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The Anechoic Chamber in the London Test Section of the British Post Office

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This article describes an anechoic chamber built for the Quality Assurance Branch at the headquarters of their London Test Section, to permit reliable acoustic measurements to be made on a variety of transducers, transducing instruments and acoustic materials. The performance of the chamber is also given.

INTRODUCTION

Reliable and repeatable acoustic measurements, under free-field and interference-free conditions, are necessary for quality-assurance work on transducers used in hearing aids and telephones, for which the Quality Assurance Branch of the British Post Office (BPO) is responsible. These conditions demand an environment where reflected sound and ambient noise are reduced to negligible proportions.

The first of these requirements may be met by a room in which all inner surfaces are lined with sound-absorbent material (that is, an anechoic chamber); the second requirement may be achieved by providing the room with sufficient sound insulation and immunity from structure-borne vibration to ensure that interference from both sources is reduced to tolerable proportions. The field pattern from a source of sound within such a room is sensibly constant, irrespective of frequency throughout the working area. This permits measurements of the required accuracy to be made over a wide range of level and frequency. Measuring equipment used in association with the room is housed in an adjoining laboratory.

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LOCATION

In accordance with the Quality Assurance Branch policy of centralization of London Test Section test facilities, the chamber, and its associated laboratory, has been built on the same site as that shared by existing London Test Section laboratories at Studd St., North London. Here, accommodation is very limited; the needs of other departments and branches are such that any unoccupied space has little to commend it.

However, one end of a bungalow building (see Fig. 1), comprising the ground floor and basement, offered sufficient space for both laboratory and chamber, provided the floor at ground level was removed to allow the chamber to be accommodated in the combined ground floor and basement areas. This major alteration was of little consequence since the building in this area was very dilapidated and would, in any case, have needed considerable renovation to make it habitable.

Real disadvantages were that

(*a*) a substantial volume of motor traffic (mail vans and delivery vans) passed along a roadway between the bungalow and the building housing the main London Test Section laboratories,

