounding support required and hence the relative costs.

CONCLUSION AND FUTURE TRENDS

Extensive experience to date has shown that p.v.c. duct is a satisfactory replacement for earthenware duct, but more experimental field work remains to be done before a complete change over to p.v.c. duct could be effected. The cost of the duct is related directly to the amount of material used so any future duct development should be towards reducing the amount of basic material. Since the rigidity of the section is dependent upon the diameter of the duct, the wall thickness, and the flexural strength of the material, and as the standard bore size for P.O. use is fixed at a nominal $3\frac{1}{2}$ in, one way of reducing the amount of basic material is to use more rigid type of p.v.c. This is available and a 30 per cent reduction in raw material is possible, but further tests must be undertaken to establish how far this increased material strength is obtained at the expense of increased brittleness and whether this is of any consequence.

Another possibility being explored is corrugated duct which, to a degree depending upon the shape and size of the corrugation, is much stiffer than plain duct for a given wall thickness. Although savings in wall thickness are offset by extra material required for the corrugations, this duct could be coiled on to large diameter drums for mole ploughing where the speed of laying is high and the length of each section is between 100 and 150 yd. It should be possible to coil lengths of 150 yd on a 7 ft 6 in diameter drum which would avoid delays caused by making joints. If joints should be required, however, corrugated duct does lend itself, surprisingly enough, to very satisfactory methods of jointing.

Consideration is also being given to the use of corrugated duct for normal laying, as, by suitable design of the corrugation, combined with a reduction in wall thickness, it would be possible to obtain a moment of inertia equivalent to that of duct No. 54 but reduce the material used by 20 per cent. The most efficient form of corrugation, however, would be both tall and coarse, which would make rodding and cabling difficult. Also, a duct having too thin a wall would be liable to puncturing during the back-filling of trenches.

ACKNOWLEDGEMENTS

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The Foreign-mails Office at Southampton

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Unusual postal operational requirements often call for special design of equipment. This article describes the general mail-flow through the Southampton Foreign-mails office and highlights the novel mechanization techniques adopted to overcome specific handling problems.

INTRODUCTION

A sorting office containing some unusual design features was opened at Southampton by the Postmaster General on 16 May 1966. This office is important because it not only serves Southampton in respect of its normal inland letter and parcel mails but, in addition, connects the United Kingdom inland traffic with the surface foreign traffic to and from the U.S.A., South Africa, East Africa and many other countries.

The building, sited on recovered land in the West Docks area, is linked by rail with both British Rail and the docks railway systems. Road services also exist to serve ships quickly on sailing days and connect the office with the normal road services in and around Southampton.

The rather special postal requirements of the office brought forth in the design of the mechanization equipment a number of novel features, particularly the way of handling mail bags into and out of the rail brakes stationed alongside the rail platforms. The opportunity was also taken to introduce other new ideas into the general design. The object of this article is to describe these novel features against the background of a general description of the office.

RAIL-PLATFORMS HANDLING EQUIPMENT

The office is served by three external rail-platforms. The main rail-platform extends the full 180 ft of one side of the office, and the other two platforms are formed by the two sides of an island rail-platform which is joined at one end to the main rail-platform.

Inward Mails

The main rail-platform is used for loading and unloading rail brakes in which foreign mail bags are shunted to and from the ships' sides. Bags arriving at the office for dispatch to inland destinations, i.e. "inland foreign," are manually discharged from the rail brakes on to a flat rubber-impregnated band conveyor set into and flush with the surface of the platform (see Fig. 1). This conveyor, which is reversible, runs at 10 ft/min carrying parcel bags in one direction and letter bags in the other direction. The conveyor was installed as closely as possible to the edge of the platform to minimize the task of man-handling the bags, some of which weigh as much as 100 lb, and it was necessary for the band to be rubber impregnated to withstand the climatic conditions of the exposed platform.

At both ends of the band, bags are discharged into short chutes positioned at right-angles to the platform edge. Each of these chutes feeds the bags on to another rubber-impregnated band traversing the platform beneath the walking surface. The sorting-office floor is at ground level and the loading platform is raised above this level by 3 ft 6 in so that the incoming bags are able to pass into the office by permanent conveyors which do not impede pedestrian or truck traffic along the platform.

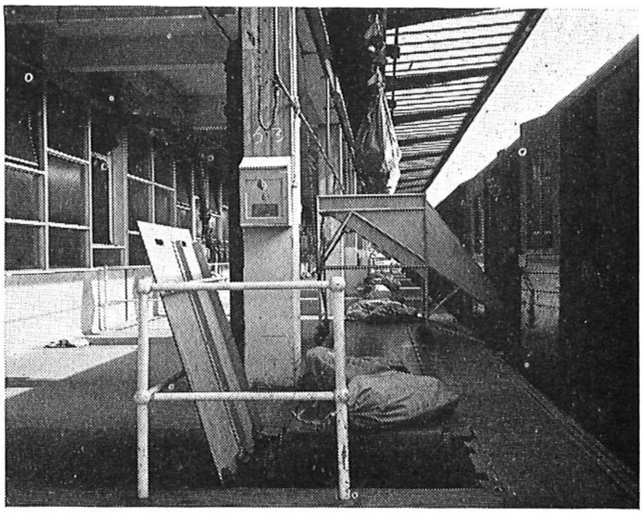

Fig. 1—Main rail platform

The transfer of rain-water from the platform-edge band conveyor into the sorting office, via the chutes and traversing bands, has been minimized by the provision of drain holes across the chutes near their bottom edges; the water drains into a sump under each chute, from which it is discharged by a double-acting hand pump. The driving-motor pit is also provided with a hand pump and has, additionally, electric heaters to keep the drive equipment dry and to ease starting conditions during very cold weather.

Double draught-doors and photo-electric blockage detectors are provided in the under-platform tunnels, and security doors, with full interlocking switching and signalling arrangements, are provided on the office ends of the tunnels.

The arrangement described above enables the number of postmen employed for discharging the rail brakes to be reduced to only those needed for manually handling the bags within the brakes themselves.

Inward-foreign letter bags, once inside the building, are off-loaded from their platform traversing band and are immediately loaded on to a chain conveyor which transports them to a stacking area in the letter section of the office. At the other end of the building, inward-foreign parcel bags are off-loaded from their traversing band and are stacked locally to await customs examination.

Outward Mails

Outgoing bagged mails are dispatched to the rail brakes by chain conveyors and mobile chutes. The latter feed directly into the rail brakes and thereby minimize both the effort and the staff required to handle the work (see Fig. 1).

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The difficulty of positioning the chain discharge ramps and chutes to line up with the variable position of the doors of the rail brakes was overcome by developing movable ramps (see Fig. 2) and mobile chutes. Each ramp is supported by,

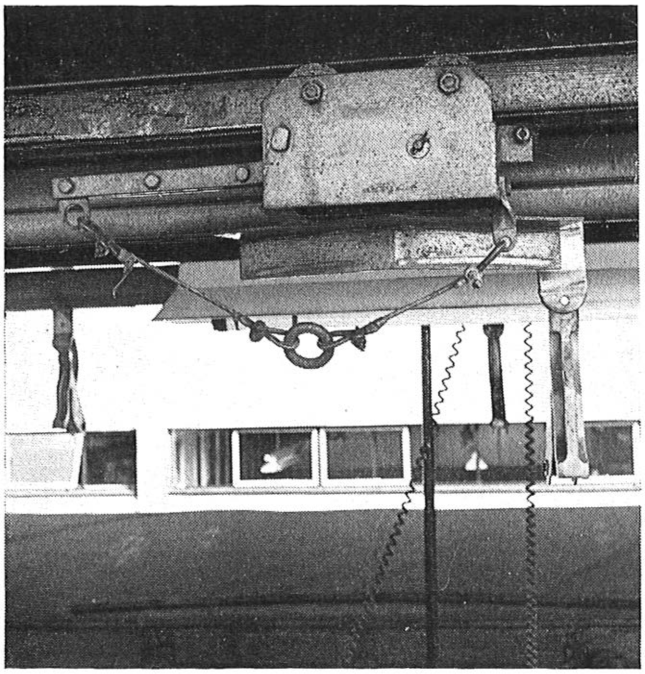


FIG. 2—Mobile discharge ramp

and is able to move on, one or the other of two steel rails fixed one on each side of, and parallel to, the chain track. Each rail over the main rail platform has two ramps; the ramps on one side of the chain track operate "normal" bag carriers, and the ramps on the other side operate "reversed" bag carriers. The last ramp to be reached on each rail is of a "fixed" type (as shown in Fig. 2), but the others are retractable so that bags can pass it undischarged as necessary.

Movement of the ramps along their rails is achieved by the use of a pole with a window hook at the end. This hook can be engaged in the operating ring which, when pulled down (vertically or at an angle), automatically releases a brake and permits the ramp to be run along its rail. Release of the ring automatically re-engages the brake. Engagement of the pole hook in another ring on the unit enables the ramp blade to be set to the discharge position or retracted from it.

The mobile chutes have braked wheels which enable them to be moved and parked in safety beneath the discharge ramps. Brakes are necessary not only to avoid the possible accidental rolling of a chute off the platform edge but also to stop movement due to the impact of the bags as they strike the chute's inclined surface. The design of the chutes on the main rail-platform is such that the wheels straddle the surface band to permit bags to pass comfortably along beneath, as shown in Fig. 1; rail brakes can thus be loaded and discharged at the same time.

On the island rail-platform it was necessary to arrange for six rail brakes to be loaded at the same time. To achieve this without resorting to the expense of a "code-on-load" chain conveyor, the novel arrangement of bag carriers with three different "ball heights" used in their two possible orientations, was adopted; the bag carrier with the longest operating arm has the highest ball height, and that with the shortest arm has the lowest ball height. Previous to this installation only two heights of ball arm had been employed together in their two possible orientations to serve four discharge stations.

The movable island-platform discharge ramps are not retractable but have blades of different depths. The narrow blade operates carriers with the longest arms, the medium-depth blade operates carriers with the longest and medium-length arms, and the deepest blade operates all three types of carrier. Care has to be taken, therefore that the order of discharging is carefully observed at the chain loading-point. To assist this, each type of carrier (long, medium or short armed) is painted a different colour.

Pile-up guards to stop the chain conveyors are provided on all movable discharge chutes used on the main and island platforms. The electrical signals from the guard equipment on each mobile chute are connected to the signalling and control system by a flying lead which, when not in use, is hooked up over the platform as illustrated in Fig. 3. The mobile chutes

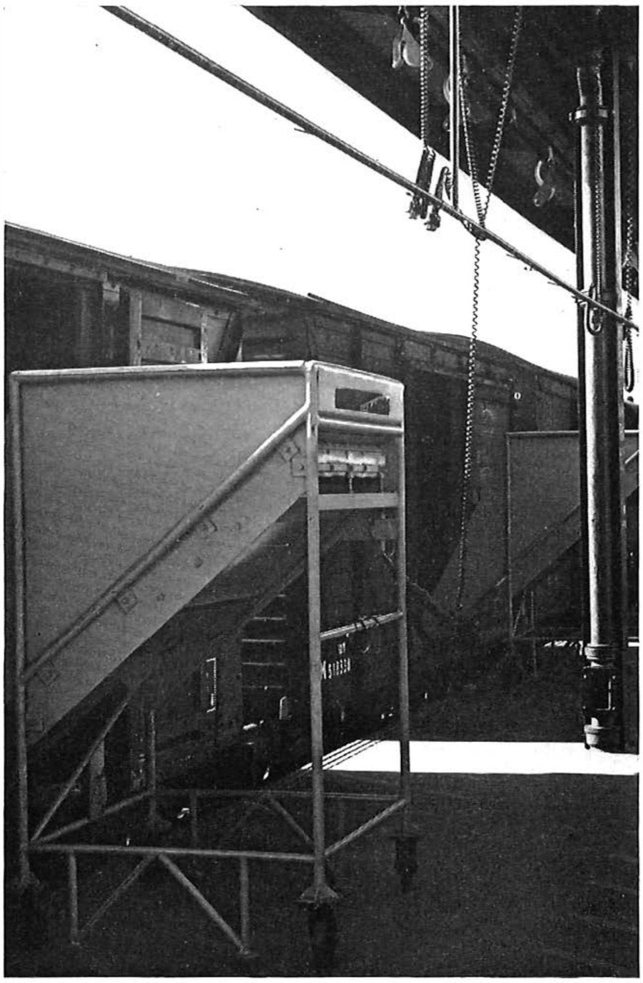


FIG. 3—Island rail platform

are fully padded to avoid damage to the mail when the bags are dropped off the chains.

ROAD-PLATFORMS HANDLING EQUIPMENT

The office is served by two road platforms one for parcel mails and the other for letter mails. Collection bags, i.e. unsealed bags of items collected from pillar boxes, sub-district offices and scale-payment offices, and firms' parcel bags, off-loaded from road vans, are emptied on to one of two sloping roller conveyors which protrude through apertures from inside the office. Vertically-sliding counter-weighted lockable security doors are provided on the inside wall-face of the office to seal these apertures and rubber draught curtains are also provided.

On one road platform, outward-foreign parcel bags are loaded on to a chain conveyor which transports them to the first floor for processing. Outward-foreign letter bags are loaded on to another chain conveyor on the other road platform for transportation to the foreign-letter section. Collection bags are treated in a novel manner in that the bags are loaded on to a steel-band conveyor which performs the dual functions of a transporting and a storage device. The use of a steel band in place of a woven-cotton band permits a vertical stop-board to be placed across the band and in intimate contact with it, thereby guarding against bags becoming jammed under the stop-board but allowing bags to pile up backward towards the input point with the band sliding under them and without their contents being crushed. Bags may also be dragged off the band at right angles to its direction of movement without affecting the tracking of the band or seriously affecting the disposition of the other bags piled up behind.

Despatches are made to road vehicles at three points. "Sailing-day" parcel bags are despatched via a chain conveyor to a motorized cantilever chute which has discharge positions at three different heights to suit all sizes of vehicles. Letter delivery bags, however, are dropped directly from a chain conveyor into road vans via two "Peterborough" type chutes (see Fig. 4). The use of this particular type of chute avoids the need for a loading platform and minimizes the labour required for van loading. When the ramp leaves the fully-down position the associated discharge ramp is inhibited and when in the up condition the wall aperture is sealed.

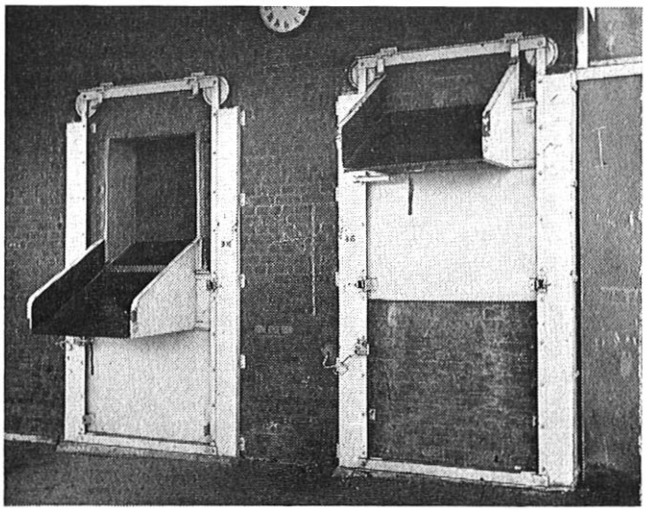


FIG. 4—"Peterborough" chute

MAIL PROCESSING

Letter Mail

The office has to deal with incoming-foreign and outgoing-foreign mails as well as the normal collection, delivery, forward and distribution traffic. Outward-foreign mails are processed separately and are despatched in bags to the rail brakes alongside the main platform via the same chain conveyor that is used for outward-foreign parcel bags. The normal and reversed bag carriers, in co-operation with the movable retractable ramps mentioned earlier, enable both types of bags to be transported at the same time for despatch to different rail brakes.

Collection letter mail is processed by passage through a segregator and automatic-facing machine. The packets separated from the letters by the segregator are fed, via a 35° rising grip-face belt conveyor, to a tilted-band conveyor, by which the packets are distributed to four concentrators, providing six sorting positions.

One novel feature of this tilted-band conveyor is that it does not employ the usual arrangement of "twist" sections at both ends but is tilted throughout its length, including the head and tail rollers and also the return strand. A second novel feature is the use of pneumatically-operated guillotine-type gates.

The design of a tilted band without twist sections was essential to enable the packet-sorting positions to be set closer to one wall of the office than would otherwise have been possible. Normally, at least 8 ft is required in which to satisfactorily twist a band of the type used for these conveyors from the horizontal to 37°, due primarily to the transverse stiffness of the band. The no-twist arrangement thus saves the provision of over 32 ft of band and, more especially, enables the equipment it serves to be better sited.

