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The London Radiophone Service

J. L. HYATT, A.M.I.E.E.†

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The article describes the London Radiophone Service, which provides a radio connexion between mobile subscribers in the Greater London Area and the public telephone network. A description of the equipment is given, and proposals for the future expansion of radiophone services in the United Kingdom are discussed.

INTRODUCTION

WITH the opening of the London Radiophone Service on the 5 July 1965 the facility of being able to make and receive telephone calls in moving vehicles was made available to subscribers in the Greater London Area. This is the second land radiophone service to be introduced in the United Kingdom. A smaller scheme* was brought into operation in South Lancashire during 1959 for the benefit of mobile subscribers in the Manchester and Liverpool areas. The two schemes are somewhat similar, but the opportunity has been taken to introduce a number of refinements into the London scheme which reduce the operational demands made upon the subscriber and generally make the service more attractive.

Public radiophone services can be regarded as being complementary to private mobile-radio services. Whilst private services are widespread—there are at present some 45,000 mobile stations throughout the country—their main use lies in the direction and co-ordination of mobile staff, and messages passed are of short duration. Third-party traffic is not in fact permitted, and connexion cannot be made to the public telephone network. It is this latter need which the radiophone services meet, and, in general, they appeal to a rather different type of user who requires to carry on a rather more lengthy conversation. Since the services are adjuncts of the telephone network the Post Office has assumed responsibility for their introduction and operation. To date, however, mobile subscribers have had to provide their own mobile equipments either by renting or by outright purchase from the manufacturers. Nevertheless, to ensure satisfactory operation all equipments have to be type-approved to a Post Office performance specification before they may be used in the service.

Ideally, the standards of performance of a radiophone service should approach those of the telephone service. Although it is doubtful whether this aim will be realizable under the worst of the varying radio conditions, e.g. where the mobile station is in heavy traffic and beneath the lee of a hill, a generally high standard can be attained by ensuring that ample signal is available in the published service area.

BASIC FACTORS AFFECTING DESIGN

In the planning of the London service certain basic factors which exerted a considerable influence upon the final system design had to be taken into consideration. These factors were as follows.

(*a*) The service had to be economically viable.

(*b*) The cost of the mobile equipment had to be kept to a minimum, consistent with reliability and the essential operational requirements.

(*c*) Operational demands made upon the mobile subscriber had to be minimal.

(*d*) Reliable service was to be provided over as much as possible of the area where demand was likely, i.e. the centre of commerce and the surrounding dormitory areas.

(*e*) The basic system design had to be capable of extension on a national basis.

SYSTEM PARAMETERS

In the light of the foregoing basic factors, the service has evolved to provide the following system parameters.

Coverage

Three base stations provide coverage over approximately the whole of the Greater London Area (see Fig. 1). For practical and economic reasons these are located at established radio stations, where suitable aerial towers are available.

Control

The three stations are all controlled from a special manual position in Tate Gallery Telephone Exchange, to which they are linked by landline circuits. Each station is equipped with four radio circuits, three of them being exclusive to that station and used for connexion to telephone subscribers. The fourth—the control channel—is common to the three stations and is used for calling mobile subscribers prior to the call being completed over a connecting channel. Since the Tate Gallery exchange operator has no prior knowledge of the whereabouts of a subscriber it is essential that the call signal should be radiated throughout the whole of the serviced area.

Mobile stations are called selectively by means of an encoded 4-figure number. Receipt of the correct code by the mobile equipment operates visual and audible alarms to alert the subscriber.

Mobile subscribers call the operator by transmission of a short period of a 2,060 c/s tone modulation over any suitable connecting channel. Use of the control channel for calling the exchange is not normally permitted.

Each mobile subscriber can manually select any of the 10 channels which are available. To minimize the risk of losing calls, due to incorrect channel selection when in the stand-by condition, equipments are arranged to revert automatically to the control channel on replacement of the microphone or handset.