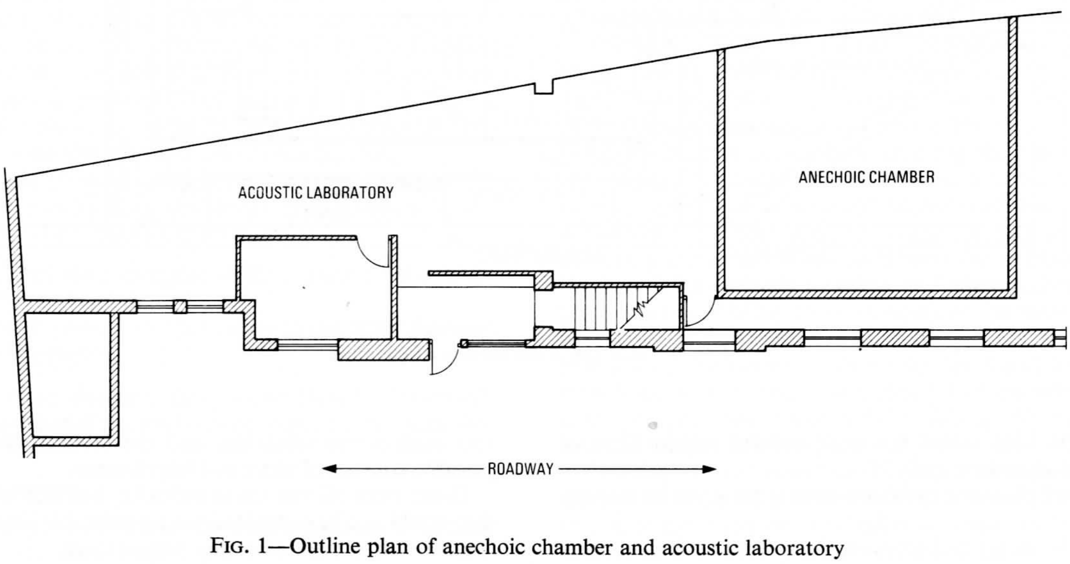

Fig. 1—Outline plan of anechoic chamber and acoustic laboratory

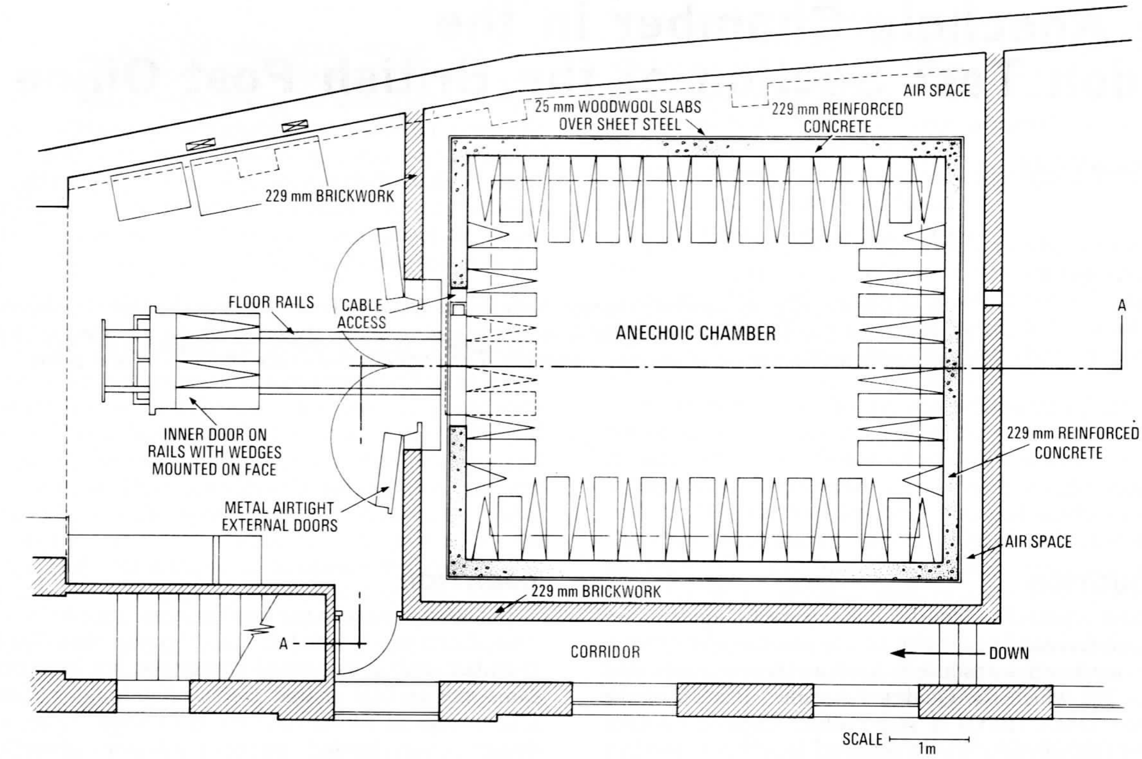

FIG. 2—Plan section of chamber

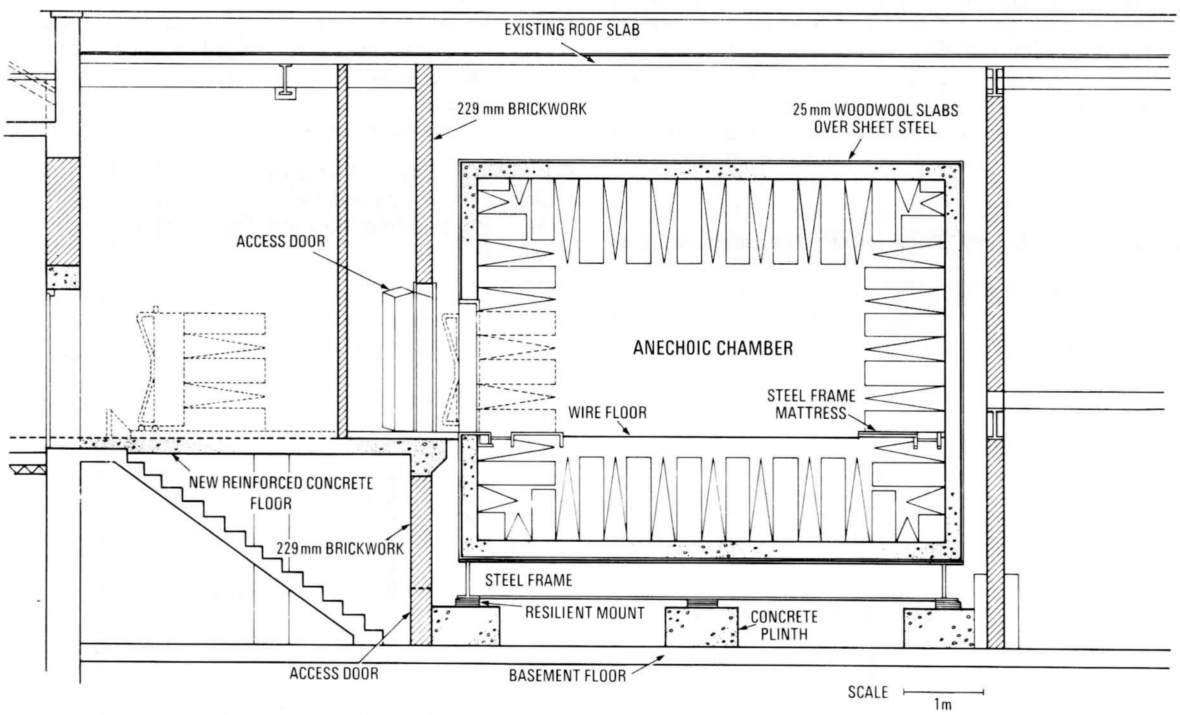

FIG. 3—Side elevation section of chamber

(*b*) Victoria Line trains ran underground within 61 m of the proposed chamber, and

(*c*) EHT and photometry laboratories were in the immediate vicinity.

The vehicles in (*a*) and (*b*) were sources of air-borne noise and earth-borne vibration, and the laboratories in (*c*) were possible sources of electrical interference.

These were all serious drawbacks, but not so serious that they could not be contained within tolerable limits by suitable measures incorporated at the design stage.