Parcel Mail

The parcel section of the office consists of a double-storey building, the ground floor being used for sorting inward foreign and internal (i.e. locally-collected) mails and the upper floor for sorting outward-foreign mails.

Outward-Foreign Parcel Mail

Outward-foreign parcel mail is carried in bags "neck down" by chain conveyor from the road platform to the first floor, where the bag string ties are cut whilst still moving suspended from the chain. The parcels are deposited into various sections of a 100 ft long wooden storage glacis (see Fig. 5) dependant upon their final destination country. After sorting and bagging-up the foreign parcel mails are despatched, via a chain conveyor, to the rail brakes alongside the main platform for eventual carriage to the ships.

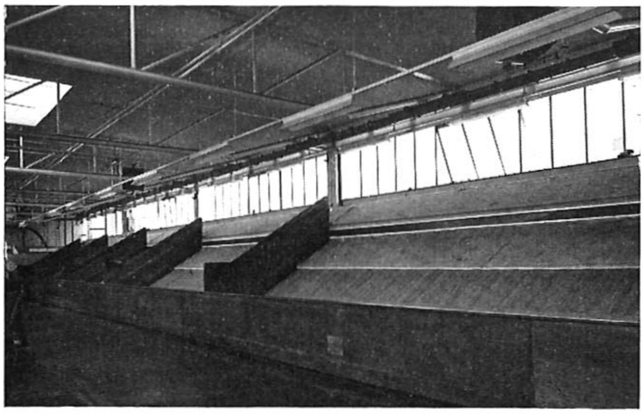


FIG. 5—Foreign parcel glacis

Inward-Foreign and Internal Parcel Mail

The stacked bags of inward-foreign parcels are emptied on to a floor-level band conveyor which feeds two customs examination points. Parcels which are passed through these examination points are integrated with internal mails and fed, via a hammock-type elevator conveyor rising at an angle of 85° to the horizontal, to two pre-primary storage units. Both of these pre-primary storage units have band conveyors at their outputs by which the parcels are fed forward as required by the sorter.

The sorters' positions (Fig. 6) are sited at a mezzanine level between the ground floor and first floor, so that the tilted-band machines can run at high level over the ground floor. The pre-primary stores are "folded back" immediately above the sorters' positions to enable the lengths of the tilted sorting bands to be as long as possible within the length of the office. The distance between the centre lines of the two storage conveyors of the pre-primary stores is greater than between those of the sorting machines; furthermore, none of these centre lines coincides, the maximum difference being approximately 4 ft. It was necessary, therefore, to design two linking chutes, both taking the shape (and name) of a lobster's back, which provide not only reversing paths but also

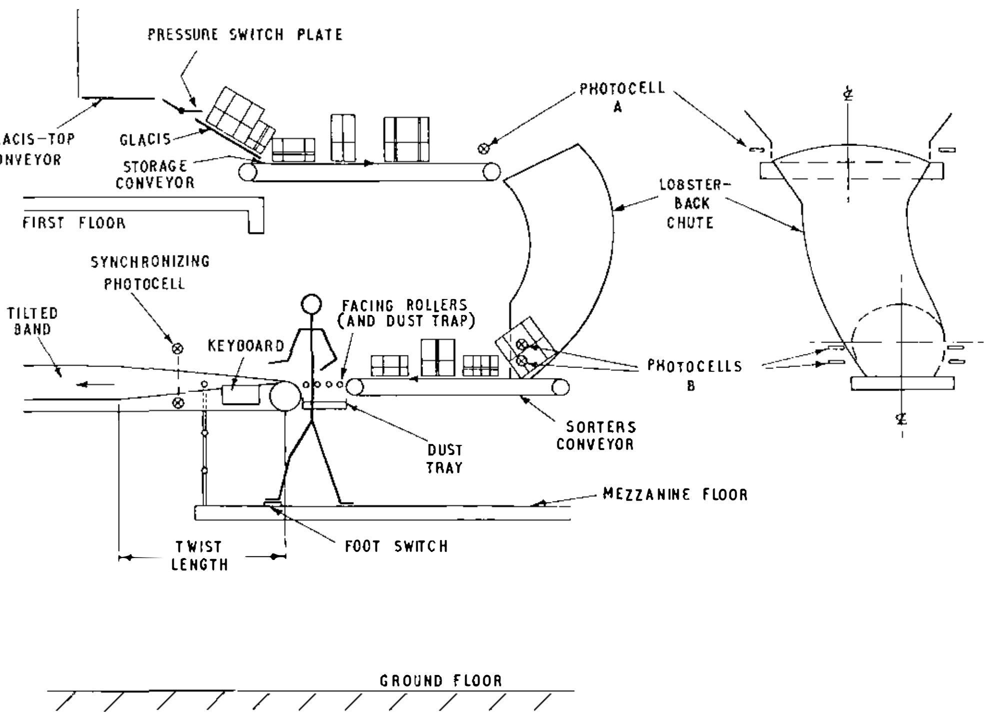


FIG. 6—Parcel sorting machine feed arrangement

have their input and output centres out of line by differing amounts and, therefore, act as a sideways link.

The relative position of the sorters' positions and pre-primary storage units made it virtually impossible to site a control position from which could be seen both the flow of parcels into the pre-primary storage units and, at the same time, the sorters' positions so that the out-flow of parcels to the sorters via the lobster-back chutes could be regulated.

Television monitoring was considered but, because this meant employing a separate control postman or, alternatively, vesting the control in one of the sorters with the subsequent reduction in his average sorting rate, the idea was not pursued. A fully-automatic and novel control scheme was devised which has proved to be completely successful in practice.

The pre-primary stores are fed from a glacis-top conveyor. Parcels passing along this conveyor are diverted by a fixed plate into the second, i.e. more remote, pre-primary storage unit. As parcels build up over the glacis surface they eventually spread across it and rest on a strategically placed pressure switch-plate for a period longer than the transit time of a parcel passing across it. The store is then assumed to be full and a pneumatically-operated diverter swings across the glacis-top conveyor, diverting the parcels to the first pre-primary storage unit. The operation of a similarly placed pressure-sensitive switch at the first pre-primary storage unit when it is full either causes the restoration of the divertor, if the second storage unit has emptied sufficiently for its switch to be cleared or, if both units are full, causes the complete feed system to stop. When either of the two sorters' positions is used for single sorting-machine working this control is inhibited.

Parcels from the two pre-primary stores are fed, via the two lobster-back chutes, to the primary-sorting positions under photocell control, the chutes merely acting as links and not as storage devices. A photocell (A in Fig. 6), located just above the discharge roller of the storage conveyor of each pre-primary store, controls the running of the band in its base in order to arrange that parcels are always brought to the entry of the lobster chute. The beam of the photocell is then broken and the band automatically stops. Two other photocells (B in Fig. 6) are located at the base of the lobster chute just above the sorter's conveyor. When the beams to both these photocells become unbroken the pre-primary storage-conveyor band runs for a fixed period of two seconds, during which time approximately a dozen parcels can be discharged into the chute. The beams to photocell B then become broken and the discharge is inhibited whilst the sorter deals with those in the chute. Directly the beams to both photocells B are again cleared a few more parcels are discharged into the chute. If the beam to photocell A becomes unbroken due to the absence of parcels at the output end of the storage conveyor of the pre-primary store, the band will commence (or continue) to run even though the beams to photocells B may be broken. By these automatic controls a steady trickle of parcels is delivered to the sorter's position.

The parcels at the bottom of the lobster-back chute are brought to the hand of the sorter by a band conveyor, the movement of which the sorter has under foot control. Any dirt, string, lead seals, etc., mixed in with the parcels are permitted to pass into a tray under a short section of roller conveyor at the sorter's end of the link.

At the beginning of the sorting band is the keyboard of the memory unit which enables the sorter to select the destination of each parcel. The sorter puts the parcel on to the band and presses the appropriate button which causes the destination information to be stored. At the appropriate point, the sorting band is slowly tilted from the horizontal to an angle of $37\frac{1}{2}°$ in approximately 8 ft of belt length. At this angle the band transports the parcels to the appropriate one of eight selections (see Fig. 7).

After the final discharge, the band is restored to the horizontal before passing round the drive pulley and drop-weight tensioning gear. The last station is a permanently open gate which acts both as a selection and an overflow outlet. Should any earlier outlet reservoir fill up, a photocell guard inhibits the opening of the corresponding gates of the two sorting machines and the parcels pass to the overflow outlet. If the reservoir fed by the latter also fills up, the two sorting machines automatically shut down. However, the primary and secondary sorters are warned precisely of the various pile-up conditions so that early action can be taken to minimize double handling of the parcels in the overflow store. On the other hand, each sorting machine automatically stops if a period of 5 minutes passes without a parcel being sorted.

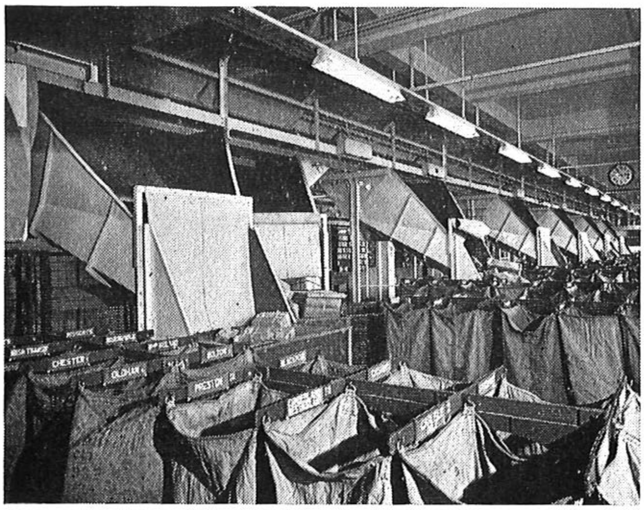


FIG. 7—Sorting machine outlets

The two 125 ft-long sorting machines feed into six common concentrators and two common direct-selection chutes, all sited on the ground floor. The gates of the sorting machines are electrically controlled from the memory units and are pneumatically powered. The pneumatic actuators exhaust to the atmosphere via individual silencers and no noise problems have been encountered.

Parcel mails are despatched by chain conveyor from this secondary sorting area to the island rail-platform for distribution to inland destinations.

Sorting-Machine Memory Units

Each sorting-machine memory unit consists of a large-diameter wheel rotating on a horizontal axis, carrying near its periphery three concentric rings of coding pins (see Fig. 8).

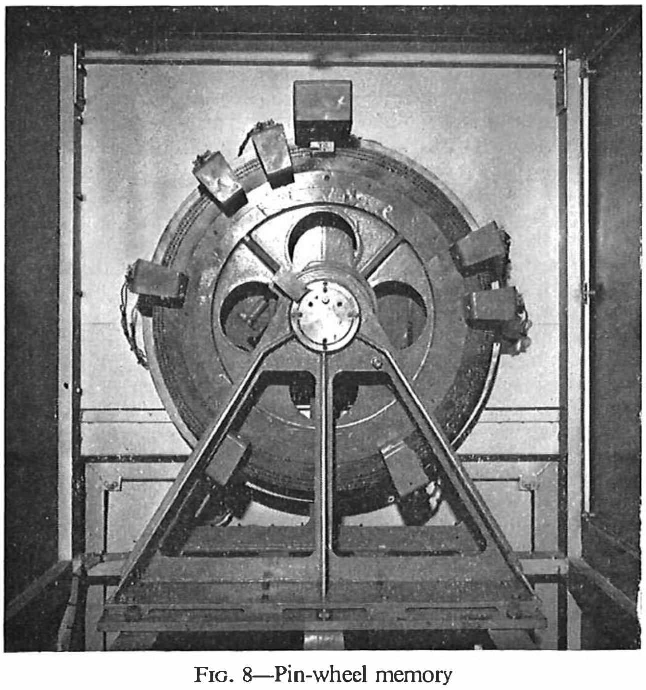


FIG. 8—Pin-wheel memory

Each pin in each group of three in a radial plane can be individually displaced horizontally in one direction when "set" by the code-setting electromagnets, providing the eight code combinations for the eight discharge stations.

Although the two memory units have performed satisfactorily, the particular design does not lend itself for general application to tilted-band parcel-sorting machines because the number of selections is limited, as also is the memory length for a reasonable diameter of pin wheel.

The primary sorter places a parcel on to the sorting band at the tail roller where the band is horizontal when an illuminated sign informs him that the keyboard is "free" for the depression of the appropriate destination button. A keyboard memory stores this information and busies the keyboard so that the depression of other buttons cannot affect the coding until the held information has been passed to the pin-wheel memory. However, if the sorter realizes he has made a keying error before the keyboard information has been passed to the pin-wheel memory, he can cancel the code by operation of a CANCEL button.

As the parcel passes along the sorting band its leading edge breaks a photocell beam which initiates the transfer of the keyboard information to the pin-wheel memory. The asynchronous keyboard operation and placement of the parcel on to the sorting machine band are thereby synchronized to the rotation of the pin-wheel memory with a maximum error of 4 in of band travel between the leading edge of the parcel on the band and the pin-wheel's angular position, the error being determined by the pitch of the memory pins and the rotational speed of the memory wheel in relation to the linear speed of the band.

At the appropriate angular position round the pin-wheel one of the "read-off" switches, each of which can recognize its own code combinations of set pins, is operated, causing a solenoid valve and pneumatic actuator to open the appropriate gate.

SIGNALLING AND CONTROL

The final novel feature of the Southampton installation is the centralized signalling and control system. Various less extensive (and less expensive) signalling and control systems have been employed in other offices, as, for example, for the control of the parcel storage and uplift-conveyor system at the London Western District Office, but the Southampton installation was the first fully centralized system. The success of this scheme of integrated postal-conveyor control from a central point resulted in the decision to extend the application to other large offices such as Birmingham, Manchester, Reading and London West Central District Office.

At Southampton there are two main control centres, each with its mimic diagram; one is in the letter section of the office (shown in Fig. 9), the other is in the parcel section of

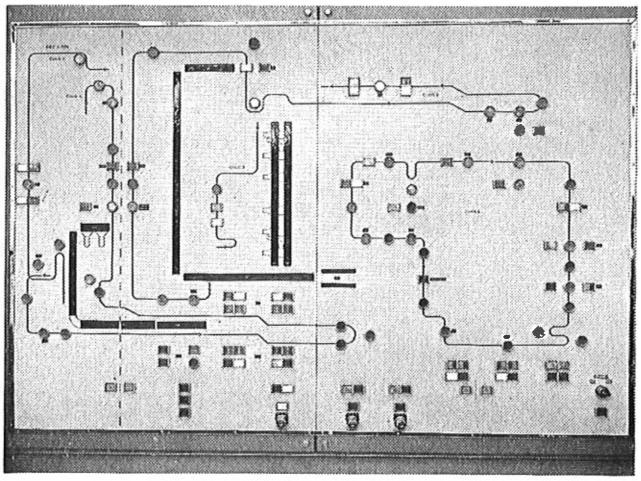


FIG. 9—Letter office mimic

the office. In both cases, the circuits are designed so that unless all the required signals have been correctly registered on the appropriate mimic control, the conveyor systems to which the mimic control applies cannot be started.

The controlling officer can, therefore, give executive commands via buttons on the mimic display to indicate his wishes with respect to mail he wants loaded (or not loaded), and also to indicate to the despatch points the type of mail they are about to receive.

Each mimic display contains complete information about the state of all the equipment and staff points in the office under its control. Any change of state of the mimic control originated by a remote operator, by a change of condition on the conveyor, or by the overloaded state of the storage units it serves, is drawn to the attention of the controlling officer by the sounding of a buzzer and the winking of the lamp on the mimic display representing the originating point in the office. The lamp stops winking when the controller has taken appropriate action; he can also independently cancel the buzzer operation. At some special points in the office the attention of the staff is drawn to "mail-arriving" conditions originated from the mimic control by sounding of buzzers. In this way staff are kept informed of the mail-flow conditions.

The whole system of conveyors has full electrical interlocking for the safety of both the postal operating staff and the engineering maintenance staff. The mimic displays give clear indications as to whether conveyors stoppages are due to reasons which can be dealt with by postmen (e.g. chute pile-ups) or require engineering staff attendance. The latter includes such information as the operation of bag fail-to-release detectors on chain conveyors and overheat detectors associated with the air pumps.

CONCLUSIONS

The foreign mails office installation has undergone minor changes as the result of experience gained with handling live mail in quantity, both from postal and engineering standpoints. However, the novel features described in this article have all proved to be worth-while additions to the increasing store of techniques for dealing with postal-mechanization problems.

In particular, pneumatics for controlling sorting-machine gates, parcel ploughs, etc., is becoming generally adopted as a better and cheaper technique compared with the electrical and hydraulic arrangements hitherto employed.

