

The Plesseyphone: a new design approach

By W P GREENSLADE and W G SOAR
*Switching Division II
Telecommunications Group*

SUMMARY

This article describes a new table telephone of advanced design and economic cost. Now being produced, it employs unit construction and printed-wiring techniques and is only half the weight of the traditional two-piece telephone. It is compatible with all types of c.b. and automatic exchanges and is tropically finished throughout.

EVERY telephone added to a national network means an increase in capital and operating costs for the responsible administration. As telephone growth continues, the need becomes more urgent for an instrument designed to facilitate financial economies wherever possible. In recent years considerable line-plant savings have accrued from the improvement of transmission efficiency to the highest international standard. Thus, today, any further benefits are most likely to be realised by increasing the reliability of the telephone, making field maintenance easier and reducing product cost to the minimum.

To achieve all three objectives with a single telephone clearly calls for an entirely new design approach, with a systematic programme of painstaking research and cost-conscious planning. Essentially, such an approach should be directed to the construction of the telephone, simplifying it by the development of high-quality components of improved function and reduced complexity. Ideally, the new telephone should be presented in conventional two-piece form to comply with popular demand for traditional-type instruments.

Since Plessey, in conjunction with the British Post Office, designed and introduced the Type 706 (known as the Etelphone outside the UK) in 1959, improvements in component design, construction materials and production/engineering techniques have progressed considerably. Now they have been applied to a new telephone—the Plesseyphone, a simple, efficient instrument incorporating all the cost-saving qualities sought by administrations, as well as new and improved user features that make for more



Figure 1 The Plesseyphone, showing some of the major design changes

comfortable telephoning. It is shown in figure 1

DESIGN AIMS

To ensure a true value-for-money product, exacting design aims were specified for the new instrument

- 1 Unified functional design attractive from all angles.
- 2 Compatibility with all types of automatic and c.b. exchanges.
- 3 Three standard colour schemes in addition to black.
- 4 Shock-resistant construction, using a minimum of components and flexible to permit design variants.
- 5 High-quality components and parts suitable for use in tropical conditions.
- 6 Small weight and dimensions.
- 7 Easy portability
- 8 Hygienic handset and housing, simplified for purposes of manufacture.
- 9 Handset to be as light as possible and dimensioned to suit ear and mouth (that is, conforming to recommended CCITT dimensions).
- 10 Lightweight extensible cord of durable construction.
- 11 Handset to return to normal rest position however carelessly replaced, and to be positively trapped.
- 12 Maintenance-free cradle-switch mechanism.
- 13 Front central handset cord to prevent premature call cancellation by cord-fouling of cradle plungers.
- 14 Lightweight dial mechanism, providing long maintenance-free operation.
- 15 Easy-to-read dial numbers and improved finger plate to aid dialling.

16. Transmission performance complying with CCITT recommendations.
17. Automatic regulation of sending and receiving levels.
18. Simplified ringer with side-operated volume control.
19. Inclusion of pressbutton, when required, for operator-recall or shared-service purposes.

SIMPLIFIED DESIGN

Because overall simplicity was essential to the economic aim, the methods of value engineering and analysis were consistently applied throughout all phases of design. Each part used in the Plesseyphone has been systematically questioned, its function carefully defined, and end-use requirements diligently specified. Even the most insignificant design detail has been assessed on a function/true-cost basis with due regard to reliability, quality and the need for automatic assembly wherever possible.

From this analytical approach has evolved a telephone built with a minimum



Figure 2. Generous rear recess for easy portability

of components arranged in associated electrical and mechanical groups and assembled as units. No dial cord, or screw connections are used. The units simply interconnect by means of integral plugs and push-on connectors. This modular construction, which is novel in telephone instrument design, has the important advantage of restricting field maintenance to the renewal of a unit in the event of a fault, avoiding the need for skilled subscriber-maintenance personnel. In addition, it reduces the range of spares which an administration must maintain.