Channel Allocations

The radio channels are 2-frequency ones, and are drawn from the two frequency blocks 163·675–164·4 Mc/s and 159·175–159·9 Mc/s, which are reserved for public land correspondence services in the v.h.f. band (see Table 1).

†Mr. Hyatt is in the Radio Services Department, Wireless Telegraph Section, but was formerly in the Inland Radio Planning and Provision Branch, E.-in-C.'s Office.

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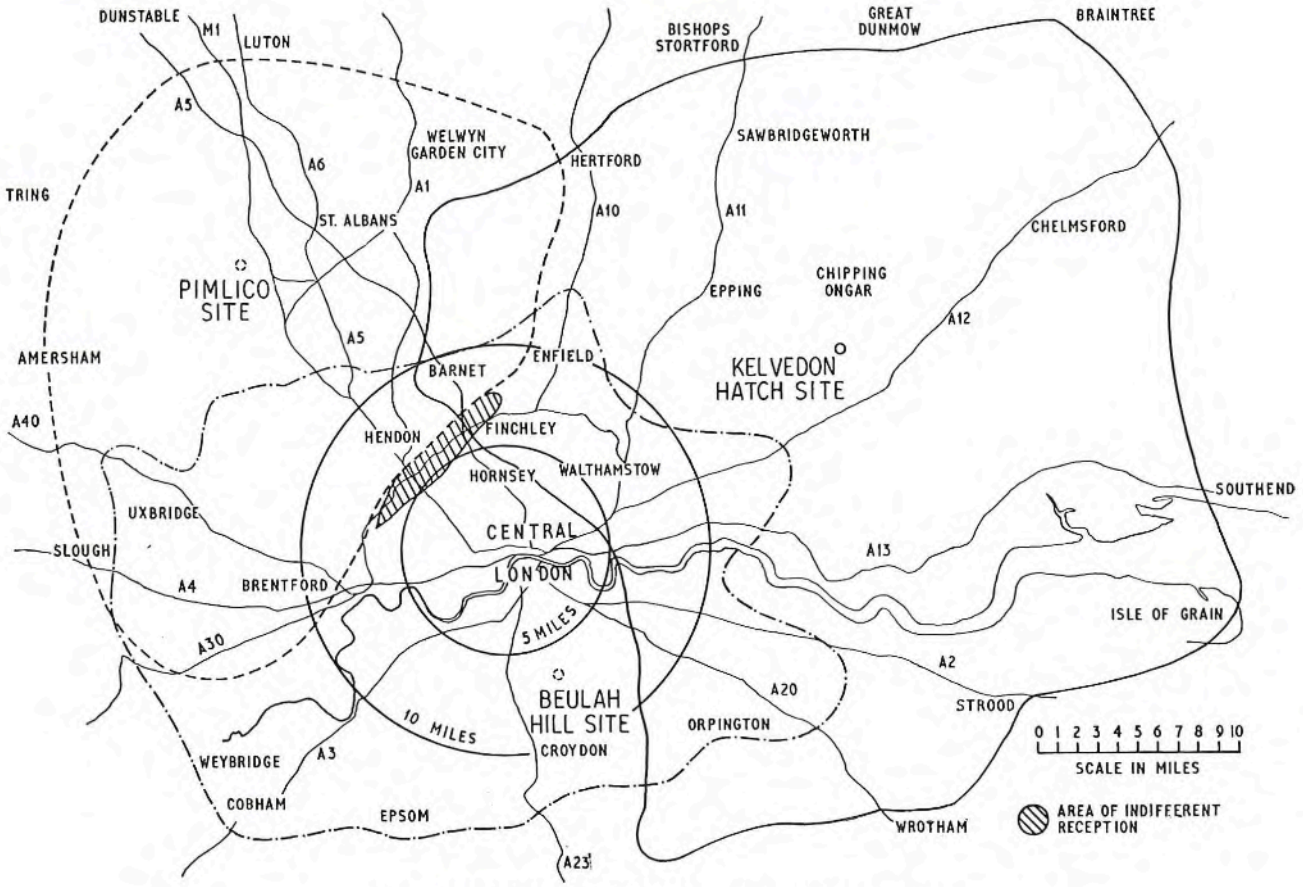