The no-twist tilted-band conveyor and customs-examination arrangements are being considered for other offices now in the design stage. Large multi-floor offices employing extensive chain conveyors for inward, outward and inter-floor transportation of bagged mail are becoming increasingly wedded to central control. The Southampton experiment has given the Planning and Mechanization Department a wealth of basic experience in the value of mimic diagram control. Experience has also been gained with cost estimating of such complicated control schemes.

ACKNOWLEDGEMENTS

Acknowledgement is made to Mr. C. R. S. McCarthy and Mr. A. G. R. Pettit for assistance in the preparation of this article and also to the postal and engineering staff at Southampton. Acknowledgement is also made to the contractor, New Conveyor Co. Ltd., the sub-contractors Messrs. Teleflex and M.T.E. and to the Ministry of Public Building and Works who designed the building.

Book Reviews

"Matrices, their Meaning and Manipulation." W. G. Bickley, D.Sc., F.R.Ae.S., A.C.G.I. and R. S. H. G. Thompson, B.Sc. English University Press Ltd. xiii+168 pp. 9 ill.

There are many books available on the elementary theory of matrices. This gives the reader the right to expect a high standard in any new book on the subject. The book should contain a clear exposition of the basic theory, and plenty of advice on numerical methods and practical applications. The book under review contains plenty of examples drawn from engineering, but in general these are rather elementary. It also contains a large amount of material on numerical methods. This part of the book should be very helpful to anyone faced with matrix computations for the first time.

However, the theory of matrices is badly presented. This is a pity since matrix theory is the starting point of the theory of linear systems, and a clear understanding of what matrices mean is essential for more advanced work. Whether the full description of numerical methods makes up for the deficiencies in the presentation of the theory, depends on what the reader wants from the book, but the claim on the jacket of the book that it will "help the student to read with understanding the language of matrices" is certainly overstated.

W. E. T.

"Low-Noise Microwave Amplifiers." H. W. Daglish and others. Cambridge University Press. viii+167 pp. 36 ill. 20 plates. 45s.

This book is the second in a series of IEE monographs on electrical and electronic engineering. It reviews the current state of development of low-noise microwave amplifiers suitable for use as receivers in applications such as satellite and terrestrial communications, radioastronomy and radar. Following a brief introduction, which outlines the necessity for very low-noise amplifiers to exploit the microwave "window" in the earth's atmosphere from 1 to 20 GHz, there are chapters on travelling-wave tubes, the maser, the varactor-diode parametric amplifier, tunnel-diode amplifiers and transistor amplifiers; there is also an excellent chapter on microwave-mixer and detector diodes for use in superheterodyne and video receivers.

The emphasis throughout the book is on the limits of performance so far achieved by practical devices, the causes of these limitations and how they are being, or may possibly be, overcome. To this end extensive use is made of theoretical results, but no theory is derived—apart from the basic principles of the maser—and the interested reader must refer to a comprehensive list of up-to-date references for any basic background information he may require. The authors have attempted, as far as possible, to deal with each device in a similar manner, thus making it easy to draw comparisons between them. Topics general to all the amplifiers discussed include gain, bandwidth, noise temperature, dynamic range, intermodulation and distortion. A significant portion of the book deals with the technology of semiconductor diodes and transistors and the physical properties of the materials required in their fabrication. It is apparent, now that the maser is being superseded by the parametric amplifier, and the travelling-wave tube replaced by tunnel diode and transistor amplifiers, that future advances in low-noise amplifiers depend mainly upon the development of solid-state technology. Even improvement in the noise performance of the travelling-wave tube by the use of cold cathodes, will depend upon the development of suitable solid-state tunnel cathodes.

Although this is a relatively small book it contains a fund of information in a very concise form, and the authors have done well in the circumstances to present it in a generally readable manner. Not only will it form a "compact introduction . . . for graduate students" but will become a useful little reference book for those actively engaged in the field of low-noise microwave amplification.

J. T.

Notes and Comments

F. N. Martin, B.Sc.(Eng.), C.Eng., M.I.E.E.

Mr. Martin's many friends at home and overseas will be delighted to learn of his recent promotion to Staff Engineer in the Research Department. He joined the Post Office in

Derby as a Youth-in-Training in 1937, and in 1942 came to the Telegraph Branch of the Engineering Department. During his four years in that Branch he obtained an honours degree in engineering, and in 1946 he was successful in the open competition for Probationary Engineers. After a brief spell in the Telephone Branch on the development of national signalling systems, he went to Dollis Hill, where he took part in the pioneering work on electronic exchanges and acquired valuable experience in the application of electronic techniques to switching and signalling problems.

Shortly after his return to Telephone Branch in 1960 he was promoted to duties concerned with the development of international signalling systems, and during the period 1961-68 attended many meetings of C.C.I.T.T. Study Groups XI and XIII in Europe and more distant parts of the world —latterly as chief U.K. delegate to Study Group XI. In the course of this work he has made many friends overseas and has become an internationally respected figure.

Mr. Martin's wide experience of switching and signalling will be of great value to him in his new post, where he will head a branch responsible for system studies relating to electronic exchanges, and this experience coupled with his helpful and considerate personality will ensure for him that future success which is the sincere wish of all his colleagues.

B.R.H.

R. T. Mayne, B.Sc.(Eng.), C.Eng., M.I.E.E.

Richard Mayne, the new Controller (Deputy Head) of the Post Office Appointments Centre, started his career in the former Engineer-in-Chief's Office in 1946 as an engineering graduate-entrant to the telephone traffic engineering group. In 1950 he moved to Sheffield for experience in Area planning and management. Promoted Senior Executive Engineer in the Engineering Department in 1957, he worked to improve methods for exchange area layout planning, helped with standardization of terms and symbols and later became closely involved with exchange equipment economics and planning the trunk transit network.

After a brief spell as Area Engineer in Brighton, he was promoted in 1966 to Assistant Staff Engineer, concerned mainly with graduate, HND and A-level engineering recruitment, limited competitions and university scholarships. Early in 1968, when the Post Office Appointments Centre was set up, he moved over to help with the take-over of recruitment from the Civil Service Commission.

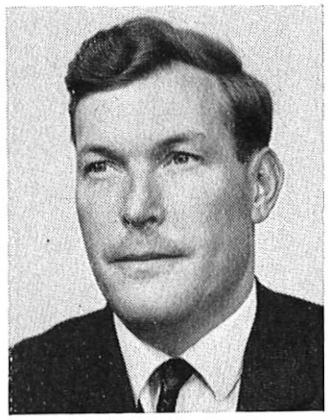
Richard Mayne's new post brings him special responsibility for the rapidly expanding recruitment of graduate engineers and scientists, where his ability as an engineer and his wide experience are distinct assets. His friendly, patient and

perceptive nature backed by unlimited enthusiasm for the job have helped enormously in building good relations with universities and attracting the best graduates to Post Office engineering and science. His many friends wish him every success in his new job.

J.M.M.

J. Martin, B.Sc.(Eng.), C.Eng., M.I.E.E.

Mr. Martin's promotion to Staff Engineer of the Telephone Systems Co-ordination Branch will be a source of great pleasure to his many friends and colleagues. It will be particularly welcomed by readers of this Journal, of which he was formerly an Assistant Editor and is now the Managing Editor—posts to which he has jointly given ten years of valuable service.



Mr. Martin joined the Post Office as a Youth-in-Training in Canterbury in 1943. After completing his national service in 1948 he passed the Limited Competition for Assistant Engineers, and in 1955 he was successful in the Limited Competition for Executive Engineers. In 1958 he obtained an honours degree in engineering.

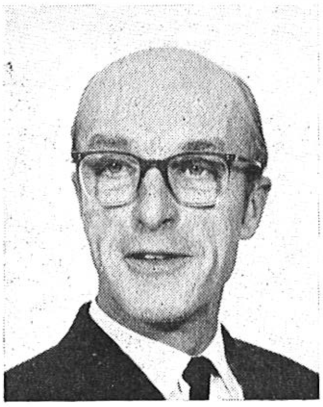
From 1949 to 1963 he was employed in the Engineering Department on the development of improved maintenance techniques, related particularly to the introduction of s.t.d., but embracing a wide range of activities. In 1963, on promotion to S.E.E., he became closely concerned with the development of large electronic exchange systems, a field in which he quickly demonstrated his versatility and his particular aptitude for engineering management. More recently, as an A.S.E., he has been concerned with the introduction of project accounting procedures in the Exchange Systems Division and with the resolution of problems arising from the winding up of the B.T.T.D.C. His diverse background will stand him in good stead in his new post where he will be concerned with all aspects of switching and signalling development.

An enthusiastic and co-operative colleague, who works well under pressure, Mr. Martin's many friends and associates confidently wish him every success in his new appointment.

B.R.H.

D. J. Harris, B.Sc.(Eng.), C.Eng., F.I.E.E.

Douglas Harris commenced his career in the Post Office as a Probationary Inspector in the Power Branch of the Engineer-in-Chief's office. From then on, with the exception of his



war service, he became one of that select band of professional engineers specializing in power and accommodation services. He served in the Royal Signals throughout the War in Algeria, Tunisia, Italy and Austria. In 1947 he was successful in the Reconstruction Examination for Assistant Engineer and until 1954 he was employed on postal machinery and mechanical aids. In 1954 he became S.E.E. in the ED Power Branch, engaged on accommodation services. In 1959 he moved to the Home Counties as Power Engineer and in 1963 was promoted to A.S.E. in the joint PO/MPBW Research and Development Group on the development of Telecommunications and Postal accommodation. In 1966 he became Regional Engineer in the LTR with responsibility for all Power work and extension of deep level cable tunnels. His recent promotion to Assistant Secretary OPD will enable him to make full use of his professional knowledge as he will be responsible for accommodation research including the joint PO/MPBW research and development group for telecommunications building.

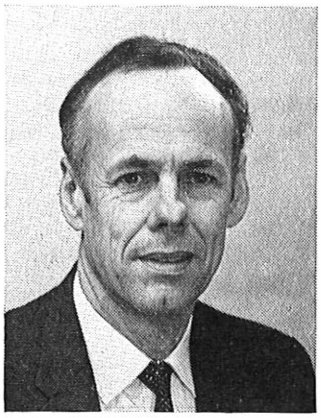
His quiet manner and technical competence made him a lot of friends in the LTR and in the wider power circles. He has always maintained interest in the IPOEE, serving for two years as a council member. His many friends wish him every success in his new post.

A.J.T.

C. J. Hughes M.Sc. B.Sc. C. Eng. M.I.E.E.

Charles Hughes' many friends will be delighted to learn of his appointment as Staff Engineer to head a new branch of Research Department devoted to the technological aspects of electronic switching.

He joined the Post Office in 1955 after service with Cable and Wireless during which time he spent several years abroad in Kenya and Ceylon. After some five years in the old Radio Branch at Dollis Hill he took up an appointment as an I.T.U. expert on radio communications in the Sudan where on occasions "he had to put down his soldering iron and advise the



Minister on policy". On his return he joined the Electronic Switching Division where he rapidly took a leading role in the realization of the Empress Digital Exchange which was then in the very early stages of conception. He undertook the selection of integrated circuit elements for the exchange and has since become expert on many aspects of modern circuit techniques.

Charles Hughes brings to his new post a broad range of experience which coupled with his infectious enthusiasm and agile mind will ensure the success which all his friends wish him.

W.T.D.

D. R. B. Ellis

Dave Ellis's promotion to Planning and Works Controller in ETE was received with great pleasure among his many friends in THQ, the Regions and the telephone exchange industry.

He started his Post Office career as a Youth-in-Training in 1935 in the Peterborough Area and had attained SW I rank very early in life before being called up for the Fleet-Air-Arm in 1944. In his capacity there as a senior lecturer in a training school he claims the misfortune neither of going to sea, nor flying a plane.

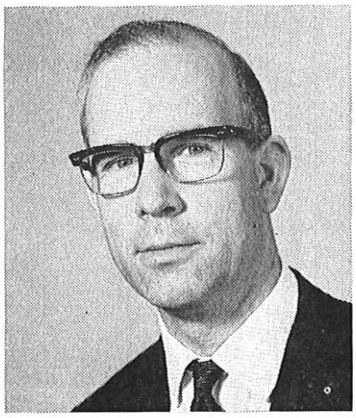
A year after his return from the services in 1947 the magnetism of the metropolis drew him first to the old Telephone Branch and subsequently to E Branch giving him valuable experience on exchange facilities, design, programming and installation. On reorganization he took his old E Branch A.S.E. post and responsibilities to the new Control and Progressing Branch of Purchasing and Supply Department where his wealth of experience and his abilities for getting things done were invaluable.

His new post is probably more demanding than most and, happily, will still keep him in close touch with his telephone exchange colleagues. We wish him well in the knowledge that ETE business is in good hands.

L. T.

D. L. Benson, C.Eng., M.I.E.E.

His many friends were pleased to hear of David Benson's appointment as Staff Engineer in LRS Division. Their feelings stemmed not only from an appreciation of his friendly, open nature but also from their knowledge of the sound achievements which warranted this promotion. Starting from local



area duties he tried his hand at radio maintenance, both at Baldock and RTT, before he joined Telephone Branch of the E in C.O. on the study of new switching systems. His introduction to electronic techniques was formed by a short stay in Research Branch, which he later turned to good account by assisting in the development of the new range of register-translators required by s.t.d. Many people were introduced to this subject by his lecture tour, the clarity and exposition of which earned him an award from the IPOEE. Such work naturally led to the electronic switching field, where he performed pioneer investigations into bothspacedivisionand low-speed T.D.M. exchanges. His new appointment will help him to take part in forming the future of such devices, but it is hoped that it will not dim his interest in the more mundane studies of railways and motor racing.

H. B.

Board of Editors

Mr. J. Martin is resigning from the post of Managing Editor of the Journal on his promotion to Staff Engineer. The Board wishes to take this opportunity of thanking Mr. Martin for his long and valued service. Mr. N. J. H. Ninnim has been appointed acting Managing Editor pending the formal appointment of a new Managing Editor. The new Deputy Managing Editor is Mr. R. A. Sudell and two new Assistant Editors, Mr. D. Millington and Mr. T. K. R. Raitt, have been appointed.

Mr. J. Martin has been co-opted to represent the Telecommunications Development Department on the Board.

Post Graduate Awards, 1969

The Post Office makes a number of post graduate awards to selected staff each year. The awards are tenable at universities which have facilities for research or advanced studies relevant to Post Office problems. In previous years the awards have been confined largely to telecommunications science and engineering subjects, but this year they have been extended to include all subjects relevant to Post Office management and services. In appropriate cases the awards enable holders to qualify for M.Sc. or Ph.D. degrees. The primary objective, however, is to further research and develop expertise of special value to the Post Office. Awards made this year are listed below.

Mr. C. R. J. Shurrock, Senior Executive Engineer, North West Telecommunications Region, Regional Headquarters and Mr. D. J. O. Brown, Executive Engineer, Telecommunications Headquarters, Service Department have both been awarded a one-year M.Sc. course in Electrical Engineering, specializing in Communications Systems at the University of Aston in Birmingham.

Mr. D. Allen, Executive Engineer, Telecommunications Headquarters, Management Services Department and Mr. A. K. Gibbons, Executive Engineer, London Telecommunications Region, City Area, have both been awarded a one-year M.Sc. course in Administrative Sciences at the City University London.

Mr. J. C. Stockbridge, Executive Engineer, London Telecommunications Region, South West Area has been awarded a one-year M.Sc. course in Operational Research and Management Studies at Imperial College London.

Mr. R. Edwards, Assistant Executive Engineer, Post Office Headquarters Scotland, Glasgow Area, has been awarded a one-year M.Sc. course in Industrial administration at Strathclyde University.

Mr. L. D. Greenidge, Executive Officer, London Telecommunications Region, Regional Headquarters has been awarded a one-year LL.M degree course at the Faculty of Laws, University College London.

The following Executive Engineers from Telecommunications Headquarters have all been awarded a one-year M.Sc. course in Telecommunications Systems at the University of Essex:

- Mr. J. P. Kendall, Research Department,
- Mr. B. W. Moore, Service Department,
- Mr. P. Rolfe, Research Department,
- Mr. K. L. Tabor, Telecommunications Development Department,
- Mr. A. Thomas, Research Department,
- Mr. J. F. West, Research Department.

Mr. R. W. Etches, Assistant Postal Controller II, North Eastern Postal Region has been awarded a one year M.Sc. course in Management Services at Durham University Business School.

Mr. R. M. Tabor, Assistant Postal Controller II, London Postal Region, Planning Division has been awarded a one-year M.Sc. Course in Management and Business Studies at Warwick University.