The use of miniature components, printed wiring and lightweight construction materials has resulted in a dramatic reduction in overall weight. The Type 706—which was considered light—weighs 3½lb (1.58kg). The new telephone weighs only 1¾lb (0.79kg)—a 50 per cent weight saving. The handset weighs only 5oz (141.75g) compared with 9oz (255.15g) for the Type 706. This weight reduction translates into lower transport costs. But—more important from a subscriber's viewpoint—it contributes to portability. For with the in-built carrying facility (figure 2),



Figure 3. The Plesseyphone handset (top) with its predecessor

it allows the instrument to be picked up and moved easily from room to room where plug-in points are provided. Alternatively, the instrument can be comfortably held as body and handset by those addicted to room-walking telephone conversations.

Breakages annoy subscribers and add to servicing costs. Special attention has been given to ensuring that the new telephone will withstand the worst shock treatment imposed during normal everyday use. This characteristic derives from low weight, the high-impact mouldings and the careful placement of unit fixing screws and components.

The lightweight handset (figure 3) is dimensioned to suit ear and mouth and yet departs markedly from its predecessor. Its near-symmetrical shape, enhanced by liberal corner radii, blends harmoniously with the lines of the casing and the plinth-

like base, emphasizing the low silhouette and compactness. The low-line look is stressed further by a characteristic concave face with partly recessed dial, and by the absence of the traditional cradle horns. These have been made superfluous by a new handset cradle which, in conjunction with deep handset-trapping recesses, ensures improved handset pick-up and replacement.

The front-central cord is an innovation which not only adds to the character of the instrument but affords three main advantages over instruments fitted with side or rear-positioned cords

1. Greater freedom of handset movement to both left and right-hand users,
2. No tendency of the telephone to spin round when the handset cord is fully extended.
3. No tendency of the cord to cut off a call by fouling the cradle plungers.

The dial is angled at what is generally accepted as the optimum, and the transparent finger plate, of tough acrylic material, has a larger diameter than current designs. The finger holes are correspondingly increased in size and are coned, both to assist aim and to offer greater contact area with the finger, reducing the risk of slipping.

The thermoplastic material used for the shell mouldings can be produced in an almost infinite variety of colours, but it would obviously be uneconomic from the viewpoints of maintenance, stock holding and manufacture to provide an over-wide

Figure 4. The telephone broken down into its five unit assemblies



TABLE 1. Component colour schemes

	Scheme 1	Scheme 2	Scheme 3
Case and handset	hemp beige	lava green	silver grey
Base	loam brown	ilex green	concord blue
Cords	elephant grey	ilex green	concord blue
Desk block	dusk grey	dusk grey	dusk grey

selection. Choice has therefore been restricted to black and three pleasing colour schemes (see Table 1), selected to give as meaningful a variation as possible yet suited to most schemes of internal decoration. However, as in the past, demands for special colours can be met for instruments ordered in sufficient quantity.

High-grade pigments are used throughout the range, each shade being processed under strict instrumental control to ensure a close colour match of replacement parts.

CONSTRUCTION DETAILS

The Plesseyphone comprises five unit assemblies as shown in figure 4:

1. Baseplate and ringer.
2. Cover with integral dial.
3. Handset and cord.
4. Desk terminal block and cord.
5. Transmission unit.

Simple fixing arrangements permit further breakdown when required—the removal of the dial, ringer, cords and handset. All internal components are contained in the instrument cover with the exception of the ringer and transducers. This is an unusual departure from the current practice of mounting the majority of components on the baseplate, but it confers the advantage of greater efficiency and simplified manufacture provided steps are taken to ensure that the components are accurately related to permanent features of the cover, such as the dial position and the cradle-switch plunger slots.