FIG. 1—SERVICE AREA OF THE LONDON RADIOPHONE SERVICE

Table 1
Channel Allocations

Station	Channel Number	Frequencies (Mc/s)		Channel Allocation
		Transmit	Receive	
North East	1	164·05	159·55	Control Channel
	5	164·375	159·875	Traffic Channel
	6	164·3	159·8	Traffic Channel
	7	164·25	159·75	Traffic Channel
	8–12	–	–	Reserved for future expansion
North West	1	164·05	159·55	Control Channel
	13	164·325	159·825	Traffic Channel
	14	164·2	159·7	Traffic Channel
	15	164·15	159·65	Traffic Channel
	16–20	–	–	Reserved for future expansion
South	1	164·05	159·55	Control Channel
	21	164·35	159·85	Traffic Channel
	22	164·275	159·775	Traffic Channel
	23	164·225	159·725	Traffic Channel
	24–28	–	–	Reserved for future expansion

Channels No. 2–4 are reserved for additional control channels

The frequency allocations to the base stations have been determined by the need to avoid the possibility of intermodulation interference either with other radiophone channels or with private mobile services, operating in adjacent frequency bands. In common with private services, an overall channel spacing of 25 kc/s has been adopted. However, by limiting the minimum channel spacing at any one station to 50 kc/s, suitable channel allocation has made it possible to permit a higher peak-modulation deviation. Phase modulation is employed, resulting in a maximum deviation of $\pm$ 10 kc/s in contrast to the $\pm$ 5 kc/s to which 25 kc/s channelling systems are normally limited. In this way a signal-to-noise advantage of some 3 db is obtained.

Channels have been arbitrarily numbered for identification purposes on the assumption that all the available channels may eventually be taken up, providing up to eight connecting channels at each station and two control channels in the Greater London Area. Separate channels would then be available for use as control channels in any adjacent radiophone service that may be established.

CIRCUIT ARRANGEMENTS

The circuit arrangements of all channels are basically similar and are shown in Fig. 2. The 2-wire audio pair from the switchboard is connected, via a terminating set, over a 4-wire circuit to the radio equipment. Outgoing signals pass via a constant-volume amplifier (c.v.a.), which compensates for variations in speech level over a range of 28 db and ensures a high average depth of modulation of the radiated signal. The transmitters are switched on by a d.c. signal controlled by the switchboard sleeve circuit and extended via the phantom of the 4-wire circuit.