In addition, Mr. J. R. Thomas, Senior Executive Engineer, Telecommunications Headquarters was awarded a post graduate award for the M.Sc. course in Computer Science at the Institute of Computer Science, but is instead being granted one year's study leave to undertake, on official duty terms, advanced computer studies at the Carnegie Institute, Pittsburgh in the USA.

Notes for Authors

Authors are reminded that some notes are available to help them prepare the manuscripts of the Journal articles in a way that will assist in securing uniformity of presentation, simplify the work of the Journal's printer and draughtsmen, and help ensure that authors' wishes are easily interpreted. Any author preparing an article for the Journal who is not already in possession of the notes is asked to write to the Managing Editor to obtain a copy.

It is emphasized that all contributions to the Journal, including those for Regional Notes and Associate Section Notes, must be typed, with double spacing between lines, on one side only of each sheet of paper.

Each circuit diagram or sketch should be drawn on a separate sheet of paper; neat sketches are all that are required. Photographs should be clear and sharply focused. Prints should preferably be glossy and should be unmounted, any notes or captions being written on a separate sheet of paper. Negatives or plates are not needed and should not be supplied.

Letters to the Editor

Dear Sir,

In my article entitled "Telecommunications in the next Thirty Years" published in the last issue of the Journal the diagram printed as Fig. 3 was, unfortunately, not the one that I had intended to show. The correct diagram is shown in Fig. 1 accompanying this letter, and shows telephone penetration plotted against GNP per head.

The diagonal line is a best fit straight line calculated on a least squares basis, and it can be used as an elementary yardstick against which to compare the telephone density in countries at different stages of economic development.

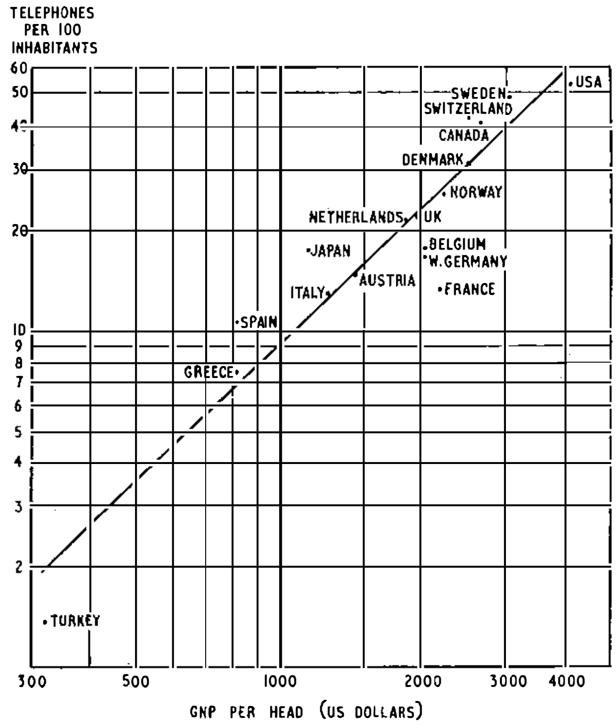


Fig. 1—Telephone Density and GNP per Head 1967

It is interesting to separate the penetration achieved in the business and residential markets, and this has been done in Fig. 2. This not only shows the direct correlation between

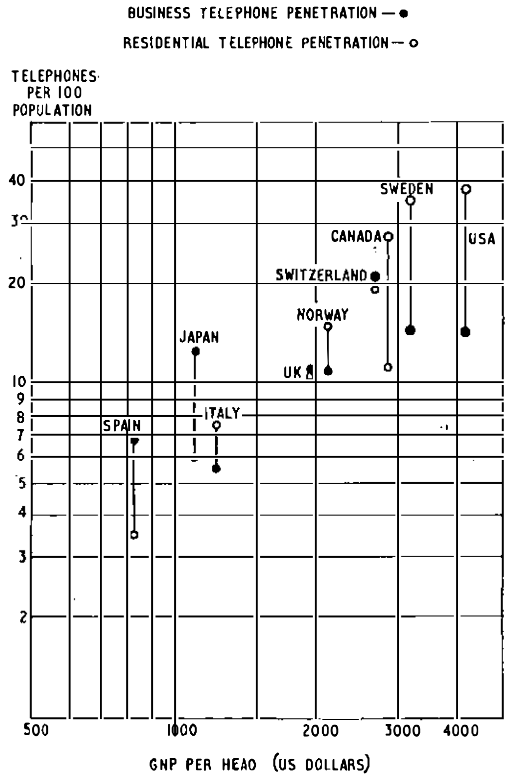


Fig. 2—Telephone Density and GNP per Head 1967

penetration and GNP per capita for the residential market but also illustrates the very much smaller spread in density in the business market between the wealthy and less wealthy countries.

Yours sincerely,

J. S. WHYTE

Long Range Studies Division,
Telecommunication Headquarters.

Publication of Correspondence

The Board of Editors would like to publish correspondence on engineering or technical aspects of articles published in the Journal

Letters of sufficient interest will be published under "Notes and Comments". Correspondents should note that, as it is necessary to send copy to the printer well before publication date, it will only be possible to consider letters for publication in the April issue if they are received before 15 February 1970.

Letters intended for publication should be sent to the Managing Editor, P.O.E.E. Journal, Room 264, 207 Old St, London E.C.1.

Press Notices

"Tell You" Phone Services Grow More Popular

The "tell you" phone services continue to grow and attract more custom year by year from people seeking information of various kinds. The latest, introduced earlier this month, keeps investors up to date on the share index.

Other telephone information services exist to tell you the way the weather is likely to behave; the state of major roads resulting from traffic or weather conditions; what to provide for the family dinner; and the main tourist attractions in London and Edinburgh. They will tell you the time or play you a pop record.

The year ending 31 March brought an increase in both the number of centres at which telephone information services are available and in the number of calls made to them.

Weather: More than 11,175,000 calls were made—an increase of over three million—with the number of centres offering the service stepped up from 37 to 44.

Motoring: This all-year-round service, giving details of road traffic and weather conditions, was introduced in May 1968 and was offered in 34 centres by the end of March 1969. It replaced the old Road Weather Service. A big demand—especially in the first three months of this year—pushed the total calls to over 1,124,000 which was 50 per cent more than were made in the previous year in 28 centres to the old winter-only service.

Teletourist: Nearly 200,000 more calls were made to the London service and the year's total was over 891,000. This service is now available in English, French, German, Italian and Spanish.

Recipe: A 200,000 increase in calls was recorded, taking the year's total to 2,259,000. The number of centres with the service increased from 36 to 42.

Dial-a-Disk: Calls made were more than 15,000,000—approaching double the previous year's total. The service was available in 23 centres at 31 March—seven more than 12 months before.

Time: The nationally-familiar speaking clock received 240,850,000 plus calls—over 15 million more than in 1967–68. The service is available for a local call charge to 90 per cent of the nation's telephone subscribers.

Share Index: Introduced on 21 July, the *Financial Times* Industrial Ordinary Share Index is available as a public telephone information service on 01-246 8026.

P.M.G. Inaugurates Goonhilly Earth Station

Television Link with Japan via Satellite

The Post Office satellite communications earth station at Goonhilly, in Cornwall, which supplies Britain's television and telecommunication links via satellite with the rest of the world, was inaugurated on 6 August by the Postmaster General, the Rt. Hon. John Stonehouse, M.P. The station, which, the P.M.G. said, "has played a vital part in satellite communications since 1962," is now complete with two giant dish aerials "locked on" to satellites in both the eastern and western hemispheres.

The P.M.G. also inaugurated service via the new Intelsat III satellite over the Indian Ocean. This made possible the first direct live television exchange with Japan. The P.M.G. exchanged greetings with the Japanese Minister of Posts and Telecommunications, Mr. Toshio Kohmoto. The exchange was shown live in Japan in a special programme arranged by British and Japanese broadcasters.

In a preliminary address to an invited audience at Goonhilly, representing the Japanese Embassy, British Industry, the press, radio and television and senior Post Office officials, the P.M.G. reviewed developments in satellite communications since the first television transmissions were beamed across the Atlantic ocean using Telstar.

"In the few short years since then," he said, "satellite developments have been breathtakingly rapid, and Goonhilly has kept in the forefront with several 'firsts' to its credit. The Goonhilly aerial design was the first to dispense with a protective radome cover, and thus set a pattern which has now been followed by the rest of the world. Goonhilly was," he said, "the first station outside the United States to take part in telephony tests, the first to transmit colour television, to receive television transmissions direct from Australia and colour transmissions direct from Canada."

Reminding his audience that Goonhilly had been the earth station responsible for providing the world with live television coverage of the Investiture of the Prince of Wales and the earth terminal which received for European television coverage of the Apollo moon landing, the P.M.G. expressed pride in the Post Office engineers at Goonhilly and took the opportunity of thanking them personally.

Goonhilly is not only concerned with television links, he went on to point out. "Its primary day-to-day function is the provision of a high-quality telephone and telex service with many parts of the world," he explained. "Less glamorous though this task may be, it is the vitally important one of ensuring that the nation gets the best possible facilities to meet the ever-increasing business and social communications demands of our modern world. The policy of the Post Office is, as always, to be at the forefront of communications developments, and Goonhilly is truly illustrative of the pace of progress.

"Central to this progress in satellite communications is the organization which provides the satellites themselves. This is INTELSAT—the International Telecommunications Satellite Consortium—a remarkable international commerical undertaking which, in the space of five short years, has given the world an advanced global satellite telecommunications system. The nineteen nations which originally came together to form the Consortium—the number has since grown to nearly seventy—had no firm evidence that a global commercial satellite system was a practical possibility; but through their foresight and confidence the foundations for the system were laid down and we can all take satisfaction in the fact that Britain was among the founder members.

"As INTELSAT has progressed, the Post Office had played an important role in the Consortium on behalf of the United Kingdom. We are second only to the USA in importance and influence in the Consortium, through our level of investment and of use of the satellite facilities it provides. In addition, we make a major contribution to the work of the organization by bringing to bear the skill and experience which we have acquired as a world leader in international telecommunications.

"Goonhilly is a product of Post Office expertise and modern British technology, Indeed, its very existence springs directly from the Post Office's own research and development activities. The P.M.G. said he was delighted to see important representatives of British Industry present and to have an opportunity of thanking them for their part in constructing and equipping Goonhilly. "I mention in particular," he concluded, "the part played by Marconi, GEC/AEI, Mullard, and Husband and Company for their work in producing the new aerial and in modernizing the original aerial. With these new provisions, the Post Office has gone over to a system of ordering earth stations which places on industry the full responsibility for design. British Industry has responded to this challenge—with results that are open for you to see today. As a consequence, our industry is now favourably placed in the important market for overseas earth stations."

The P.M.G. unveiled a commemorative plaque.

NDPS to Show Data-Capture Machine

The GPO's National Data Processing Service demonstrated its newly-developed data-capture machine publicly for the first time at Datafair '69, held at Manchester in August. It was the first time NDPS had exhibited at Datafair.

The machine, developed by English Numbering Machines Ltd under contract to NDPS, is designed to capture transaction data at the counter or point-of-sale for subsequent computer processing.

Already many prospective customers have shown interest. Building societies, banks, gas and electricity boards and rental firms are among those to whom the machine has already been demonstrated. Because of the basic design concept, the machine is adaptable for use in retail sales applications and other commercial fields.

Its most important feature is a small magnetic tape cassette with a capacity of 12,000 characters. This is inserted at the start of business each day. Transaction details are keyed into the machine via a simplified numeric-keyboard and, as well as being recorded on the magnetic tape, are printed on either a pass-book or document. Several methods, including two check-digit verification systems, are incorporated to safeguard against errors and a program ensures that the operator follows a pre-determined sequence of operations. A visual display of keyed data is provided.

It is envisaged that the magnetic tape cassettes from each machine will be taken after close of business to a local data transmission centre where they would be sent by the telephone switching network to a receiving processor for editing and merged to standard computer tapes. These tapes can then be processed on site or, if required, data transmitted at high speed to other processing centres.

This low-cost, compact machine of pleasing modern design is decimal working and will be introduced in 1971.

Britain Front-Runner in Data Transmission

The Post Office is in a "unique and favourable position" to set an international lead in data transmission and to encourage the wider use of computers.

This is emphasised in a report recently submitted to the Post Office by Scicon, well-known consultants who were commissioned to carry out the most comprehensive market survey of the country's data-transmission needs ever undertaken.

The report follows eight months of intensive work by a specialist team who interviewed representatives of commerce and industry and other large-scale users of the data-transmission services which make it possible to use computers at long distance. They sought to establish how the present Datel services are used; to forecast the total demand for facilities over the next five, ten and fifteen years; and to assess what types of facility users are likely to need.

Even against the present rapid expansion of demand for Datel services, the potential for growth for the 1980s is phenomenal. Nearly 6,000 terminals are operating in Britain today, compared with under 3,000 a year ago, and the consultants estimate that by 1973 there will be over 50,000 terminal points in operation, by 1978 about 250,000 and by 1983 over 400,000.

Because unforeseeable events can have a major effect on the use of computers and consequently of data-transmission services, Scicon stress that forecasts so far ahead in such a rapidly developing technology must contain a margin of error. They therefore combined three methods—a direct forecast for each sector of the economy; an assessment, based on independent forecasts of the growth of computers and of the number likely to be in use needing transmission facilities; and a mathematical model—taking into account all the factors likely to affect use of the Datel services.

They found a "very encouraging feature of the UK situation." This is that "unlike the American telecommunication corporations" the Post Office controls nationwide telecommunication services "and is in a position to co-ordinate and draw on all possible existing services for data transmission.

"We consider," they declare, "that the Post Office could place the United Kingdom in a unique and favourable position in data transmission which would enhance our use of computing equipment and set an international lead in this important and prestige activity."

Two other main points are stressed in the report. One is that, because of the "climate of uncertainty" among potential customers about their future needs, forecasting of demand will need to be continuous, with regular updating. The facility is still at too early a stage for users to appreciate fully its far-reaching potential (the Post Office introduced its first Datel service in 1965): with relatively few users data transmission is showing a rapid growth rate; and demand can be radically influenced by "surprise" features, such as overnight decisions by major concerns to computerize for decimalization.

The consultants' other main conclusion is that apart from specialized requirements, they cannot yet identify a major need for a high-speed (above 10,000 bits a second) switched transmission service. This need will arise, they point out, but add that a 10-kilobit switched service should satisfy the great majority of potential users for the next five, and possibly ten years. Nevertheless, they urge, technical and market studies should continue, to enable a switched high-speed service to be set up whenever it is needed. (Post Office preparations for an experimental 48-kilobit switched Datel network is expected to be ready for use early next year and representative users have been invited to experiment with its use free of charge.)

The Scicon study and three technical studies on data network techniques now being carried out for the Post Office* form the first part of a three-stage assessment of Britain's data-transmission needs into the 1980s. Using these studies, in the second stage the Post Office will develop a fully-costed plan for future data-transmission services so that a scale of charges can be drawn up. This plan is expected to be ready in Spring 1970. The third stage will be a market survey to assess the demand for specific services.

"No-Hands" Data Transmission

Computers will soon be dialling their own calls in Britain, with the aid of a new data control unit built to Post Office specifications based on international recommendations.

It will be the first time in Britain that data has been transmitted over the public telephone network entirely without human intervention. Unattended answering by remote data terminals is already a fact, but at present these calls have to be initiated manually.

A business using the new control units will be able to "tell" its computer to make a series of "no hands" calls at a predetermined time, either to send or collect data. A typical use could be to gather details of the previous day's sales figures from a chain of branch stores. This could be done during cheap-rate periods at night or at weekends, or using the new Midnight Line facility, which allows unlimited calls between midnight and 6 a.m. for a fixed annual charge.

Similarly, figures on stock held at various points could be gathered overnight to speed up re-stocking. Instructions could be sent automatically either by telephone or Telex to distant offices for attention first thing next morning.

Present plans are for the Post Office to start marketing the new control units about the end of this year. They were first shown publicly in a Post Office demonstration at Datafair '69, held at Manchester University from 25 August to 29 August. There were live demonstrations over the public telephone network and visitors were able to see on a series of coloured display panels how the system works.

This and other Post Office displays at Datafair '69 showed the enormous resources of the Post Office which are available to cater for customers' telecommunications needs, with particular emphasis on data transmission.

One display, on the growth of Post Office Datel services, introduced new modems for use on the 48-kilobit switched Datel network planned to link London, Birmingham and Manchester by the end of this year. These modems can also be used on private "group band" circuits.

Visitors also saw a Datel test centre in action similar to ones already in use at London, Birmingham, Leeds, Brighton, Edinburgh, Bristol, Manchester and Norwich to test Datel equipment by remote control.

A program of lectures was presented daily covering data-transmission policy, an outline of the U.K. telecommunications network, the fundamentals of digital communication, existing and future Datel services and various aspects of planning, installation and maintenance of customers' data, transmission networks.