Past designs using component-to-cover fixing techniques suffered from the physical separation of the chassis-mounted cradleswitch and its operating plungers which slid in bores in the instrument cover. As a result, liberal movement tolerances had to be allowed for on components to achieve correct switch/plunger registration when fixing the chassis to the cover, an empirical exercise consuming both patience and time.

In the Plesseyphone this drawback has been overcome by accommodating the cradleswitch mechanism and its operating plungers as a complete assembly on the transmission unit and orientating this unit with the cover by plug-in connection to a single pilot point, namely the dial. No separate mounting brackets are used. In-



Figure 5. Convenient off-hook position

stead the unit is screw-fixed directly to the dial housing formed in the cover moulding. Critical movement tolerances are avoided, a minimum number of fixing screws are used, and correct component-to-cover relationship is assured.

COVER

The cover is a single envelope and, like the handset and base, is moulded from a

Figure 7. Components of the new dial



Figure 6. Dial mounting and typical moulded-in grip for positive cord anchorage

copolymer of acronitrile butadiene styrene. This is a material well noted for its excellent processing properties, surface gloss, light-fastness, and an unusually useful combination of impact strength and stiffness. Contact with cosmetics, inks, oils and most chemicals has no injurious effect and any blemish arising from these can be removed easily with a soft cloth moistened with water.

A main requirement of the cover is to provide a stable rest position for the hand-

set. This dynamic function is met by a cradle so shaped that the handset is correctly received and naturally gravitates to the correct position, no matter how carelessly replaced. Thus exchange equipment is not held unnecessarily, nor the user inconvenienced through loss of incoming calls. In addition, the cradle is dimensioned to accept the handset as shown in figure 5, providing a convenient off-hook facility

Vertical openings in the carrying recess, in combination with the cradle-switch plunger slots in the handset-trapping wells, give adequate ventilation to the interior, while admitting sufficient light to deter any insect from setting up home in the instrument.

The integral dial housing takes the form of an open-ended cylinder to which the dial mechanism is secured by three self-tapping screws. Three further screw-in points are provided for the transmission unit.

Internal ribs stabilize the shape of the cover and ensure accurate registration with the base outline. Integral cord grips at the front and rear make the special cord grommets, clips or strain cords usually used in contemporary instruments unnecessary. The grips used in the cover and elsewhere in the instrument consist of staggered moulded projections, forming a zig-zag channel into which the cords are pressed, as illustrated in figure 6, the grips removing all strain from the conductors and terminations within the telephone.

DIAL COMPONENTS

The automatic dial, comprising the components shown in figure 7, is a new development, but retains the operating principles of the well-known Type 21 with its articulated-trigger action. Components formerly machined or pressed from metal are moulded in polyacetal resin, a low-friction, virtually non-moisture-absorptive material. The only exceptions are governor parts, excluding governor cup and bearing. The cup mounting-plate moulding, with the cup attached by ultrasonic welding, incorporates a slotted projection which precisely locates the contact springsets, minimizing tensioning and adjustments. The two off-normal springs (visible in figure 6) are operated by a projection on the return-spring box. Socket receptacles for the transmission-unit plug pins are formed integrally with the contact springs.

The choice of return-spring material and lubricant—most critical to maximum life—has received special attention, with particular reference to tropical conditions. Life tests have shown an expectation in excess of 10^6 operations, speed and ratio

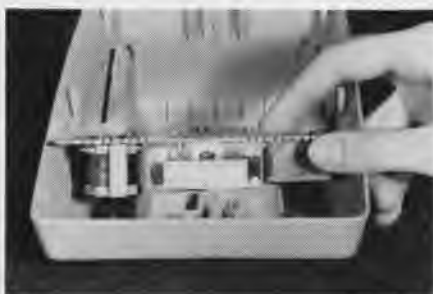


Figure 8. Cut-away view showing plug pins of transmission unit entering dial sockets

remaining within the stated tolerances throughout.