In the absence of signals the receive path is normally

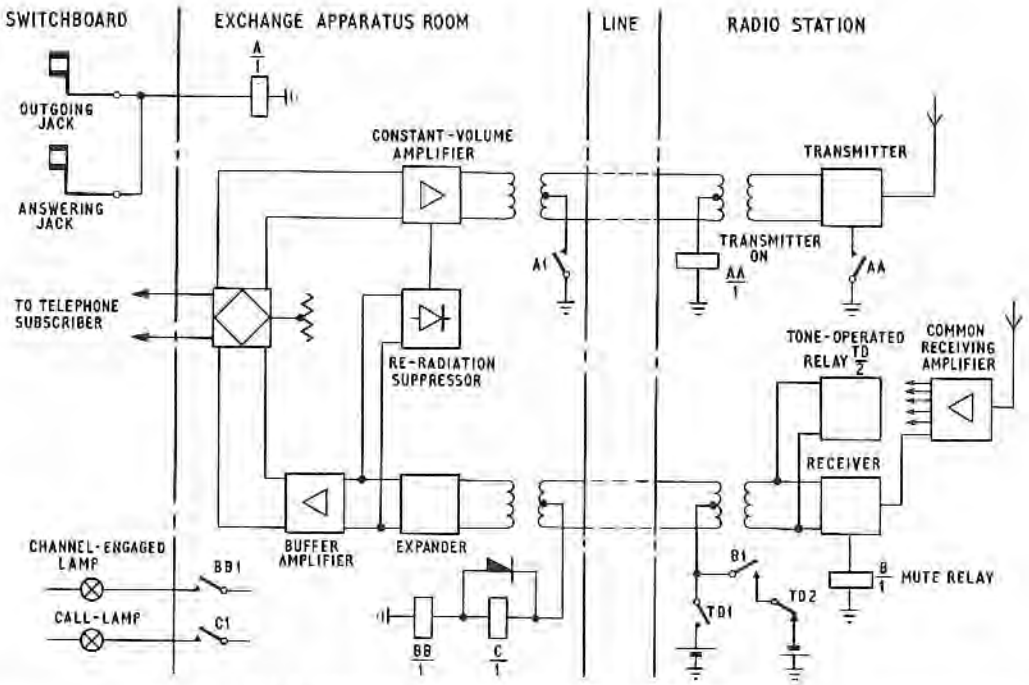

FIG. 2—GENERAL ARRANGEMENTS OF TRAFFIC CHANNELS

blocked. Receipt from a mobile subscriber of signals of sufficiently high level to provide a signal-to-noise ratio of 26 db at the output terminals of the receiver opens the receiver-muting circuit and completes the receive path. Possible re-radiation of the received signal due to high-level leakage across the terminating set is avoided by deriving a control voltage from the received signal to reduce the gain of the transmit c.v.a. Under marginal reception conditions, when the re-radiation suppressor is not fully effective, re-radiation of noise during pauses in received speech is minimized by the noise reducer or expander unit. The effect of this device has previously been discussed in some detail.*

Two supervisory conditions are signalled from the receiver by means of polarized relays. Operation of the mute switch gives a "channel-engaged" lamp indication. Receipt of the mobile-subscriber's calling tone operates the tone-detector circuit connected across the receiver output terminals to signal the calling condition at the switch-board.

The control channels have additional facilities for calling purposes (see Fig. 3). Insertion of the operator's plug into the outgoing jack, which is common to the three control channels, prepares the encoder for use, connects the encoding equipment to the three transmit paths, and switches on the three transmitters. On receipt of the ready-to-start signal, which is indicated by the dimming of the supervisory lamp, the operator dials the required number, which is transmitted simultaneously from the three stations.

DESCRIPTION OF EQUIPMENT

Radio-Station Equipment

The three radio stations are situated at Kelvedon Hatch, near Brentwood (North-East Station), Pimlico, near Kings Langley, (North-West Station), and Beulah Hill, near Crystal Palace, (South Station).

Kelvedon Hatch and Pimlico are Post Office radio stations, and the radiophone aerials are accommodated on 300 ft towers provided for other purposes. At the South Station the aerials are installed on the Independent Television Authority's (I.T.A.) tower at Beulah Hill, but in this instance the equipment is accommodated in Livingstone Telephone Exchange, which is adjacent to the I.T.A. site.

The installations at the three stations are to all intent identical. Two 3–6 db omnidirectional receiving aerial arrays are provided, each of which is connected to a common receiving amplifier capable of supplying up to nine receivers. The gain of the amplifier is adjusted so that the overall sensitivity of amplifier and receiver is similar to that of the receiver alone.

When the service was planned it was not practicable to use common transmitting aerials, and each of the transmitters is connected to a separate zero-gain omnidirectional aerial. To minimize the generation of intermodulation products, aerials are spaced vertically down the side of the aerial tower some 12 ft apart; Fig. 4 shows the arrangement at the Pimlico station.

Connexion between aerials and equipment is by means of a low-loss (0·66 db/100 ft) coaxial feeder, the average loss being 3 db.