Since 1964, Post Office Datel services have offered an increasing range of facilities for transmission of digital data at varying speeds over Post Office telecommunications networks.

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* By Standard Telecommunications Laboratories Ltd, British Telecommunications Research Ltd, and International Computers Ltd.

Acoustic Coupling—New Development in Data Transmission

To help travelling businessmen seeking portable devices for transmitting data by telephone to their office computers, the Post Office has drawn up detailed standards to guide designers of this kind of apparatus.

It is possible to transmit data signals from a telephone by using acoustic, coupling equipment which fits over the telephone handset and feeds sound signals into the transmitter.

The Post Office welcomes this development as a further extension of the usefulness of the telephone. Its detailed Code of Practice aims to guide designers of apparatus intended for use with standard modern (700 type) telephones —not Trimphones—to secure the best performance and provide safeguards for other telephone users.

Design and use of all data acoustic couplers will need Post Office approval because wrongly-designed equipment, particularly equipment using electric mains supplies, could interfere with other calls or even cause injury to people (telephone users or Post Office staff) using the telephone system.

The Post Office, like other telephone authorities, recognizes that acoustic couplers cannot give the same standards of transmission as purpose-designed wired-in data terminals and warns that efficient transmission of data using a telephone designed for speech cannot be completely guaranteed. Nevertheless, it sees a useful future for the data acoustic coupler.

Automatic Telephone Exchanges Increase

More than 6,000 of Britain's 6,123 telephone exchanges are now automatic. Only 121 were still operated manually at the end of August after 53 had been converted from manual to automatic working in 12 months.

Automatic service is now available to 98·35 per cent of all exchange connexions compared with 97 per cent a year ago.

"Most Significant Year" for Post Office

Introducing the last Annual Report and Accounts of the Post Office as a Department of State, Rt. Hon. John Stonehouse, MP, Postmaster General, said. "This has been a most significant year for the Post Office. This great enterprise has produced a profit which would be a credit to any business organization given the constraints under which we have operated.

"In view of the undoubted fact that we charge lower prices than most other countries for both postal and telecommunications services it is a tribute to public enterprise that we can now declare a profit of £44 m, even after meeting all interest charges and increased depreciation charges of £9m on last year.

"I warmly thank all those in the service of the GPO who have made this possible as well as the customers who have, generally, given the Post Office loyal support during a year of change."

The scene is set for the new Post Office corporation to maintain Britain's postal service as the world's best, to put the telecommunication service in the same leading position, and to build up the two new services, National Giro and National Data Processing Service (NDPS), says the Report (Cmnd 444, 16s 6d, HMSO).

Surveying the twelve months to 31 March 1969, the report sees this period as "the most significant in the history of the Post Office since . . . Rowland Hill." During the year the Post Office Bill, under which the new Corporation took over the running of Post Office services on 1 October, received its first and second readings and went through committee stage in the House of Commons (the Bill received Royal Assent in July).

Major developments included the new inland letter post introduced in September 1968 in "a glare of publicity and controversy"—which subsided, the report recalls, "as the public accepted that without the new letter service, charges would have been higher and the reliability of next-day service more difficult to maintain."

Last October the Prime Minister opened the National Giro which offers a wide range of low-cost money-transfer and banking facilities. The White Paper which in 1965 announced the Government's intention to set up National Giro put the likely level of demand at 1·2 million accounts within five years: the report notes that by the end of March there were more than 100,000 accounts, of which one in five was a business account.

Telecommunications

Overall, the rapid expansion of telecommunications continued, with a record investment in fixed assets of £326 million—12 per cent more than the previous year.

With demand at nearly the same level as the previous year, 821,000 new telephone exchange connexions were provided for subscribers—a record, 28,000 more than in 1967–68. Exchange connexions in use increased by half-a-million to 7·9 million and, despite the high level of demand, the waiting list was reduced by 50,000 (36 per cent). By the end of March automatic local service was available to nearly 98 per cent of customers; only 141 manually-operated exchanges remained to be converted; subscriber trunk dialling (s.t.d.) was available to nearly 6½ million customers.

The appointments scheme for installing telephones at agreed dates was working in all areas. This scheme, which covers most straightforward orders, is to be extended to allow more complicated installations to be undertaken on agreed dates.

Local telephone calls increased by 8 per cent, trunk calls by 12½ per cent, and oversea calls by 20 per cent. The proportion of trunk calls made by s.t.d. went up from 65 per cent to 70 per cent, the number of trunk calls dialled by customers in off-peak periods increased by 16½ per cent, and 57 per cent of Continental traffic was dialled by the customer. Britain's telephone users made a total of 8,618 million inland calls—674 million more than the previous year—and the overseas exchanges handled 25·6 million calls.

There was considerable progress in providing new buildings and extensions for telecommunication plant. During the year 291 buildings including 275 telephone exchanges were completed—60 per cent more than the previous year.

In the trunk network, 10,000 long-distance circuits were added—a growth of 15 per cent and 30 per cent more than the growth in 1967–68—and 47,500 shorter-distance circuits, an increase of 8 per cent. There was also an 8 per cent growth in the local lines network which connects subscribers' premises to telephone exchanges with more than 915,000 lines added.

Contractors completed the installation of 600 new exchanges and extensions—twice the number in each of the two previous years but still substantially below what had been hoped for. Four very large trunk switching units (exchanges controlling s.t.d. calls) were opened in London, Manchester and Leeds.

Although the number of telephones increased by 6·6 per cent during the year and calls by 8·6 per cent, the report notes that total staff increased by only 2·3 per cent. "The objective is still to expand the size of the system by 50 per cent from 1967 with no overall increase in staff."

The high rate of expansion in the Datel services for transmitting data to and from computers was maintained. During the year the number of data-transmission terminals in Britain more than doubled and the report notes customers' growing interest in nation-wide systems for various applications. Datel 2400 was introduced, offering transmission at 2,400 bits (binary digits) a second on telephone circuits and a wide range of optional facilities, and the international Datel 100 service was extended to 10 countries in Europe. New modems (modulator/demodulators) for wideband data transmission at up to 48 kilobits a second were under development. And independent studies were commissioned to help in assessing the nation's data-communication needs.

Tariff changes and increased business contributed to the higher income from telecommunication services, which reached the new peak of £568 million—£83 million above the previous year. And higher prices and pay awards contributed to a rise in expenditure of £68 million, as did changes in allotting some items of expenditure between capital and revenue accounts. Overall, these services made an 8 per cent profit which, at £50·1 million, was nearly £15 million above the previous year's return.

Profit is assessed as a percentage of net assets—the current value of the nation's telecommunication system which the report puts at £1,941·3 million.

The Mails

Although in March the Prospects White Paper forecast a loss on the Postal and Giro services of £7 million, this was, in fact, kept down below £6 million. At £377·8 million, income was 5 per cent up on 1967–68 but expenditure including interest rose by 7·8 per cent, mainly as a result of pay awards and higher prices for goods and services.

For the year as a whole both letter and parcels traffic showed a decrease of about 2 per cent. Items of correspondence posted totalled 11,300 million, 1·7 per cent down on the previous year; parcels handled were 212 million, down by 2·3 per cent. The total for correspondence sent overseas by air rose by 5·4 per cent to 371 million and for overseas air parcels by 13·6 per cent to 2·5 million.

The profitability of the inland letter service was transformed between the two halves of the year. In the five-and-a-half-month period to mid-September, when letter charges were put up, the service lost £5½ million; despite a fall of about 4 per cent in letter traffic, the new inland service made a £3½ million profit in the 6½ months to the end of March.

The new letter service reduced the peak-hour pressure in sorting offices and improved the quality and reliability of the letter post. Before its introduction 92 per cent of fully-paid letters were delivered by the next weekday after posting; after its introduction this proportion swiftly rose to 94 per cent, with more than 90 per cent of the less urgent letters delivered within two working days. (The Post Office is now delivering 95 per cent of fivepenny letters by the day after posting and more than 36 per cent of inland letters are posted at this rate compared with 27·8 per cent last September).

The postal mechanization program continued, with an investment in equipment of £3 million, compared with £2 million the previous year. More than £6 million was to be invested in 1969–70. There was more progress in introducing postcodes and by March 6½ million addresses—a third of the addresses in Britain—had been given their codes. Equipment for code marking and sorting letters automatically was being installed at Croydon and work was in hand on other installations at Southampton, Newport Mon., and the East Central District Office in London.

Planning for converting the postal business to decimal currency was stepped up. The conversion will have most impact on post office counters, and planning has been concentrated primarily on measures to ensure a smooth changeover.

Giro

Setting up a project as large as the National Giro within three years was a considerable achievement, the report points out. "The many new ideas and techniques used for the first time have been studied by other countries. The Giro Centre at Bootle . . . is one of the largest computer complexes in Europe."

Since the service opened the number of account holders has grown well in line with the estimates in the 1965 White Paper. The number of transactions rose rapidly and by the end of March it had reached nearly 400,000 a week, excluding the large number of social security payments. This growth rate reflects the wide range of uses to which the service is being put: now, all gas and electricity bills, telephone accounts and broadcasting licence fees can be paid through Giro, as can most rates and water rates, insurance premia and mortgage repayments. Retail organizations are using Giro for settling monthly accounts and for counter sales, some firms have begun paying through Giro and many more are planning to do so.

Nevertheless, the report warns, "in a new project the size of Giro it inevitably takes time for the service to establish itself profitably. The Post Office aims to achieve this as soon as possible and is conducting an intensive marketing campaign. Account opening procedures have also been made more attractive. Continuing emphasis is being placed on adapting the service to meet the developing needs of customers."

National Data Processing Service (NDPS)

The year under review was the first of the four-year period for which the National Data Processing Service was set a target of 8 per cent average net return on capital. Although the 1968–69 return of 7·7 per cent was below target, it reflects initial setting-up costs and development costs which will not become revenue-earning until later.

The report records progress on all Post Office data-processing projects, with the Giro project completed on time and computer billing provided for 75 per cent of all telecommunication customers' accounts by the end of March. Computer control of engineering stores was extended; a new system to help plan expenditure on telephone exchanges was introduced; and plans were nearly complete for compiling and printing telephone directories by computer. Meanwhile NDPS continued to secure orders from non-Post Office customers to provide systems and programming services and computer processing time.

NDPS total income was £3,956,000 and expenditure £3,894,000.

Record Income

The Post Office's total income for 1968–69 reached a record £946 million. Total expenditure was £902 million, producing a total overall profit, after interest charges, of £44 million—an increase of £5 million over the previous year. But for certain accounting changes, which are detailed in the Accounts, profits would have been £53 million.

Looking back over a year of further expansion and progress, the report declares: "The picture is naturally not wholly bright. There are faults as well as virtues. But the problems are known and we are trying to solve them. The progress made in 1968–69 gives us confidence that these problems will be tackled successfully."

Scandinavian Submarine Cables Capacity Trebled

Total submarine-cable circuit capacity between Britain and Scandinavia will be trebled when a new £3m cable comes into operation in 1973.

The cable will run between Scarborough and Thisted in North Jutland (380 nautical miles) and will carry 1,260 circuits.

This makes it the equal of the three largest-capacity cables in the world, which the Post Office will bring into operation between this country, West Germany, Belgium and the Netherlands during 1971–72.

A contract for manufacturing the cables, repeaters and terminal equipment has just been placed with Submarine Cables Ltd, by the Post Office.

Although the new cable will primarily benefit callers between Britain and Norway, Sweden and Denmark it will also provide easier access to countries beyond, such as Finland, Poland and Russia.

It will be available for transmission of telephone calls, data and Telex messages.

Another 695,501 'Phone Order Met

Orders for 695,501 telephone exchange lines were met by the Post Office in the six months ended 30 September. This compares with 663,108 in the six months to 31 March, and 570,166 in the previous six months. The total number of exchange lines now in use is nearly 8,200,000.

Blueprint for the Post Office of the Future

The Board of the new Post Office Corporation will prepare and complete a broad development plan by mid-1971. It will then put into effect over the following five years this blueprint for the Post Office of the future.

This was stated by Viscount Hall, Chairman of the Board, in London on the day the Post Office became a public Corporation after 300 years as a Department of State.

Lord Hall said that the first job of the new Board would be to take a very close and very hard look at everything done by the Post Office. Nothing would be sacred; and the Board would look at the services making a profit as well as those making a loss.

"There will not be any overnight miracle," added Lord Hall, but he promised that the new Post Office would be deeply conscious of its responsibilities to its customers and to its staff. It would use the most modern and effective commercial practices to give the best services to its customers and at the same time meet its financial targets.

"I have no illusions about the size and complexity of the task ahead of us," said Lord Hall, "but our greatest asset is the loyal staff, the 420,000 people who are the new Post Office Corporation."

The Post Office had a record starred with achievements. They ranged from Goonhilly, one of the most advanced earth stations, and the use of electronic telephone exchanges to a postal service which gave the best value for money in the world.

The National Data Processing Service had just won two major orders in the rapidly expanding computer market. One was for a £5m system to control imported cargo at Heathrow Airport—a world lead. The other was for a £2m system for handling 20 million transactions a year for Trustee Savings Banks in the North-West. Others were on the way.

Giro, still under a year old, now had some 150,000 accounts worth £20m. In March it had only 100,000 accounts worth £9m.

The Post Office was spending £1m a day to improve and expand the telecommunication services. There would be a 50 per cent increase in the number of telephone connexions over five years—without an increase in staff.

Nation-wide Lecture Tour

The forty-first in the series of Faraday Lectures arranged by the Institution of Electrical Engineers is to be given by J. H. H. Merriman on the subject "People, Communications and Engineering". Prof. Merriman is the Senior Director (Development) with the Post Office and is also member for technology on the board of the Post Office Corporation. Deputy lecturer is C. A. May, Staff Engineer in Post Office Telecommunications Development Department.

The Lecture is to be given in 13 towns in the British Isles, starting in Rugby, Warwickshire, on November 18 and finishing in Belfast on 17 April 1970. It is estimated that the total audience for the lecture will be 50,000 people.

The Faraday Lecture series spotlights various aspects of modern electrical and electronic science and technology in straightforward language for the general public. Special presentations for students are being arranged at all towns on the tour. Members of the public are admitted by ticket, free of charge, to these lectures.

This year's lecture dwells on the way in which scientists and engineers in telecommunications and postal engineering respond to the changing needs of society, generate new technologies in their search for scientific truth, and put those technologies to everyday use in the service of man.

Four main activities are used as examples. In the first, the challenge of providing the Scottish Highlands and Islands with a completely new telecommunications system is described.

The second example is quite different. The way in which large-scale telecommunications engineering is matched to the burgeoning growth of the highly industrialized urban areas of South-east England is seen through the eyes of project managers, engineers and technicians.

The third part of the lecture focuses on a young development engineer grappling with the problems of putting sophisticated split-second electronics and electro-mechanical engineering into the mail services.

The purpose of the fourth example is to disclose the attitude of mind of engineers and scientists working in research and to show how they are preparing for the vast telecommunications and data explosion of the later decades of this century.

The lecture will be extensively illustrated, and, in the tradition of Michael Faraday himself and of previous Faraday Lectures, there will be a number of live experiments. Four separate pieces of film, each lasting 8 to 10 minutes, will illustrate the lecture, together with two cartoon sequences in colour and a large number of slides. The cast of the films are all Post Office personnel at work.

The four demonstrations were designed and made entirely in Post Office Laboratories. They are: an attempt at recognizing the handwriting of a member of the audience by a computer-like device; the bending or twisting of a beam of light without mechanical intervention (this was done by Faraday in 1845); the transmission of signals in the form of light through glass fibres; and the centrepiece of the lecture—a display board measuring 20 ft by 16 ft, illustrating in a concise form the principles of telephony.

Although delivered by one man, the Lecture is in fact a large team effort. On the practical side, D. J. Holmes, the Tour Manager, is assisted by a team of 8 people who will travel with the equipment throughout the tour. On the subject of equipment, this is very considerable and includes a small but nevertheless complete computer weighing 500 lb.

The presentation is fully stage-managed in the professional sense, with sequencing and synchronization of lighting, slide and film projectors, etc.

Institution of Post Office Electrical Engineers

Annual Awards for Associate Section Papers, Session 1968–69

The Judging Committee having adjudicated on the papers submitted by the Local Centre Committees, prizes and Institution Certificates have been awarded to the following in respect of the papers named.