Because the dial mechanism constitutes a single unit, it can be supplied separately, the choice of speeds being 10 ± 1 pps and 20 ± 2 pps. The nominal break/make ratio is 2:1 with limits of 64 to 70 per cent break, and the pre-pulsing lost-motion period (supplemented in practice by the variable time taken to rotate the dial to the finger stop) is 240msec minimum.

The transparent dial number ring locates in the recessed area in the instrument face and carries standard numerals screen printed on its underface. This is a process which effectively prevents defacement of the characters and allows speedy provision of any special markings required by administrations.

The clear-plastic finger plate, allowing the numerals to be seen from a wide angle of view, locates on a brass stud of the dial spindle and is retained by a single screw. Its finger holes are 0.578in diameter

(14.7mm) and spaced at 25.71° intervals. Assembly of the dial is completed by insertion of the finger stop which is a permanent push-fit in the instrument cover.

TRANSMISSION UNIT

The transmission unit consists of a printed-wiring board, the cradle-switch mechanism and all other speech-circuit



Figure 10. Microswitch in position, suitable for shared-service, line intrusion and operator recall

components except the transducers. It is tropically finished throughout and fits smoothly into position with its cradle-switch plungers located through slots in the cover, being finally plugged into the dial sockets as shown in the cut-away view (figure 8). The fixed position of the unit is illustrated in figure 9, the central area of the unit resting against the dial housing to serve the additional function of dust-cover protection for the dial mechanism.

Figure 9. Instrument interior: transmission unit in fixed position.



Printed-wiring board. This is fabricated in tough synthetic-resin-bonded paper. Its underside embodies a copper-foil circuit configuration impacted into the board material by die-stamping, an efficient process providing a robust conducting path, free from lift and hairline cracks and—of



Figure 11 Connection of units to circuit board by push-on leads

special significance under tropical conditions—corrosive residues.

The plug pins for connection to the dial and all component fixing points are flow-soldered to enlarged areas of copper. An overall protective coating eliminates tracking between conductors in moist conditions.

An appropriate number of edge-sockets are provided for the connection of the ringer, handset and line-cord leads, as well as for optional additions such as a micro-switch (figure 10) for shared-service, line intrusion or operator-recall purposes.

Termination designations are marked on the copper side of the board and so are visible without detaching it from the instrument cover. This feature, in conjunction with the simple method of push-on connection used throughout the telephone (figure 11), makes for quick, positive removal and replacement of leads during maintenance.

The transmission circuit elements, including those of the optional performance

Figure 12. New induction coil (left) compared with previous design



regulator, are reduced in weight and dimensions compared with those used in previous telephone designs, adding to the shock-resistance capability of the instrument. A contribution to increased reliability is the use of capacitors of metallised-film polyester type. These are self-healing when subjected to voltage overload caused, for example, by lightning striking the telephone line pair.

Induction coil. The induction coil is of new design and owes its reduced size and weight to the high permeability of its nickel-iron alloy core. The E-shaped laminations are assembled into a moulded bobbin with six connecting tags pressed into one end cheek. The new coil and its predecessor, both of equal performance, are shown in figure 12, from which the extreme economy of design can be judged.

Cradleswitch assembly. Dust-sealed microswitches are employed instead of the conventional cradleswitch springsets and are directly attached to the board. Their operating levers are actuated by an acrylic moulded transverse bar, provided with fulcrum projections which pivot within slots in miniature metal brackets riveted to the base. Simple circular spring fasteners serve to retain the fulcrum projections in the slots, and also produce the necessary return torque for the lever assembly. The two flat cradle plungers, also of acrylic material, are a sliding fit on the transverse bar.

The mechanical advantage of the system is considerable and the contact pressures realized (30g minimum) will ensure complete reliability of operation.

Performance regulator. This device automatically provides a near-constant transmission level, irrespective of the distance from the exchange, within the prescribed line limit. When used in a Plesseyphone serving as a PABX extension instrument, it is additionally useful since the distance may assume either of two values dependent on whether current is being fed from the PABX or from the public exchange. On zero line, sending level is reduced by 6db and receiving by 4db, referred to the unregulated performance.