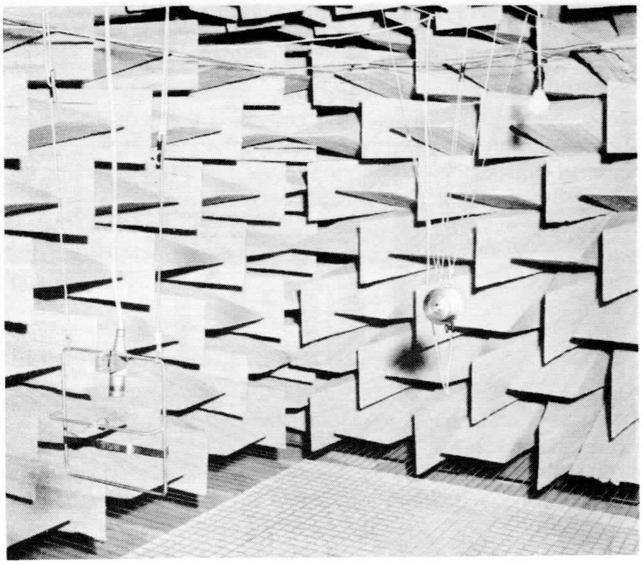

FIG. 4—Interior of inner chamber with normal test equipment in position

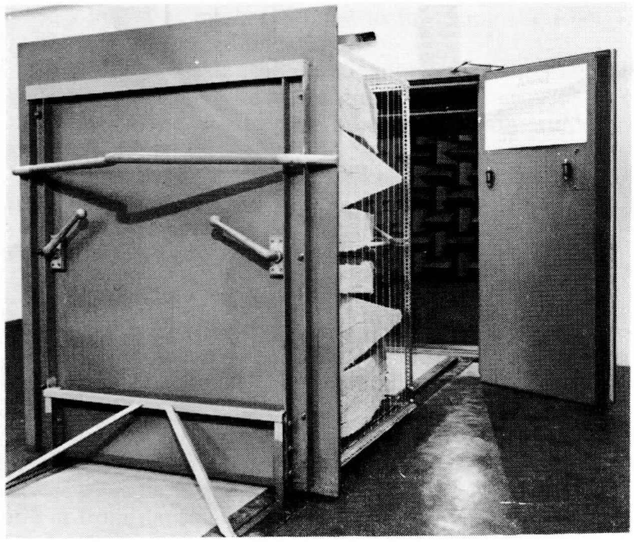

FIG. 5—Doors of both chambers in the open position

OUTLINE OF CONSTRUCTION

Figs. 2 and 3 are sectional drawings of the complete chamber. The air-borne noise has been effectively dealt with by adopting a double-shell construction, comprising 2 chambers built one inside the other and separated from one another by a layer of air. Provided each chamber is air-tight under working conditions, sufficient mass is incorporated in their construction, and the layer between the two is of adequate thickness, then externally-generated noise penetrating the inner chamber is reduced to an acceptably low level over a wide frequency range.

The inner chamber is built in 229 mm thick steel-reinforced concrete, and weighs about 120 t. The outer chamber is in 229 mm thick brickwork, and the air space separating the 2 chambers is, in general, not less than 305 mm. For structural reasons, this clearance is unavoidably reduced at some points.

OUTER CHAMBER

Fig. 2 shows a plan view of the whole chamber, from which the outer chamber can be seen to comprise three 229 mm brick walls built against the external wall of the building. The outer chamber could have been built more simply by erecting 2 walls across the width of the building reaching from basement floor-level to ground-floor ceiling-level. However, this would have isolated one end of the building from the other and contravened fire regulations which insist on free passageway between the 2 parts of the building. A corridor is, therefore, provided at both ground-floor and basement levels on the roadway side of the building.

Fig. 3 is a side elevation showing the vertical extent of the walls, and the positions of the doors giving access to the enclosed space. These doors are provided

(*a*) at basement floor-level for maintenance in the space between the 2 chambers, and

(*b*) at ground floor-level to allow entry to the inner chamber during normal operation.

Each door is so designed that, when closed, the sound-insulating properties of the walls are not significantly impaired.

INNER CHAMBER

An outline of the inner chamber and its position within the outer shell are shown in Figs. 2 and 3.

To possess good anechoic characteristics, the chamber should not be a cube; sides in the ratio of 1·0 : 1·25 : 1·6 provide a favourable basis for a successful design. The area available did not allow a very close approach to this ratio without sacrificing useful working space, but it was possible to accommodate a chamber having length, width and height of 6·4 m × 5·56 m × 5·03 m respectively, and these dimensions are sufficiently non-cubic for practical purposes.

The predecessor to the present chamber was lined with wedges consisting of loose glass fibres enclosed in a muslin bag. During the several years it was in use, the glass fibre disintegrated to the extent that minute particles of glass, floating in the air, caused appreciable irritation to any person working inside the chamber for any length of time. With this experience in mind, alternative materials were considered. Each had advantages and disadvantages, and the final decision to use glass fibre again was taken on the manufacturer's assurance that the current product was substantially free from disintegration. The present wedges, shown in Fig. 4, are rigid and are treated with a thin varnish to impart additional mechanical strength whilst leaving the sound-absorption qualities unimpaired. Time alone will prove whether the manufacturer's claim is valid, but analysis of air within the chamber indicates that contamination due to glass particles is negligible at present.