First Prize of £7 7 0:

D. Ashton, Technical Officer, Sheffield Centre. "Emergency Motorway Telephones."

Prizes of £4 4 0:

G. S. Steer, Technical Officer, Exeter Centre. "Talking Books for the Blind."

D. A. Frith, Technical Officer, Grantham Centre. "Microwave Repeater Stations."

K. F. Wood, Senior Technician, Lincoln Centre. "Circles—Clocks, Calendars, Computers."

F. J. Brown, Technical Officer, Exeter Centre. "The Work of a Voluntary Ambulance Driver."

In addition, the following paper, which was considered worthy of submission to the Judging Committee for the main award, has been awarded a prize of one guinea:

N. H. B. West, Technical Officer, Exeter Centre. "Model Engineering."

The Council of the Institution is indebted to Messrs C. A. L. Nicholls, C. D. S. G. Robertson, and B. J. Woollett for kindly undertaking the adjudication of the papers submitted for consideration.

British Postal Engineering Conference 19–21 May 1970, London

The Manipulative and Mechanical Handling Machinery Group of the Institution of Mechanical Engineers in conjunction with the Institution of Electrical Engineers and the Institution of Post Office Electrical Engineers is planning to present the first major conference in this country on British Postal Engineering.

The change from a manual system to a mechanized one is complex, involving a wide variety of disciplines. The progress of development, details of current practices, and an outline of future possibilities will form the basis of some 50 papers which will be presented for discussion.

Visits to the new mechanized letter and parcel-sorting office at Croydon are scheduled.

Registration forms may be obtained from the Conference Department, The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London SW1.

Changes to Institution Rules

As the result of the ballot held in May 1969 the changes proposed to Rules 6 and 18 are now operative. The following grades, and above, on the engineering side of the Post Office are therefore eligible to be Affiliated Members: Higher Clerical Officers, Executive Officers, Senior Photographers, Sales Superintendents, Telecommunications Traffic Superintendents, and Assistant Principals.

A. B. Wherry,
General Secretary

Regional Notes

Scotland

Submarine Cable at Loch Awe

Portinnisherrich line connector was parented on Inveraray exchange 22 miles away by two overhead junctions of 150 lb wire. A third junction was required to meet increasing traffic, the route, however, was badly damaged during the hurricane of January 1968 and it would have proved costly to re-erect and strengthen it to carry a third pair of wires.

The main-line planning group proposed providing a 4/20lb polythene cable to Ford U.A.X. No. 12, approximately eight miles to the south of the line connector.

Maintenance difficulties had been experienced with the line connector and it was decided to provide a 30 pair 20 lb/mile loaded local cable from Ford U.A.X. to serve the subscribers and recover the line connector. Loading would be by vertically mounted unicoil joint loading. The decision was influenced by the forecast which implied that such a cable would last for 20 years.

From the survey it was decided to erect single span aerial cable for approximately 1½ miles from Ford U.A.X. northwards on the existing overhead route. The overhead route from Portinnisherrich south, approximately 2 miles, would have required extensive strengthening and therefore it was decided to mole-plough the cable in to the broad grass verge. The centre section of 4½ miles where no plant existed posed a problem. The road runs alongside Loch Awe (Fig. 1); on one side the mountainside sloped steeply and pole erection would involve blasting while the other side dropped sharply to the Loch where pole erection or ploughing would prove not only difficult but dangerous.

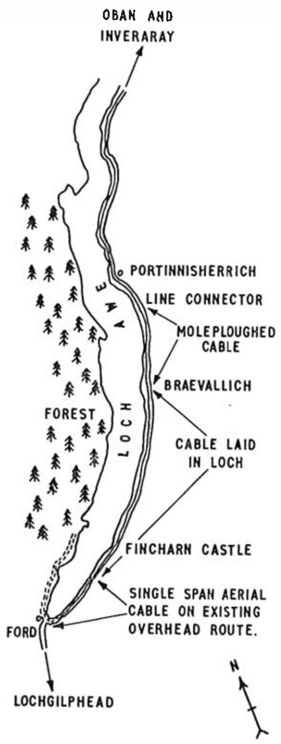

FIG. 1—Map of Loch Awe showing cable run

The answer was obviously, therefore, to lay the cable in the Loch. New problems had now to be overcome, the Loch is not charted so that loss of cable for depth needed to be estimated. Submarine branch advised the use of polythene cable since they foresaw no difficulty from chafing or "shipping" as Loch Awe is land-locked. Normally the services of submarine branch would be called upon, but even the *Iris* could not do this job, and therefore we had to find our own boat. Since there is no suitable craft on the Loch, Army H.Q. Scotland were asked if they could provide a means of flotation for a weight of approximately 16 cwt. The Chief Engineer for the Army replied indicating the Army would be pleased to assist in the operation provided the Department signed an Indemnity Form against any third party claims.

Approval was obtained from headquarters and a meeting arranged with Army representatives to decide the type of craft that would be used. Considering our requirements it was decided that a motorized raft 32 ft long and 11 ft broad (Fig. 2) powered by two powerful outboard motors would be capable of the task.

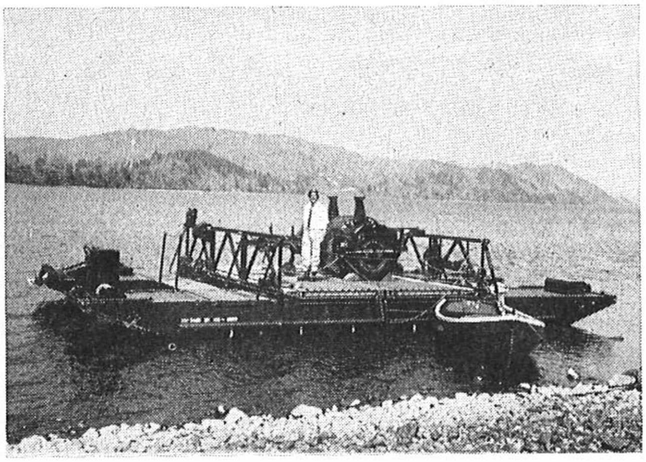

FIG. 2—Motorized raft used for cable laying

Since there was some urgency to complete the work it was decided to use standard cable lengths of 1,000 and 500 yards as there would be considerable delay in obtaining non-standard lengths. Jointing and loading would be done on the shore, the joints being mounted on stub poles, the position of the joints and loading points being approximately marked by the planning group before the start of the work.

Wayleave consent was obtained from the Forestry Commission for the Loch cable and their local representatives offered every assistance throughout the operation.

The raft was constructed over a weekend period in June this year by members of the Officer Training Wing of Herriot Watt University under Army supervision. Post Office technicians from the Oban external construction group were given instruction on the handling of the raft and by Monday cabling had started.

A Post Office drum-trailer was mounted on the raft's working platform and the cable drums were loaded using a high-wheel-based landrover. The operation went smoothly and the job was completed in 3½ days.

The Army returned to dismantle the raft and the operation was successfully completed.

We are indebted to the Army, the Forestry Commission and submarine branch for their valuable assistance in this operation.

H. LAWLESS

Radio Tower at Dunoon

In April 1969, the first of a new type of radio tower was erected at Dunoon in Scotland West telephone area. This is the forerunner of many more similar towers due to be erected in Scotland West and Aberdeen areas when the Highlands and Islands project gets under way. The Highlands and Islands project will provide an improved telephone service to the north and west coasts and islands of Scotland by means of s.h.f. radio links and h.f. cables, enabling subscriber trunk dialling to be made available to all but the most remote islands.

This tower, designated No. 4A, is made up of a number of 15 ft high box sections with a 12 ft high top section. It can, therefore, be erected to varying height requirements up to a maximum of about 150 ft.

For the higher towers, a special base section is used giving spread to the legs to gain additional stability.

The design is such that it can be erected using a mobile crane (see Fig. 1) as well as by the more usual method of using a derrick. This has certain features new to Post Office tower construction. The main members are of tubular

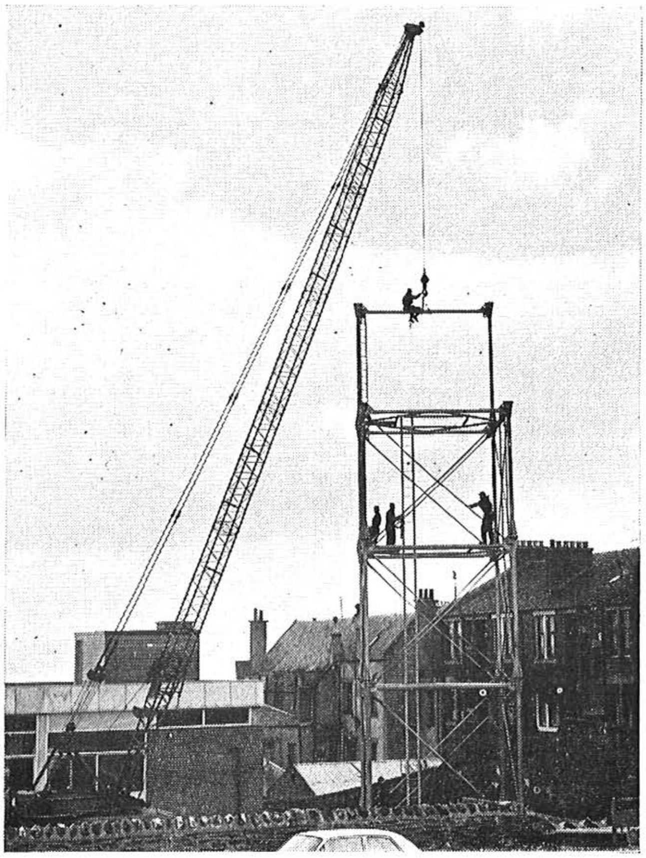

FIG. 1—Mobile crane being used to erect the radio tower.

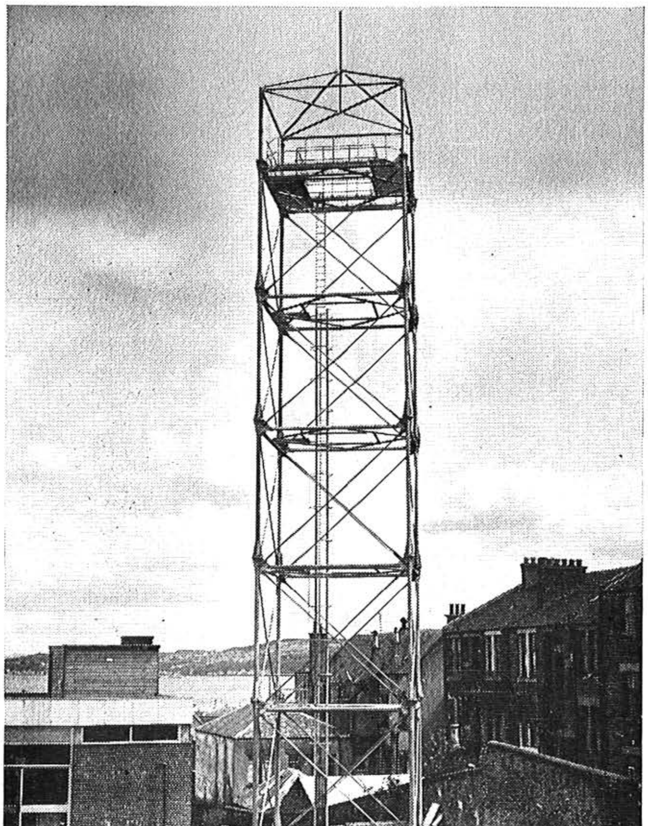

FIG. 2—Dunoon radio tower

construction, all the bracings are pin jointed and Torshear prestressed bolts are used at the leg member joints. These bolts ensure that joints are tightened to the correct degree.

The Dunoon tower was erected by a Post Office rigging gang whose members are from Scotland West and Edinburgh areas. Useful experience was gained from this work as the remainder of the towers will probably be erected by direct labour. The steelwork was completed in six days, using a mobile crane to lift the sections into place. Final straightening and alignment were achieved by adjusting the threaded diagonal braces.

As Fig 2 shows, a very rigid structure resulted on which to mount the waveguides and dish aerials which will carry telephony traffic to Dunoon.

J. I. MURRAY

South Eastern Telecommunications Region

Corroded Steel Pipes at a Reading River Crossing

Whilst locating a pressure fault on a main cable at Charvil, in the Twyford Exchange area, severe corrosion was discovered on steel pipes under a bridge over the river Loddon. These pipes, laid in 1911, carried 3 main, 2 junction and 2 local cables over the river. The corrosion extended the full length of the bridge, the cables showing through the pipes.

To replace the pipes and cables would have proved a very expensive job indeed, so it was decided to renew the pipes. Scaffolding was hired so that access to the pipes could be obtained enabling them to be cut off. The permission of the Thames Conservancy, Bridges and Highways departments of the Berkshire County Council was obtained.

The next phase was to remove the old corroded pipes, this was done by the Mechanical Aids Group, who cut them off with a Stillson Pipe Cutter using abrasive discs. It took two men, nine days to do this job. The problem of using this tool in a confined space was severe discomfort experienced by the operator because of the hot sparks. The local R.A.F. Station was contacted and a crash rescue helmet was borrowed.

After the pipes had been removed, the brick piers of the bridge were broken out until sound pipe was found. The next question was what sort of ducts to fit and how to support them. New steel pipe was not considered because of the difficulty of cutting and fitting, likewise polythene duct because once it had been split it would distort. It was decided to use self-aligning grooved duct. To support the ducts, a quantity of recovered cable racking was obtained from an exchange that was in the process of modernization. This was assembled on site and laid along the existing bridge girders. The bridge girders were drilled and extra supports fitted.

Engineer wearing the Crash Rescue Helmet.

The ducts were split, fitted around the cables and bound to each other and to the racking, with binding strips and clips. All racking and strips were painted and the bridge piers made good.

The entire operation took 224 hours and an outlay of £80 was involved. Renewal of the cables with consequent interruption to service was avoided, since they were in excellent electrical and mechanical condition.

E. R. CLIFFORD.

Petrol contamination of Post Office underground plant at Horsham, Sussex

During the period 17 to 27 June 1969 a considerable amount of high octane petrol leaked from the storage tanks of a garage at Guildford Road, Horsham, into the nearby Post Office multiple way duct track.

On 17 June, a Post Office working party using a gas leak indicator No 5 detected gas in a manhole at the Bishopric, Horsham. The South Eastern Gas Board were called and more detailed tests proved that petrol fumes were present and not household gas. The fumes were dispersed by ventilation of the manhole concerned and removing adjacent manhole covers.

The incident had been reported to the police and the Petroleum Officer, and it was finally decided on this day that petrol overspill had occurred near the manhole cover.

On the morning of 18 June, the local inspector at Horsham, Mr. I. Levett, decided to carry out further tests in the manhole at the Bishopric and also several manholes in a westerly direction along the Guildford Road. These manholes were at a lower level; one being adjacent to a petrol filling station. The manhole near the filling station and two on either side indicated a 100 per cent explosive mixture on the gas leak indicator. Petrol was also observed floating on the water in the manhole concerned. The local Police, Fire Brigade and Petroleum Officer were called and a large scale exercise commenced. After a general meeting with all parties concerned it was agreed that the road should be closed for 200 yards on either side of the garage. Pump Installation Ltd. and Shell Mex engineers were called to the site and immediate investigation for a petrol leak near the garage was commenced. The reported loss of petrol from one particular pump by the garage owner narrowed the search. The pump and installation failed the suction test and on the evening of this day a 4,000 gallon tanker arrived to clear the faulty tank of fuel. A semi-rotary pump was used with the minimum risk of sparking. The condition in the three most-affected Post Office manholes after a dipstick treated with water paste was lowered, was 7 in, 5 in, and $\frac{1}{2}$ in of petrol, respectively. The petrol in these three manholes was pumped by hand into another compartment of the Shell Mex tanker; the suction end of the pump being kept close to the liquid surface. By midnight 300 gallons of petrol and 400 gallons of water had been drawn off into the tanker. During these operations the Fire Brigade stood by, the Police controlled the site access and Post Office staff acted as watchmen. On 19 June, further tests were made in the manholes affected previously and 100 per cent explosive mixture was indicated. A submersible pump from the Mechanical Aids Section was brought on the site and its use approved by the Fire Brigade and Pump Maintenance Ltd. Shell Mex provided another tanker for collection of petrol and water from the affected manholes, which were pumped dry.

After this operation it was decided to flush out the manholes and duct system with emulsifier supplied by Shell Mex and water from a N.W. Sussex Water Board hydrant, with the Fire Brigade providing pumping assistance.

It was then decided that the manhole nearest the garage should be sealed to prevent fumes travelling along the duct tracks. This was carried out by firemen, who descended the manhole with breathing apparatus and sealed the ducts with mixture No. 2 as instructed by the Post Office. For the next three days, the flushing of the manhole with emulsifier and water continued and manhole lids were left open for ventilation.

On 23 June, excavation commenced on the petrol filling station forecourt and a broken feed pipe to the affected tank was located and replaced with a spare, *in situ*, pipe. At this stage petrol was still seeping into the Post Office duct track and manholes and it was assumed that a reservoir of petrol was still present.