The regulator operates on established principles, utilizing the line d.c. current to adjust transmission level according to the line loss between the telephone and the exchange. Rectifier units are connected across the transmitter and receiver, and line current flows through a resistance bulb, applying d.c. bias to the rectifiers. The magnitude of the bias and hence the impedance of the rectifiers, varies with the line current, which in turn depends on line resistance. The shunting effect of the rectifiers thus increases as the line resistance falls, so that the sensitivity of the telephone is controlled in such a way as to compensate for the change in level with



Figure 13. Internal view of two-part handset moulding

line length. The regulating effect is increased by the resistance bulb, which has a non-linear characteristic, its effective resistance rising as the current increases, so that the rectifier bias increases more rapidly than the line current. The rectifier unit across the receiver controls both transmission and reception performance, while that across the transmitter limits transmission only. The regulating effect decreases with increasing line length, becoming almost inoperative at a line current of 50mA.

HANDSET

Moulding. The handset moulding is a



Figure 14. Handset components

composite of two parts only (figure 13), a trough-like back piece of generally rectangular section and an inner moulding which includes both the mouthpiece and earcap. The two mouldings simply clip together by means of lips at the two ends and are further secured by two sunken screws in the handle section, the resulting assembly being free from overlap or gape at the butting joints. This simple construction contrasts markedly with the four-part assembly of the conventional handset. A particular plus-point in manufacture, and in servicing, is the absence of moulded screw threads. Pleasant handling is ensured by the smooth comfortable fit of the stem section in the palm of the hand and by the low weight of the complete assembly.