The equipment at each station is accommodated on three racks (see Fig. 5). The transmitter rack is equipped with six transmitters (three connecting channels, control channels, main and reserve, and one spare) and an aerial-connexion panel. The rack is of the enclosed type and is fan-cooled. The transmitters are of conventional design, and are capable of delivering 60 watts output power. The temperature-controlled crystal oscillator operates at 1/24 of the radiated carrier frequency and has a nominal stability of 0·001 per cent. It is followed by a chain of multiplier stages to drive the power output amplifier. A

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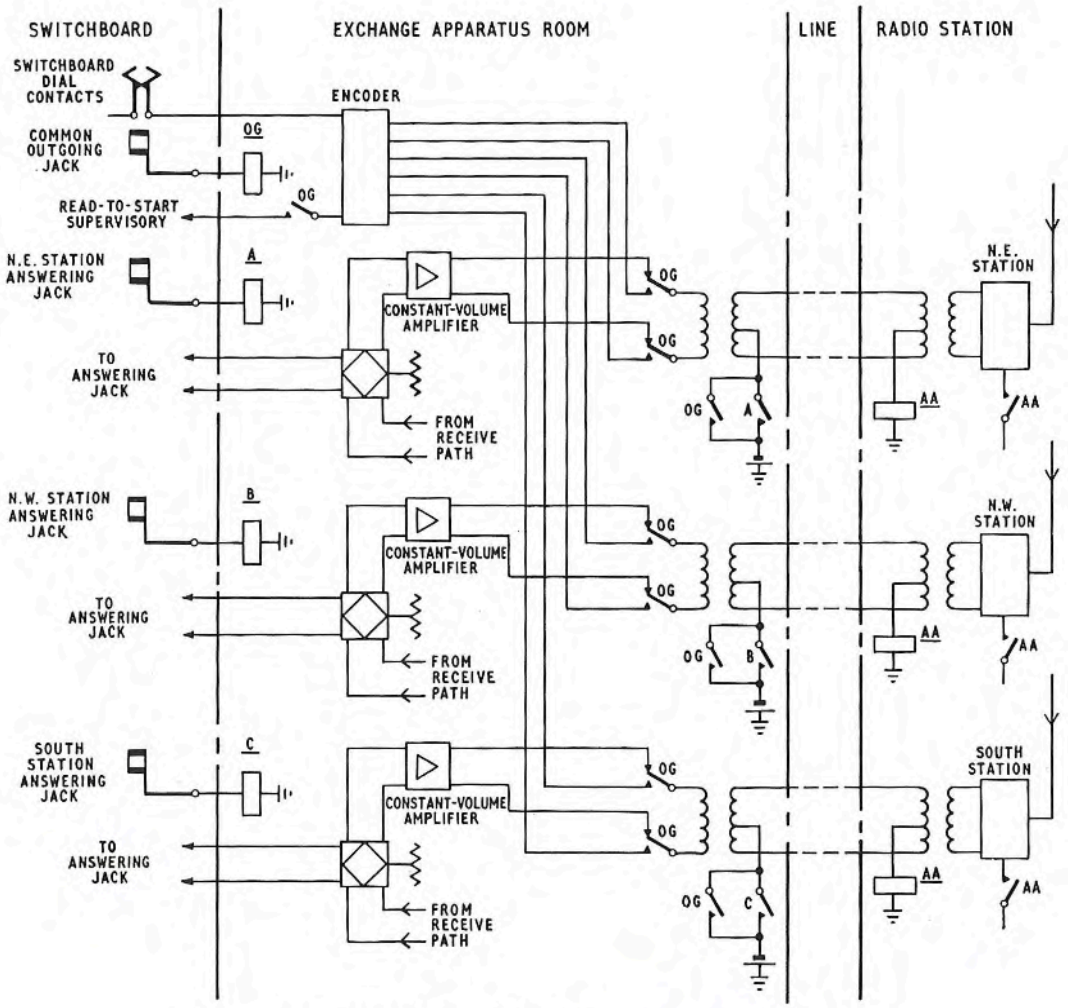


FIG. 3—CALLING ARRANGEMENTS OF CONTROL CHANNEL

low-pass filter in the output lead reduces the radiation of harmonics.