On 24 June, contractors, employed by Shell Mex, excavating in the filling station forecourt located a considerable amount of petrol below the affected tank. This was disposed of by pumping into a Shell Mex tanker. By Friday, seepage was still apparent, but on a reduced scale. The Police, Fire Brigade and Petroleum Officer decided that the main danger was over and the Guildford–Horsham road was open to traffic in that section.

On 3 July, several bore holes were dug in the verge between the petrol installation and the Post Office duct track. This operation was intended to collect the seepage of petrol still in the surrounding ground and also act as ventilation. After heavy rain on some days petrol has appeared on the surface of the water in the bore holes, and this has been pumped away. The effect of this operation has been to reduce the amount of petrol entering the Post Office duct track and manholes, and up to the present day explosive mixture readings in the manholes have declined gradually. The bore holes have been retained to date for ventilation and removal of remaining petrol in the soil.

In conclusion it is mentioned how the efficient co-operation between all the parties concerned prevented a very serious accident occurring.

S. W. J. UPCHURCH

Associate Section Notes

Bedford Centre

The program for the 1969/70 session covers quite a wide range of subjects including: "Operating a large International Airline" (following a visit to London Airport), "The Manufacture and Applications of plastics", "Satellite Communications", "Photography" and "The National Transit Network".

Visits include a large brewery, brickworks, power station, Faraday International exchange, Shell oil refinery and a racing car factory.

One of the most significant happenings in the E.T.R. Associate Section is the introduction of a quarterly Regional Magazine, the first issue having already been published. We hope that this magazine will be a firm stepping-stone on the way to bringing our Centres closer together and helping them to join each other in their activities.

E. W. H. P.

Bournemouth Centre

Have you ever spun round twice in a car on a greasy road? expected to go right but went straight on; lost, so it seemed, complete control? We did; that is those of us that attended a demonstration at the Police Driving School Devizes on 13 September.

It was an informative experience for all of us, so were the tips on driving we were given, and the lessons we learned, especially control of a car in a skid, or, perhaps more important, how not to get in a skid. Finally, we were driven around the countryside in a police car, the driver giving us a verbal "thoughts talk" as we negotiated the hazards familiar to all of us.

We thought it one of the best demonstrations we had ever attended, the Police driving school has our very grateful thanks.

H. J. G.

Edinburgh Centre

The 1969/70 Session opened on 17 September 1969, when 20 members attended a talk entitled "Aids for the handicapped", given by Mr. F. M. Holmes, Executive Engineer, Edinburgh Telephone Area. Mr. Holmes described some common forms of disability and the aids now available from the Post Office, then went on to tell us some of his personal experiences since he first took an active interest in this subject nine years ago.

Some of the devices Mr. Holmes has designed himself, although simple for the handicapped person to operate, are rather ingenious, and this proved to be a most interesting subject. The meeting finished with a short period of questions and answers.

M. K. F.

Exeter Centre

The first event of the 1969 summer program was a repeat visit to the Bristol Engine Division of Rolls-Royce Ltd. The party spent a very interesting day touring the factory to see the construction of the British undertaking in the Concordeprogramme and also an Olympus engine undergoing tests. The very high standard of workmanship that is always associated with Rolls-Royce was very evident throughout the tour. The outstanding hospitality of our hosts made this visit very memorable and the centre is greatly indebted to the management and wish them every success in their venture.

The following lectures have been held or are planned for the 1969/70 winter programme:

October,	"Modern Methods of Testing Motor Vehicles (Part II)" by T. Taylor Esq., Chief Instructor Crypton Triangle Ltd
November,	"The Radiophonic Workshop of the B.B.C." by Desmond Briscoe Esq.
January,	"Early Railways of Devon" by G. Cload Esq.
February,	"Datel and the Exeter Telephone Area" by G. W. Harris Esq.
March,	"Character Recognition with Excursions into Hyper-Geometry" by Dr. A. W. M. Coombes.
April,	Annual General Meeting.

Members are reminded that it will be necessary to attend at least one event in the programme to be given priority on summer events.

T. F. K.

Inverness Centre

Our membership cards are now printed and distributed and we held our first meeting, "The Changing Face of Inverness", on Thursday, 9 October 1969. The speaker was Mr. J. Herrick, Assistant Burgh Surveyor. His talk was illustrated with 16th- and 17th-century plans of the Burgh along with proposed plans, and promoted discussion and comment.

While addressing membership cards it was noticed just how many members the Centre lost last year due to promotions and resignations. Membership is now well below 200 but a recruitment drive this winter should bring the numbers up again, only about 40 per cent of staff eligible being members at present.

W. A. A.

Middlesbrough Centre

During the last season we had talks on the following subjects, "Middlesbrough area—Past, Present and Future", "The Lake District", "Local Town Development" and "Transit Switching".

Visits were also made to the A.E.I. Factory at Hartlepools, Rediffusion Ltd. and Teeside Airport.

Again this year the attendance at meetings did not come up to our expectations. At the annual general meeting the following officers were elected for the new season.

Chairman: W. Outhwaite; *Secretary:* K. Whalley; *Assistant Secretary:* R. D. Purvis; *Treasurer:* R. G. Inns; *Librarian:* P. K. Harrison; *Committee:* K. Roe, R. Oliver, C. Carr and P. K. Harrison.

Our new season starts with a two-day trip to London to look round the Post Office Tower.

K. W.

Oxford Centre

An exciting and varied winter's program has been arranged and follows a successful summer program of visits. The program is as follows:

23 October:	Visit to Didcot Power Station.
18 November:	Film and tour of Royal Observer Corps Headquarters at Cowley.
10 December:	Talk on Police Communications by Chief Inspector Cook.
20 January:	Demonstration of Hi-Fi Equipment.
6 February:	Talk on the Astrophysical Aspects of Space Research by M. F. Ingham.

March (Date yet to be fixed): Any Questions evening.

Talks are held at Telephone House, Oxford, commencing at 7.30 p.m. Visitors are welcome.

D. A. G.

Southend-on-Sea Centre

In April of this year we held our first dinner/dance. Mr. Sheppard, the Regional Liaison Officer was Guest of Honour. This proved to be a most successful evening and it is hoped to make this an annual function.

The annual general meeting held on 11 June this year was very nearly the "non-event" that it has come to be in recent years with only 17 members present.

Our visits program started with a trip to the North Foreland Radio Station. This was followed by an interesting visit to Carreras cigarette factory at Basildon. In October a trip was arranged to Aston Martin Lagonda Ltd., at Newport Pagnell. This visit proved to be quite well received but several complaints were made about the short duration of the visit, approximately $1\frac{1}{2}$ hours, after a reasonably long journey and also the lack of opportunity to ask questions. Our visit to the S.T. and C. cable factory was just the opposite, with really well informed guides who were able to answer any questions that were put to them.

Our program for the coming months includes visits to B.O.A.C., The *Daily Telegraph* and Harrisons Printing Works, High Wycombe. A lecture on Data Transmission has been arranged for early November.

M. V. K.

Stone Centre

Our 1968/69 session began in October with an interesting lecture on "Decimalization" given by Mr. P. Rack of N.C.R. Co. Ltd. This was followed in November by an appreciation of "The National Giro" given by Mr. D. V. Levin of The National Giro Centre which was disappointingly attended.

Mr. F. G. Buck started lectures for the new year with the development of "Radio Controlled Models" and later in the year Mr. R. C. Winnett of the R.C.A. Colour Tubes Ltd. explained the design and construction of the "R.C.A. Shadow Mask Tube". Mr. D. Briscoe introduced "The Radiophonic Workshop of the B.B.C.", which was one of the two joint meetings with Stoke Associate Section, the other being the quiz. At the latter meeting closed circuit television (by kind permission of the Visual Aids Group C.T.S.) was effectively employed for some 60 questions. The Committee wish to thanks Messrs. M. Mitchell, P. M. Mayes, J. Skinner, G. Avery and K. McBurnie who served so gallantly on the team, opposing the victorious Stoke side, not forgetting, of course, Mr. J. Cooper who performed the skilful task of television cameraman so successfully on the night.

Members enjoyed the visit to the Royal Ordnance Test Range and it is hoped that further visits will be possible next session.

At the annual general meeting the following members were elected to serve for the 1969/70 session:

President: Dr. P. R. Bray; *Chairman:* Mr. C. Blundell; *Secretary:* Mr. C. G. N. Watts; *Assistant Secretary:* Messrs I. Nicholson, B. Meyer; *Treasurer:* Mr. K. C. Brook; *Librarian:* Mr. G. Avery; *Committee:* Messrs G. Jones, M. Farnworth, J. Reeves and R. J. Loader; *Auditors:* Messrs R. Freestone and L. Neesam.

An interesting program is being planned and it is hoped that greater support from the permanent C.T.S. members will be forthcoming during the winter meetings.

C. G. N. W.

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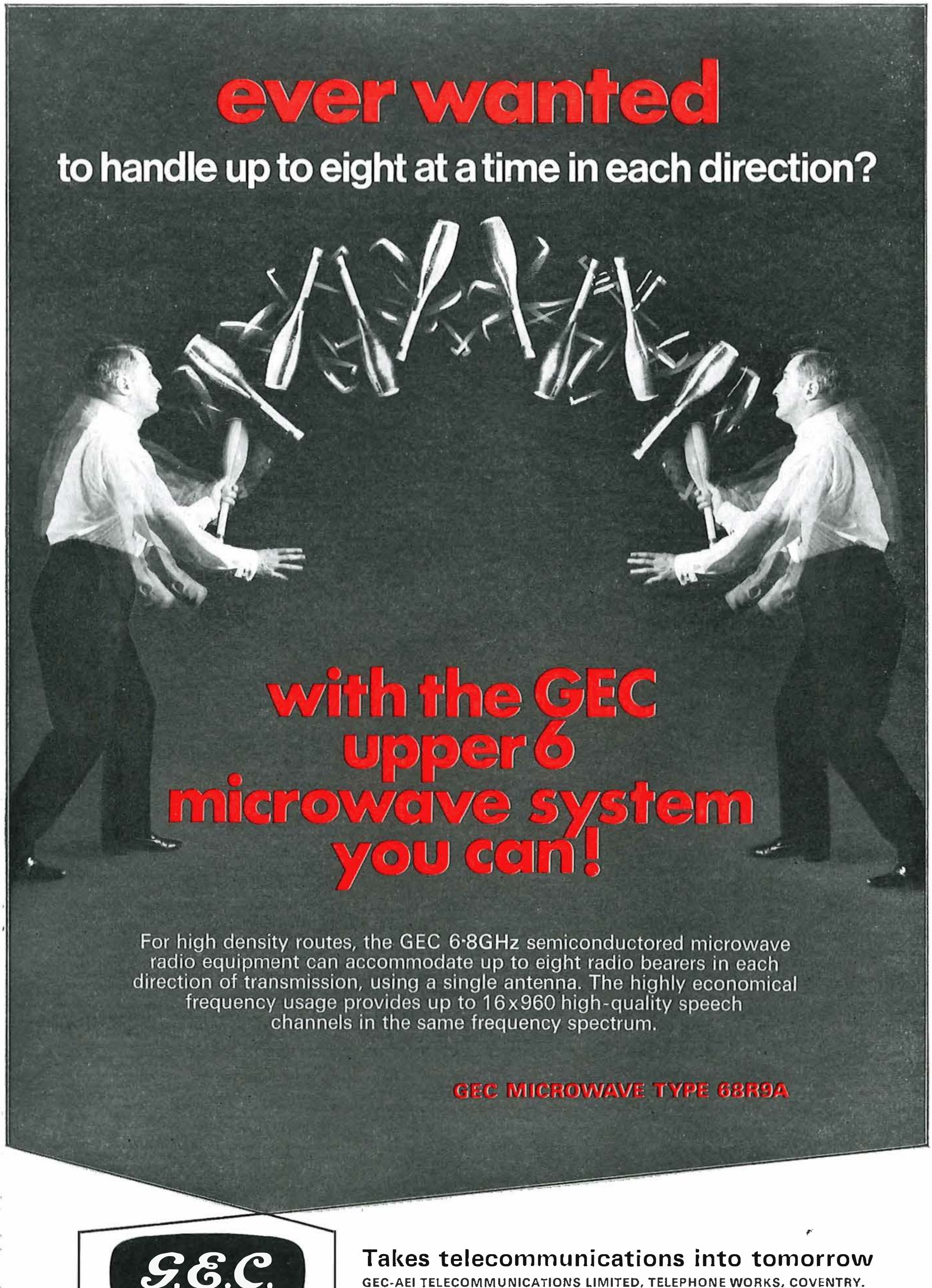
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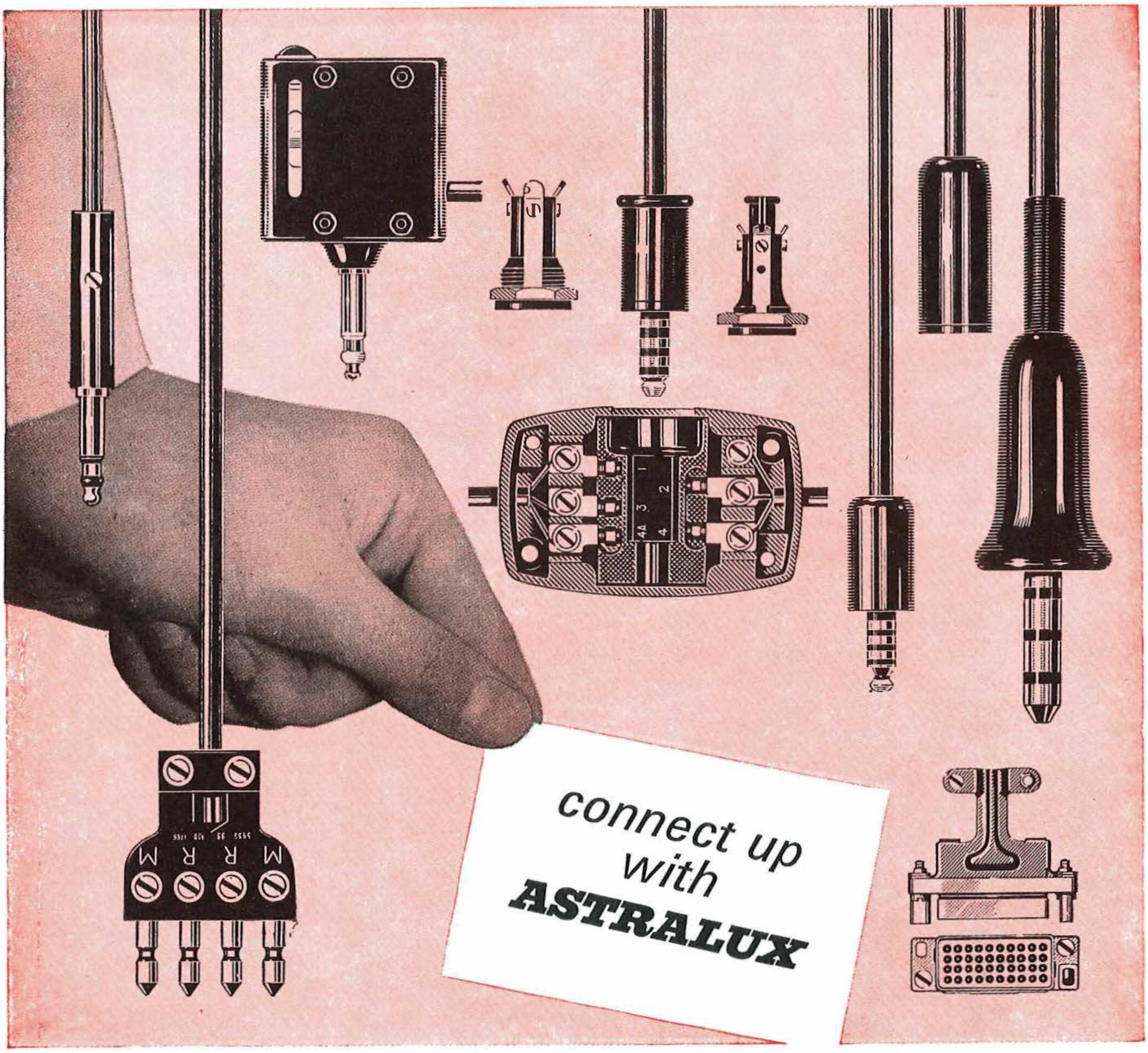