The back moulding includes a network of shape-stabilizing reinforcement ribs in

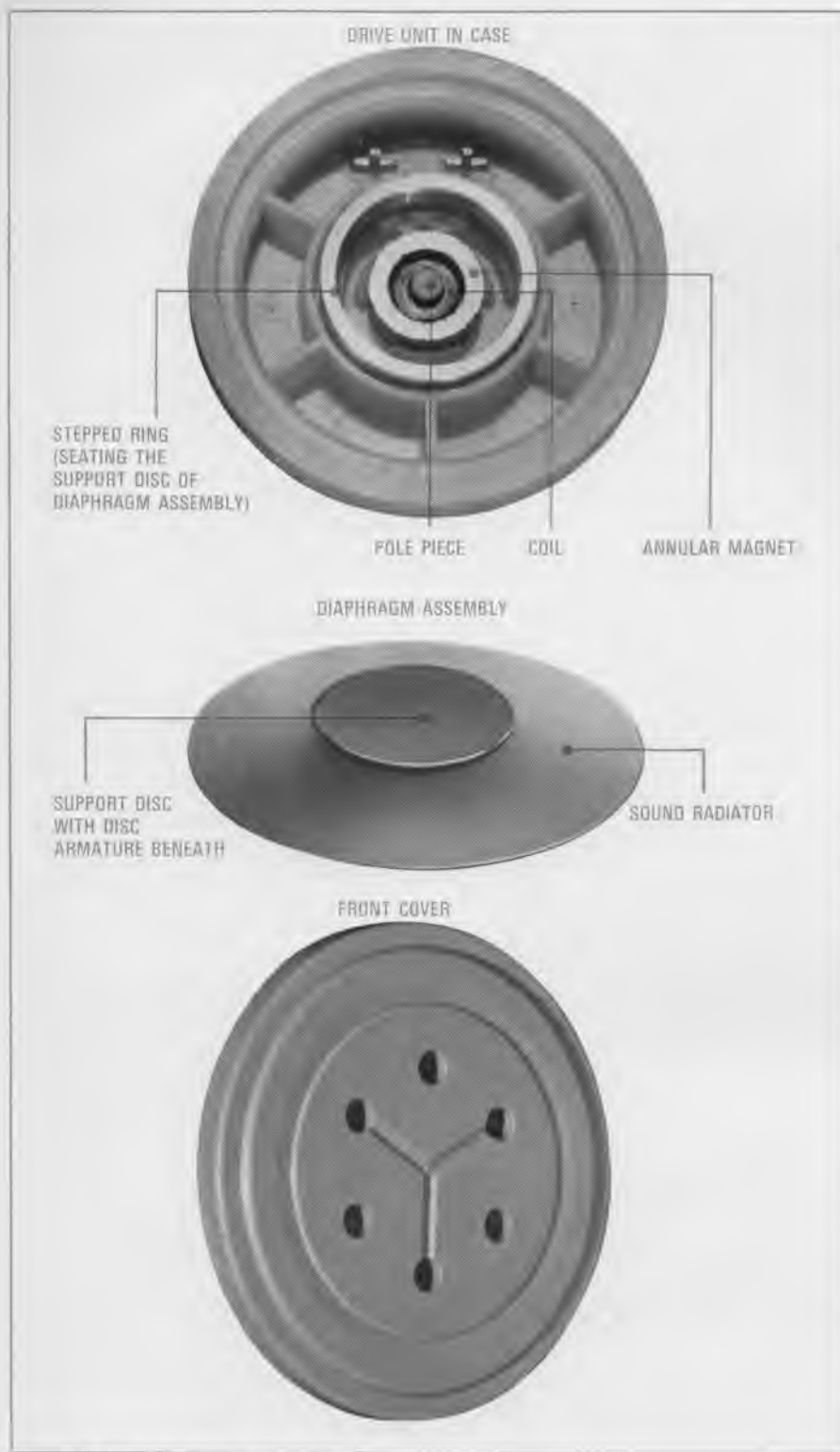


Figure 15. Capsule-receiver components

the handle section, and is also ribbed in the end cavities to provide seating for the capsules (figure 14), these are firmly retained by pressure springs under the mouthpiece and ear caps. In addition, a nest is provided for locating the helical

contact spring for the transmitter rear electrode. Cord-grip pegs are also provided in the transmitter cavity, the adjacent V cut-out is engaged by a similarly shaped projection on the inner moulding and forms the entry for the handset cord,

the leads of which rest in cut-out sections of the moulding.

The apertures in the mouthpiece and ear caps are dimensioned for optimum acoustic coupling, the louvred form of the mouthpiece aperture giving maximum protection against the insertion of sharp objects.

Relevant dimensions of the handset conform precisely with the values recommended by the CCITT for international adoption (Red Book, vol 5, 1960 p 151). **Capsule receiver.** The receiver is illustrated in figure 15 and, like the transmitter, is designed in capsule form for quick replacement. It features a single-coil drive unit sealed by the construction of its completely enclosed magnetic circuit, giving immunity from the ingress of dust and disturbance or demagnetization by external fields. In addition, the unit has a high electromechanical conversion efficiency which is converted to a similarly high overall electroacoustic efficiency by the novel form of diaphragm assembly. This comprises a concentric, cone-shaped sound radiator directly coupled to the disc armature. The latter is coaxially spot welded to a larger diameter, thinner disc of the same material which provides the required mechanical compliance. Unlike dual-purpose magnetic/acoustic diaphragms this construction requires no compromise in design, each component has a single function and attains optimum performance in terms of that function.

The coil of the driving unit is of self-bonding wire needing no former and occupies the annular space between a central cylindrical polepiece and the magnet, a parallel-sided ring. The magnetic circuit is completed at one end by the disc armature and at the other by a circular yoke, integral with the polepiece and provided with a slot for coil lead-outs. A stepped outer ring provides seating for the support disc. Owing to the concentric, single-coil construction, armature movements are purely axial and maximum useful energy is transferred to the sound diaphragm.