The phase modulator operates at crystal frequency, and the resultant deviation is proportional to frequency over the audio range 300–3,000 c/s. An audio limiter at the input of the modulator restricts the peak deviation to $\pm$ 10 kc/s, and the following low-pass filter removes harmonic products generated by the limiter and limits the audio band to the required range. In practice, the equipment is set up to give some 2 db of clipping of speech peaks, thus enabling a reasonably high average depth of modulation to be achieved with little noticeable distortion.

The receiver rack accommodates the six receivers, the two common receiving amplifiers, and two cavity band-pass filters, which are connected in the input lead of the amplifiers and reduce possible adverse effects of high-level out-of-band signals, such as intermodulation, cross-modulation blocking, etc.

Both receivers and common amplifiers are of solid-state design and reflect current practice in this field. The receiver uses a double superheterodyne circuit with crystal-controlled first and second local oscillators. Adjacent-channel selectivity is provided by a block filter operating at the second i.f. frequency of 455 kc/s. The audio signal is recovered by means of a Foster-Seeley type discriminator, and is passed to line via an adjustable-gain amplifier. The muting circuit is operated on the receipt of a signal of sufficient level to produce the required signal-to-noise ratio. An output from the second i.f. stage is amplified and rectified to provide a control voltage for operating the mute relay.

The third apparatus rack accommodates line transformers, relay-sets, and the calling-tone detectors associated with each receiver.

Radio-Terminal Equipment

The radio-terminal equipment at Tate Gallery Telephone Exchange is installed on four 10 ft high racks in the apparatus room. The constant-volume amplifier and re-radiation suppressor circuit associated with each channel constitute one unit, which has been built to a Post Office specification. The unit is of solid-state design, and module construction has been used, five of the units occupying one 10 in. high housing. The noise-reducer unit is of similar construction. Both units are designed to operate from a 24-volt d.c. supply obtained from stabilized power units.

The encoding equipment converts dial impulses into corresponding transitions between tones of 600 c/s and 1,500 c/s. This is achieved electromechanically by a

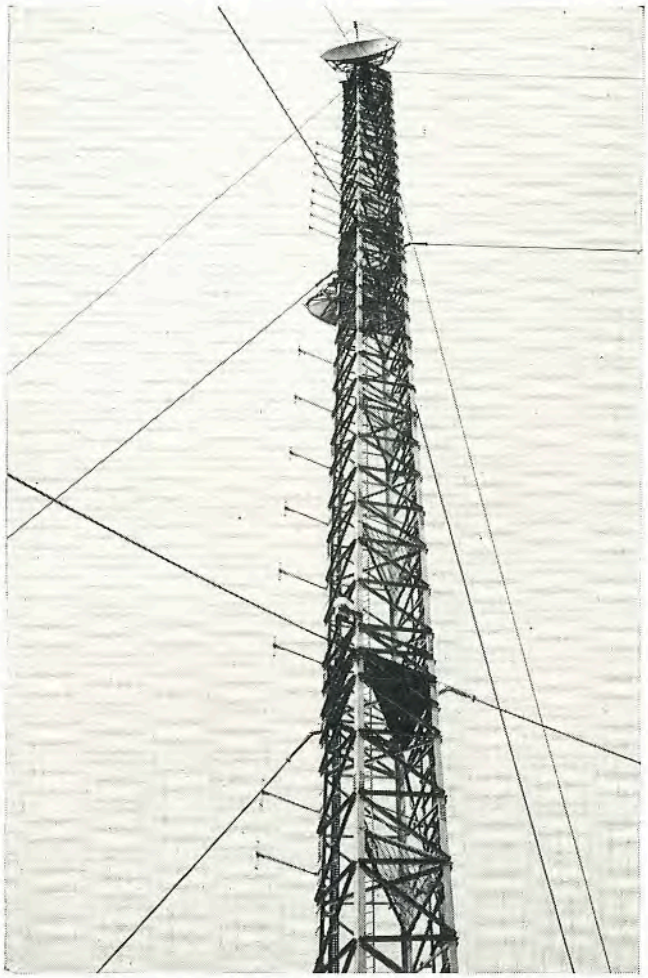


FIG. 4—AERIAL SYSTEM AT PIMLICO

series of inter-connected relays. A single "start" transition at the beginning of a code, which resets the decoders to the zero condition, and a second "finish" transition at the end, are added automatically. To prevent premature dialling, a supervisory ready-to-start condition is signalled to the operator to indicate when dialling may commence.