The working area within the chamber, measured between wedge tips, is 3·91 m long, by 2·97 m wide, by 2·44 m high. The effective height is reduced by the provision of a wire floor suspended some 0·3 m above the tips of the wedges lining the floor of the chamber (see Fig. 4). The floor consists of 3·18 mm diameter steel wires woven to form a 50·8 mm mesh, this being fixed to the chamber walls and tensioned to withstand a vertical load of 272 kg at any point without deflecting more than 38 mm. Because of its mesh construction, the floor is acoustically invisible, and adequately supports the number of staff likely to be working in the room at any one time. Fixing points and tensioning devices are sufficiently shielded by the wedges to cause no significant level of sound reflection. A fine gauze net, fitted immediately below the wire, prevents any small articles falling through the floor into the wedges below.

The door to the chamber (Fig. 5) is a single unit, with a mass and wedge treatment similar to the wall into which it fits. It is mounted on a wheeled carriage, running on rails embedded in the floor at the approach to the chamber, and

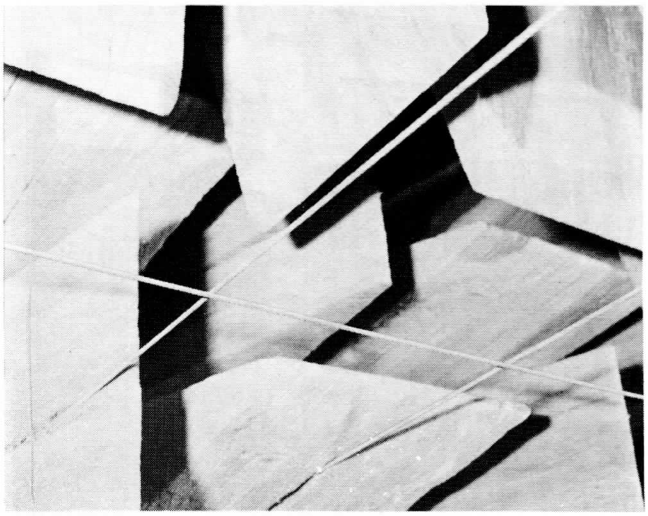

FIG. 6—Overhead support wires

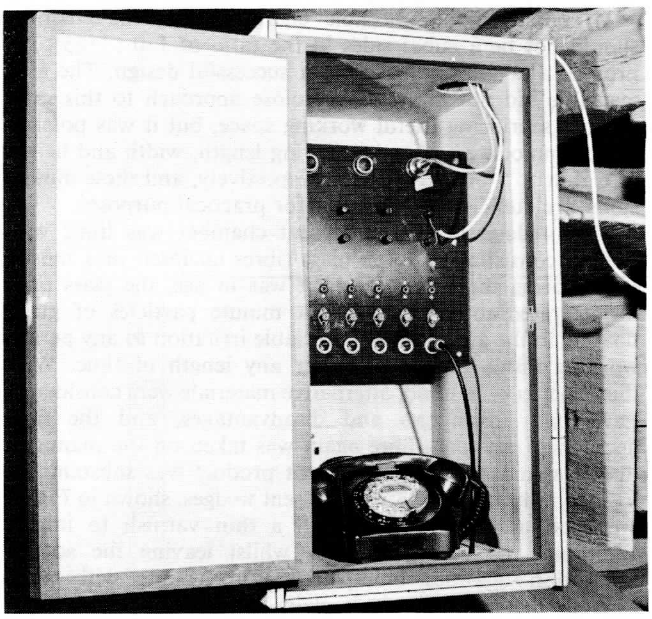

FIG. 7—Interior of termination box

when closed and locked in position, forms an air-tight and integral part of the wall. The carriage remains on its rails when the door is closed and constitutes a solid link between the inner chamber and the remainder of the building. This is obviously undesirable since it could offer a path through which structural-borne vibration may travel. Fortunately, perhaps because of the resilient nature of the seal between door and chamber, there has been no discernible interference from this source.

The door is normally opened and closed manually from outside, but because of the danger to anyone inadvertently left inside the closed chamber, provision is made to allow the door to be opened from within. Other precautions, referred to later, have also been taken to ensure maximum safety in this eventuality.