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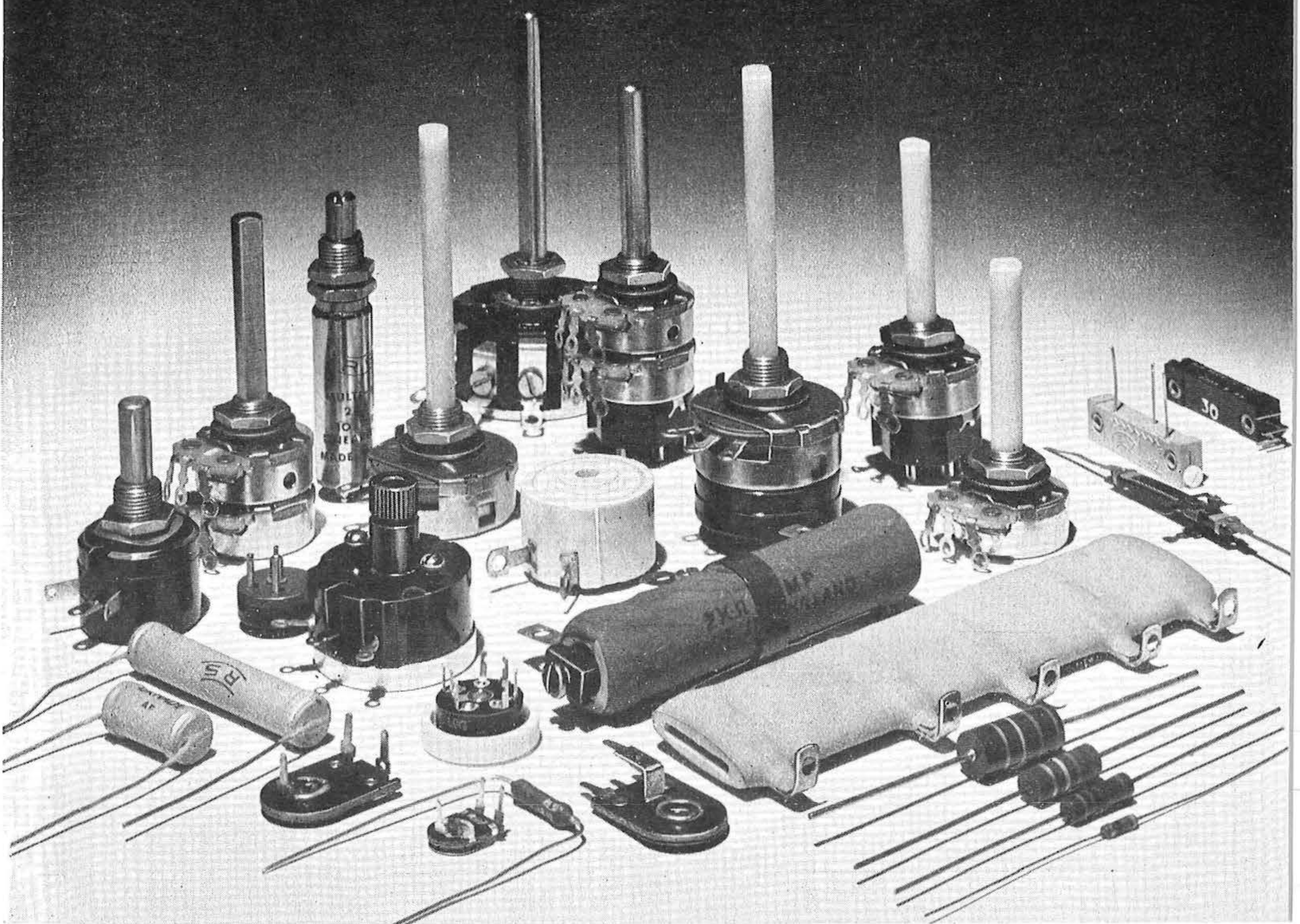

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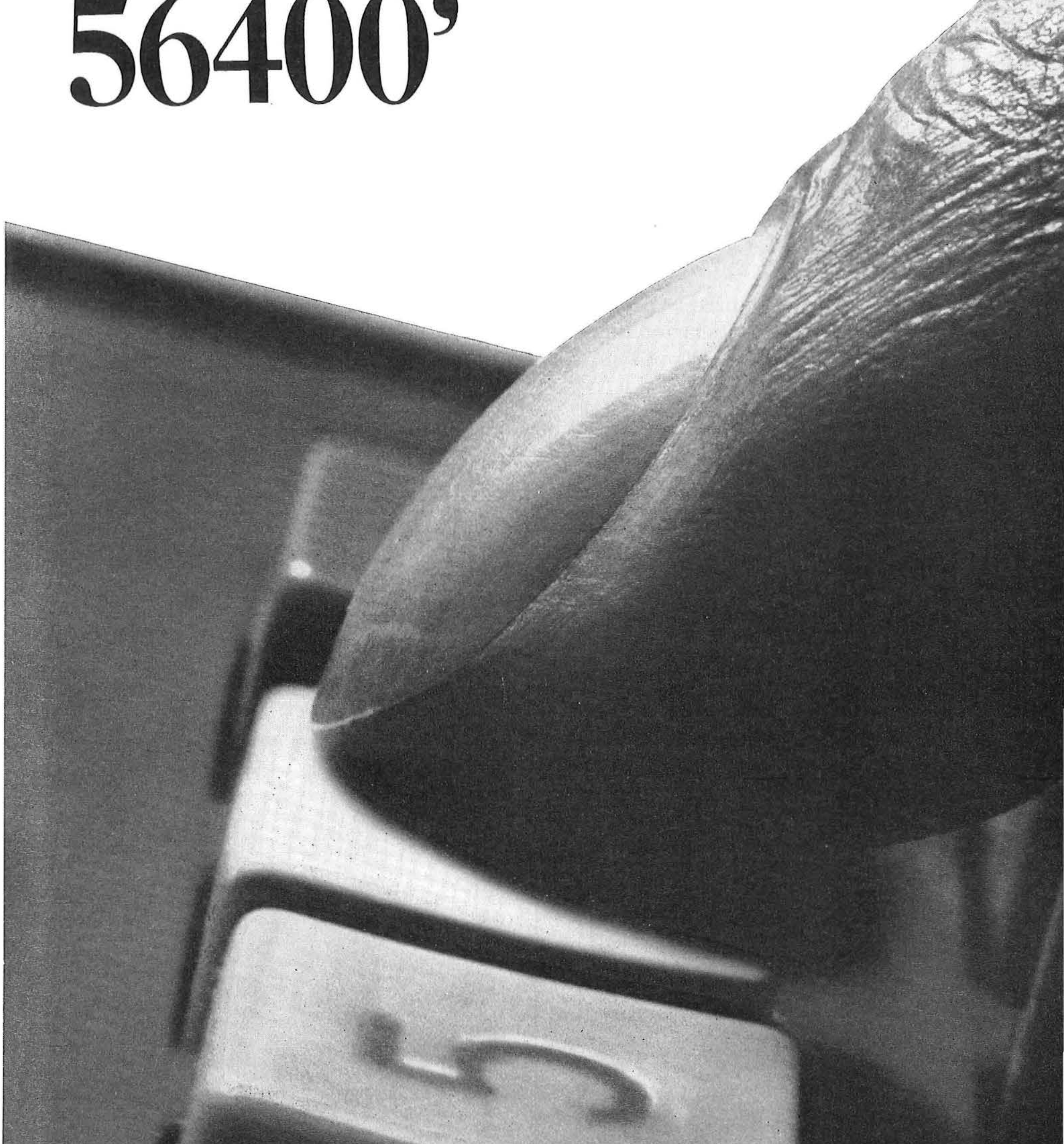

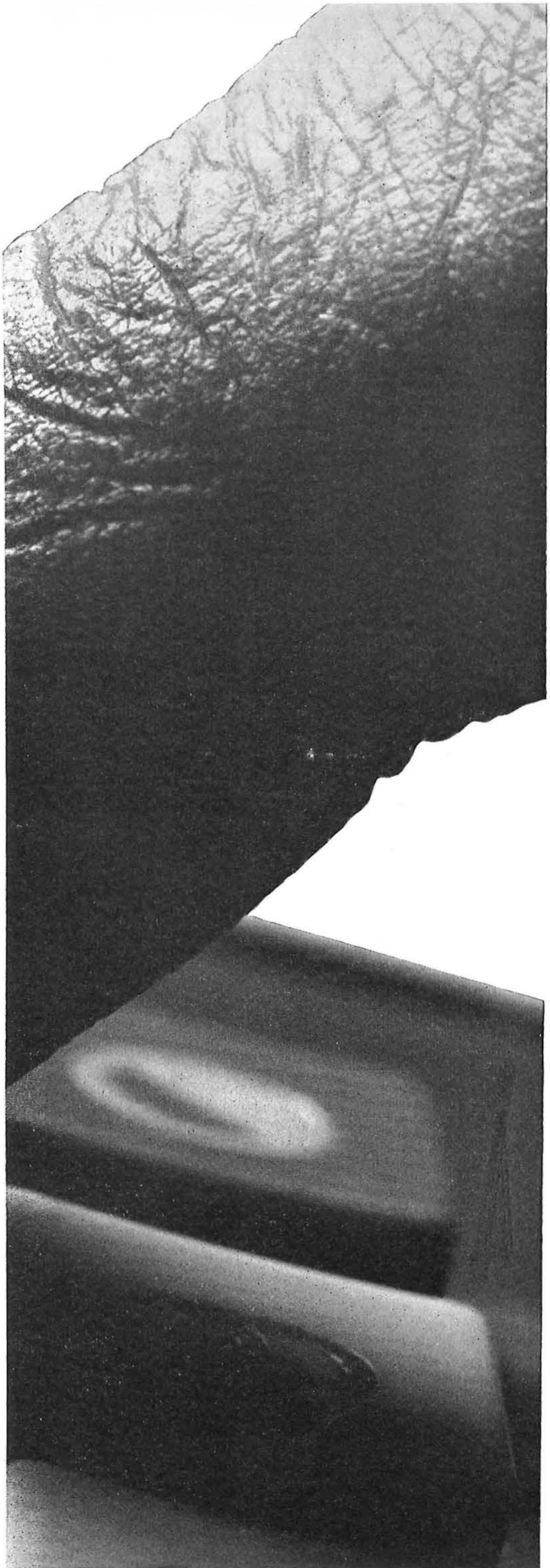

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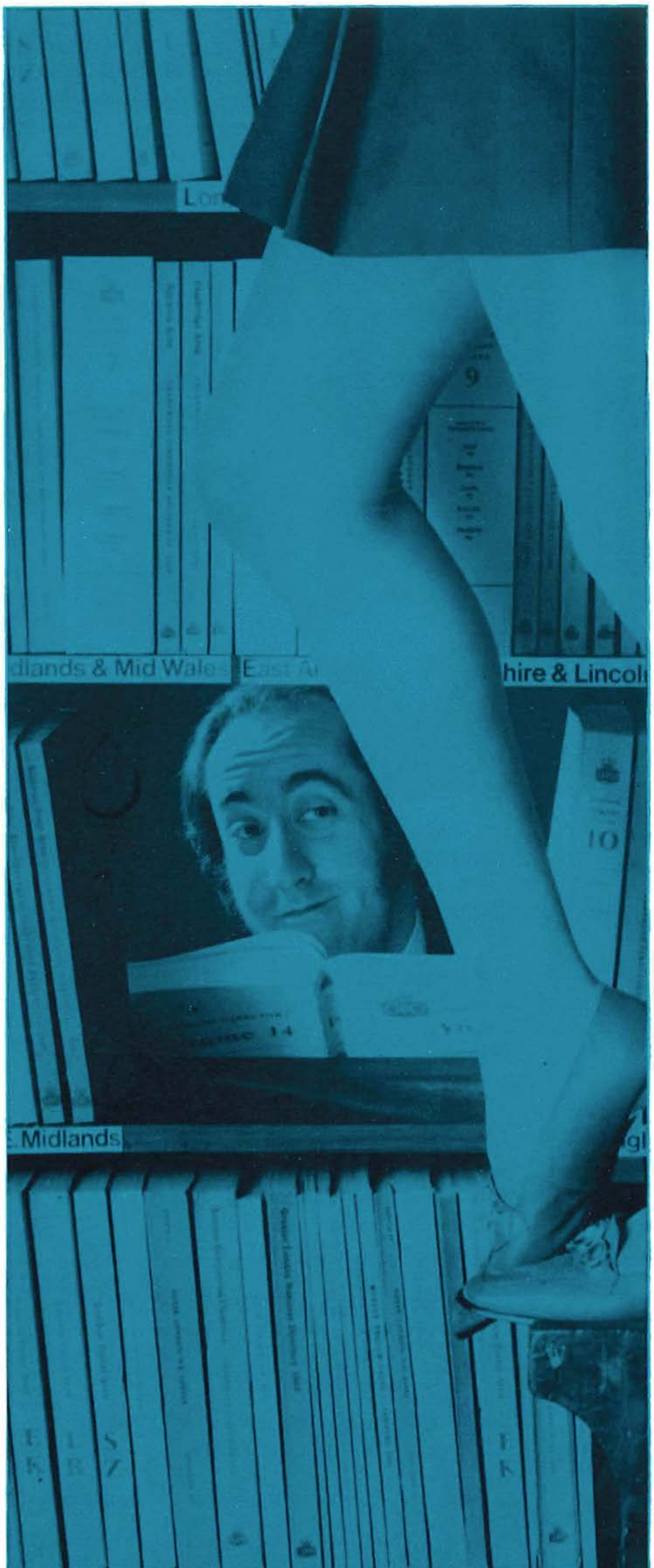

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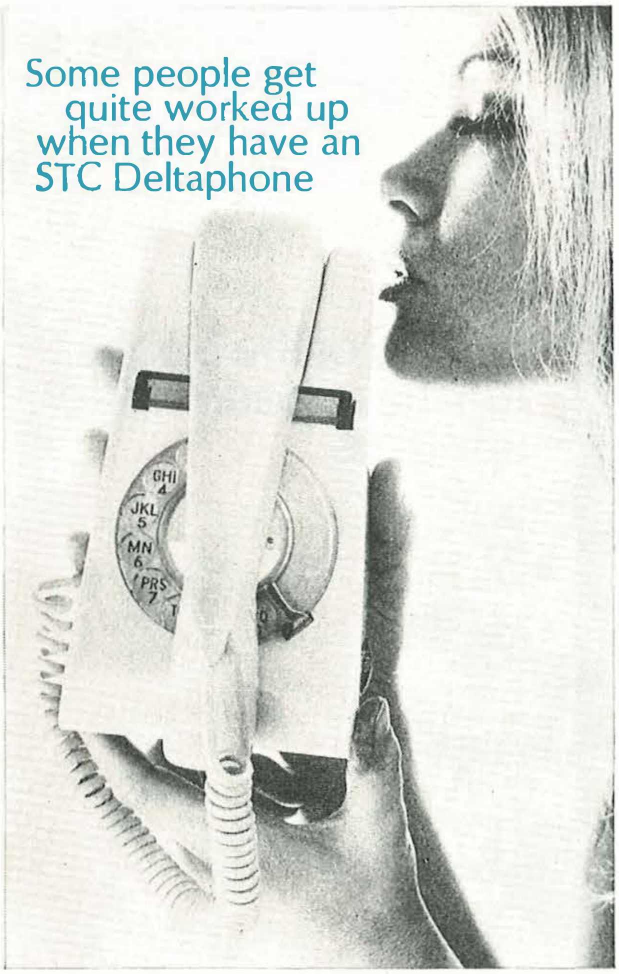

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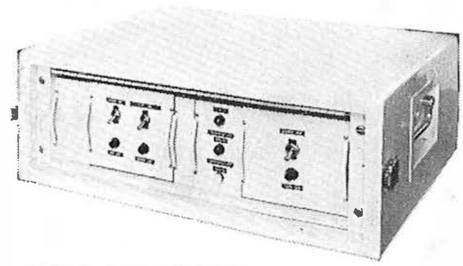

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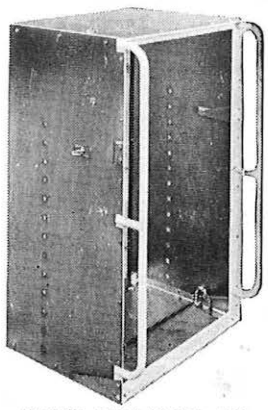

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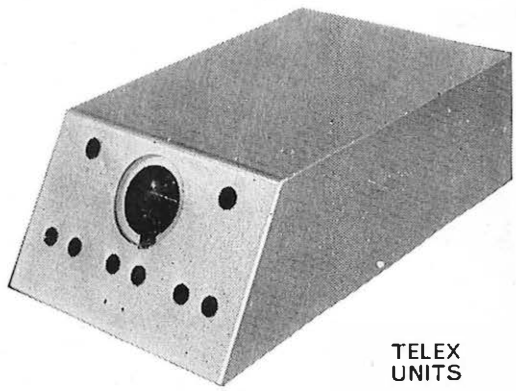

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