Mobile Equipment

Although the Post Office provides and operates the fixed stations in radiophone services, it is in no way responsible for the supply of mobile equipment. Nevertheless, fairly close control over its performance is essential in the interests of compatibility, and, as already mentioned, all equipment produced has to be type-approved to a Post Office specification before it can be marketed. Code numbers are issued under the authority of the Post Office, although, in the interests of production efficiency, manufacturers have been allotted blocks of the 4-digit numbers so that they may set the decoders during manufacture.

As far as possible the radio performance required of mobile equipments is similar to that laid down in the current private mobile-equipment specifications. In this way the use of off-the-shelf equipment, with little modification, has been possible.

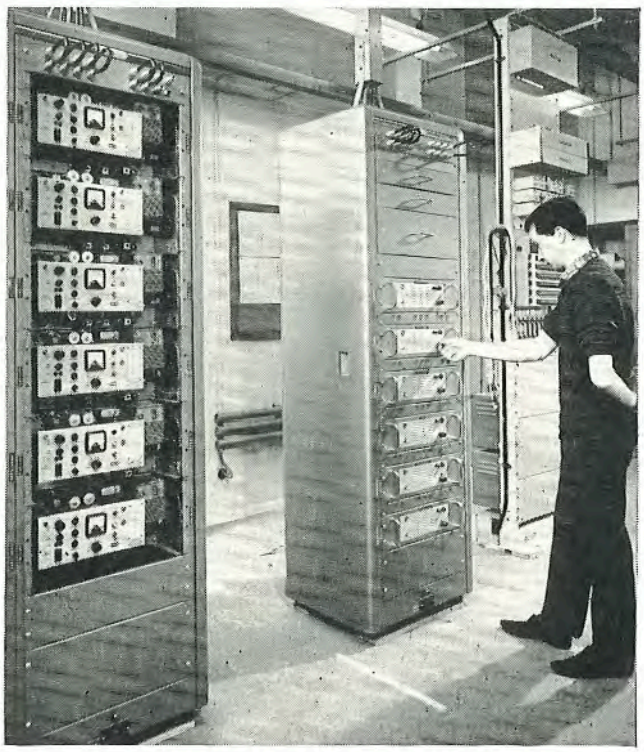


FIG. 5—INTERNAL EQUIPMENT AT PIMLICO

Designs generally follow those of the base-station equipments but on a smaller scale. Transmitter output powers are typically 12–15 watts. Each equipment has to be capable of switching to any of the 10 channels available. So far, channel-selector mechanisms have evolved around push-button-controlled electromechanical switching devices, although solid-state switching is now a practical possibility.

Typical equipments are shown in Fig. 6. The radio and decoder unit would normally be mounted in the vehicle boot and the control unit beneath the dashboard. The control unit contains the channel-selector and call buttons, and is provided with calling and channel-engaged indicator lights.

Two types of decoder unit have been used so far: one of electromechanical design, and one of solid-state design. Both are of proprietary United States manufacture. In the first, the code signal generates pulses that operate a ratchet relay having peripheral holding contacts which are set-up in accordance with the particular code number. In the other, the received code is translated into binary code and compared with the required code which is set-up in a series of binary counters.