The case moulding of the capsule has a central form which accepts the driving unit, this being secured by the internal shape of the moulded case and by the injection of epoxy resin. A precisely metered quantity is employed and acts both as an adhesive and an encapsulant for the coil.

The sound radiator, of aluminium, sits on the periphery of the case, with the tip of the cone just clear of the disc armature, mechanical linkage is effected by a spot of epoxy resin. A plastic front cover, welded to the case, completes the assembly.

The driving unit is adjusted in manufacture by reducing the static magnetization from an initial saturation level until sensitivity and frequency response, observed

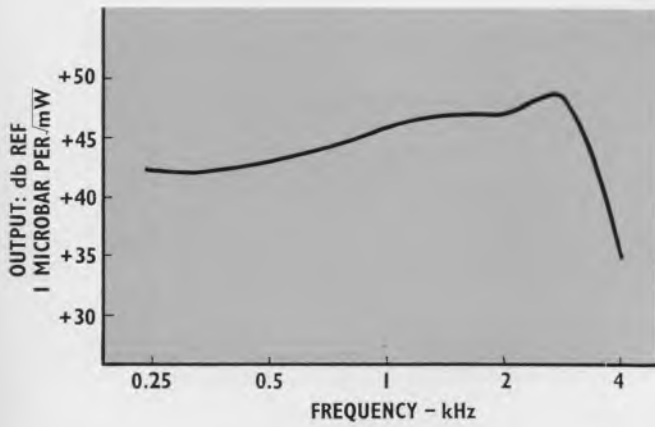


Figure 16. Frequency-response characteristic of receiver

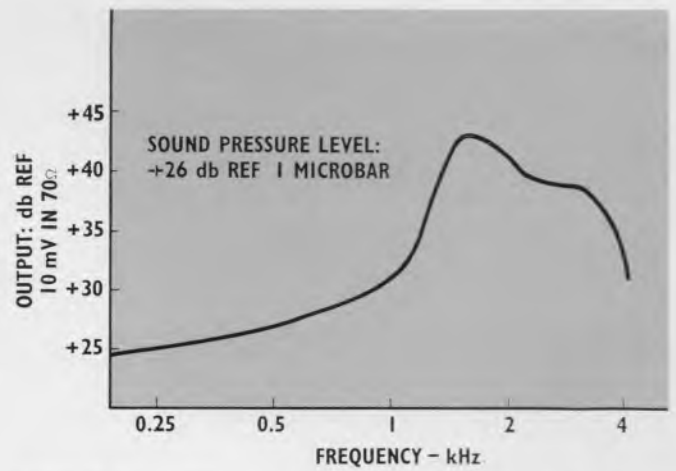


Figure 18. Frequency-response characteristic of transmitter

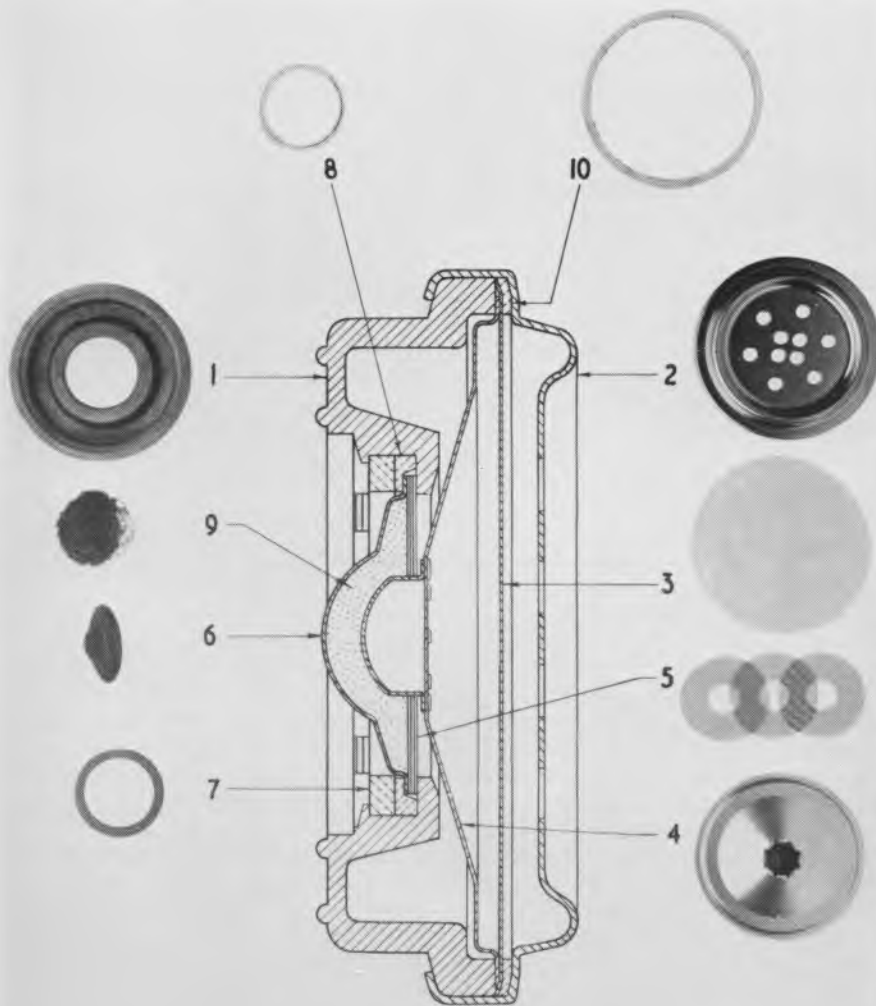


Figure 17 Transmitter components 1 Aluminium-silicon die casting, 2 Nickel-plated brass cover 3. Polypropylene membrane, 4. Aluminium alloy diaphragm with carbonized nickel electrode, 5. Rayon-cellulose woven washers, 6. Carbonized nickel rear electrode, 7 Resin-bonded fabric insulating ring, 8. Polyethylene sealing ring, 9. Carbon granules, 10. Polyethylene sealing ring