To minimize interference with the pattern of the sound

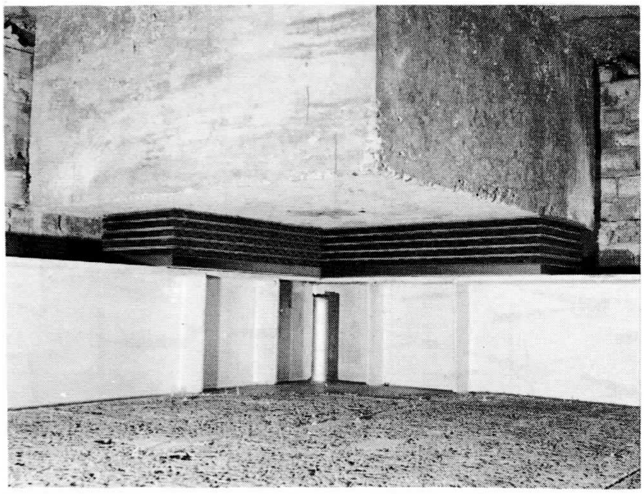

FIG. 8—Underside of chamber showing woodwool blanket, resilient pads and one concrete support block

field within the chamber, fittings have been reduced to the bare essentials. Pairs of wires along the length and width of the chamber at the respective centre lines, and a single wire along each side, are tensioned to the walls just below the tips of ceiling wedges (see Fig. 6). These provide a means of suspending test equipment, usually a sound-pressure unit (loudspeaker), a capacitor microphone and the item under test.

Lighting within the chamber is also reduced to the bare essentials of 2 unshaded incandescent lamps, suspended just below the ceiling wedges. Because of their spherical shape and small dimensions, the effect on the sound field is negligible. Electrical connexions to the interior of the chamber, including test leads to the laboratory but excluding those used for normal lighting, terminate in a box attached to the wall at one side of the door aperture. This box is sunk to wedge-tip depth (Fig. 7) and its lid is faced with sound-absorbent material.

RESILIENT PADS

Ideally, the inner chamber should be physically isolated from the remainder of the building. This is easy to arrange for ceiling and walls, apart from the difficulty with the door described earlier, but some contact has to be tolerated for the base; that is, the chamber has to stand on something. Therefore, the means of support chosen must be capable of absorbing earth-borne vibration if the chamber is to be substantially free from this form of interference.

Rubber pads offer one solution to this problem when the natural frequency of the chamber is well below that of the lowest frequency likely to cause interference. Since the natural frequency of the chamber is about 9 Hz and the lowest test frequency is expected to be about 50 Hz, a worthwhile measure of isolation is anticipated.

The pads chosen, which comprise alternate layers of rubber and steel plate, are placed at all 4 corners of the base and midway along each side. The whole chamber is raised on concrete blocks (see Fig. 8), to allow it to be jacked-up should the pads need replacement. Although the chamber weighs approximately 120 t, the compression of the pads is less than 12·7 mm.

SOUND INSULATION BETWEEN THE CHAMBERS

Over the broad band of working frequencies, the sound insulation offered by the wall–air–wall construction is sufficient to ensure that, within the inner chamber, the level of interference, caused by externally-generated noise, is insignificant. However, interference sources at certain frequencies in this band, if incident to the structural walls at critical angles, may stimulate resonances in the cavity between the chambers and this would raise the interference within the inner chamber to an unacceptably high level. This decrease in sound isolation can be offset by introducing absorbent material into the air layer, and for this purpose, a 25 mm thick blanket of woodwool is attached to, and completely encloses, the inner chamber (see Fig. 8).

ELECTRICAL INTERFERENCE

The generation of electric fields by the adjacent EHT laboratory and passing motor traffic are both possible sources of interference and, as a precautionary measure, the inner chamber is encased in an earthed sheet-steel screen, fitted immediately beneath the woodwool blanket.