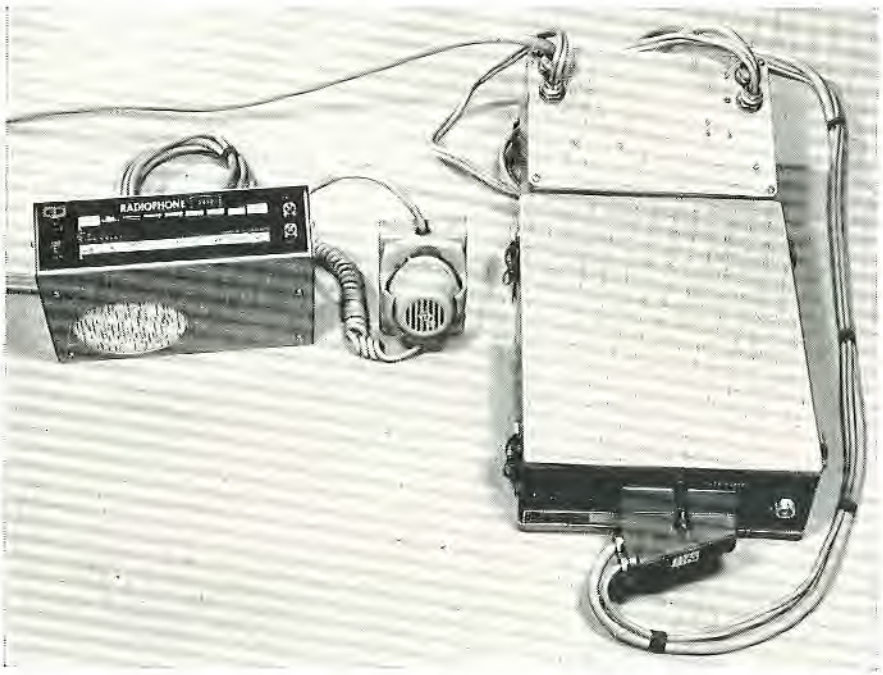
Both designs are well tried and are comparable in operational performance.

OPERATIONAL EXPERIENCE

The service has now been in operation for some 6 months, and the number of subscribers is approaching 300. In fact, in view of the lack of experience of radiophone services a temporary halt has been called on the acceptance of new subscribers until more information about calling habits has been obtained. It would appear that the South Station carries the majority of traffic.

From the technical aspect the service has settled down

extremely well. Doubts were at one time expressed about the reliability of the simultaneous transmission of the calling signal from the three base stations in the overlapping service areas. Whilst distortion of the tones and the generation of hetereodyne beat notes occurs, both types of decoders continue to operate satisfactorily anywhere in the service area as long as the beat-note frequencies are kept below 300 c/s. The control-channel transmitter oscillators are accordingly held to this accuracy: as the short-term stability of the radiated carriers is, in fact, better than 0·0001 per cent, no problem has been experienced in achieving this. It was also considered that delay equalization of the audio-tone signals to the three stations might be required in view of the difference in distances, and, consequently, transmission times, between the three base stations and Tate Gallery Exchange. In practice, delay equalization has been found to be unnecessary.



(*a*)

(*b*)

FIG. 6—TYPICAL MOBILE EQUIPMENTS

Intermittent interference has been experienced on the receive channels at the South Station. This has been found to be due to radiation from industrial radio-frequency equipment, such as plastic welders, wood gluers, etc. The bursts of interference are of short duration, and, as the range can be up to five or so miles, the sources are extremely difficult to trace in the densely populated areas around the station. Fortunately, the effect upon the service has been negligible to date.

CONCLUSIONS

The system parameters of the London Radiophone Service were chosen to permit an extension to the service by the addition of further connecting and control channels as and when the number of subscribers required it. It would also be quite practicable to introduce the service into any other area, including adjacent areas, by the judicious allocation of control channels. However, the service is rather restricted by the use of a separate calling-out channel, and any means by which this could be eliminated would greatly simplify operation and prepare the way for eventual automatic operation. Recently, mobile equipments with automatic channel-searching facilities have become commercially practicable, and it is felt that the introduction of this development is significant enough to warrant some re-appraisal of the present radiophone planning. With the new facilities that now appear possible, the radiophone service would become even more comparable with the telephone in operational simplicity.