SAFETY PRECAUTIONS

Since the inner chamber is both soundproof and air-tight it is vital that any person inadvertently shut in should be able to release himself or, if this is not possible, to summon assistance. Therefore, the following provisions have been made:

(*a*) the doors of both inner and outer chambers may be opened from within the inner chamber,

(*b*) a luminous marker is fitted to the termination box to enable it to be located in darkness,

(*c*) a light inside the termination box automatically switches on when the lid is opened,

(*d*) an external alarm may be operated from within the termination box,

(*e*) a main lighting switch is fitted near the termination box, and

(*f*) a telephone is installed in the termination box.

CONCLUSION

The facilities offered by the new chamber and its measurements laboratory are a valuable addition to the services already available from Quality Assurance Branch laboratories in Birmingham and London.

The sound field pattern over the frequency range 100–6400 Hz, measured along the normal working axis, obeys an inverse square law within a spread of 2·5 dB, up to a distance of 3 m from the sound source; up to 1·5 m from the sound source, the spread does not exceed 1·5 dB.

Interference from all sources has been reduced to negligible proportions with the exception of that arising from trains on the nearby underground railway. This is responsible for an intermittent interference at a maximum level of 40 dB sound pressure level in a $\frac{1}{3}$-octave band centred on 40 Hz, and 35 dB sound pressure level in a $\frac{1}{3}$-octave band centred on 125 Hz. This causes some inconvenience in the use of the chamber, but since the effects are known, due precautions may be taken to safeguard the accuracy of measurements.

Book Review

Materials and Processes for Electrical Technicians. L. C. Mott, A.M.I.E.D. Clarendon Press: Oxford University Press. xii+169 pp. 71 ill. £1·95 (paper), £5·00 (boards).

I think it is useful to ask oneself what should be expected of a book of 160 pages concerning materials and processes, and aimed at the trainee electrical technician. The limitation of 160 pages demands that the writing be concise and wholly relevant to the needs and capacities of the technician grade. If the technicians' view of the subject is not to be distorted, the material presented should be factually correct, reasonably up-to-date, and should not mislead, either by ambiguity or by the omission or distortion of significant areas of the topics covered.

In this book, there are few parts which approach this ideal. Section 2, on processes, is fair, although some of the information is dated, and the workshop processes are treated at an elementary level, even by trainee-technician standards. The materials chapters, up to Chapter 7, are basically sound, although even these contain scattered errors, or misleading abbreviations of topics that could have been better explained using 2 sentences rather than one. Chapters 7–13 range from mediocre to disastrous. Unfortunately for telecommunications technicians, the 2 worst chapters are on polyethylene and underground telephone cables. These deserve detailed criticism.

In the chapter on polyethylene,

(*a*) no mention is made of the fact that polyethylene is available in low-density and high-density versions, with different property ranges,

(*b*) polyethylene is not a clear material, as stated; it ranges from translucent at low densities to semi-opaque at high densities,

(*c*) to say, "It is displacing gutta percha," (for submarine cables) is to get the timing adrift by 25 years, and

(*d*) to say, "Polyethylene is attacked by ultra-violet light, unless protected by a black material, such as butyl rubber," is misleading. Butyl rubber is not black, unless made so by the incorporation of carbon-black, and weather-resisting grades of polyethylene, which incorporate directly-added carbon, have been available for 25 years. Butyl rubber is sometimes blended into polyethylene, but for the totally different purpose of improving its stress-cracking resistance.

In the chapter on underground telephone cables, no mention is made of the logical division of a cable network into long-haul trunk cable, short-haul trunks or junctions, exchange-area local cables, and local distribution cables. There is confusion over the construction of internal cables for distribution within buildings, which are insulated and sheathed with PVC, and external cables, which are not. Obsolete practices are described; for example, the use of enamelled-wire-plus-textile cables for distribution within exchanges ceased 30 years ago. No mention is made of the increasing use of aluminium as a conductor in underground cables, or the displacement of lead by polyethylene for cable sheaths on all except coaxial cables. Underground telephone-cable conductors are not made up as "singles and triples," only pairs and quads.

While these 2 sections are, undoubtedly, the worst, equally unfortunate lapses are scattered through the rest of the book and, in the opinion of the reviewer, it is not a suitable vehicle for the training of electrical technicians, or anybody else for that matter.

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