on a curve tracer, are optimum. Since the magnetic material is on the reverse part of the hysteresis loop, the final values of flux and armature gap (initially zero) are retained after removal of the unit from the adjusting rig.

The frequency-response characteristic of the receiver is shown in figure 16. The mean sensitivity in the range 300-3400Hz (measured using a driving source matched to the receiver impedance at 1000Hz and a 3cu cm artificial ear), is +46db ref 1 microbar per $\sqrt{\text{mW}}$. The receiver impedance at 1000Hz is $150\Omega \pm 25$ per cent, and the d.c. resistance is 50Ω .

Transmitter. Constructional details of the transmitter are shown in the composite photograph (figure 17). A light aluminium diaphragm carries the carbonized nickel front electrode and sits on the periphery of a die-cast, precision-machined aluminium

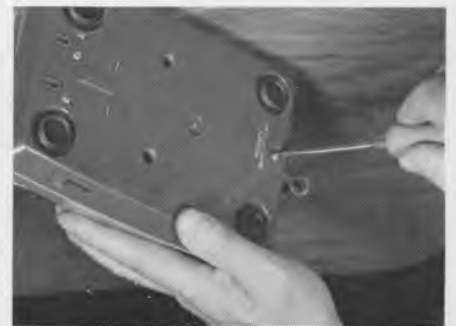


Figure 19. Simple one-screw fixing of base to instrument cover

case which houses the rayon-cellulose woven washers, carbonized-nickel rear electrode and granules. A nickel-plated brass front cover retains the diaphragm and the overlying polypropylene moisture-proof membrane.

The parameters of the diaphragm and the dimensions of its adjacent cavities are

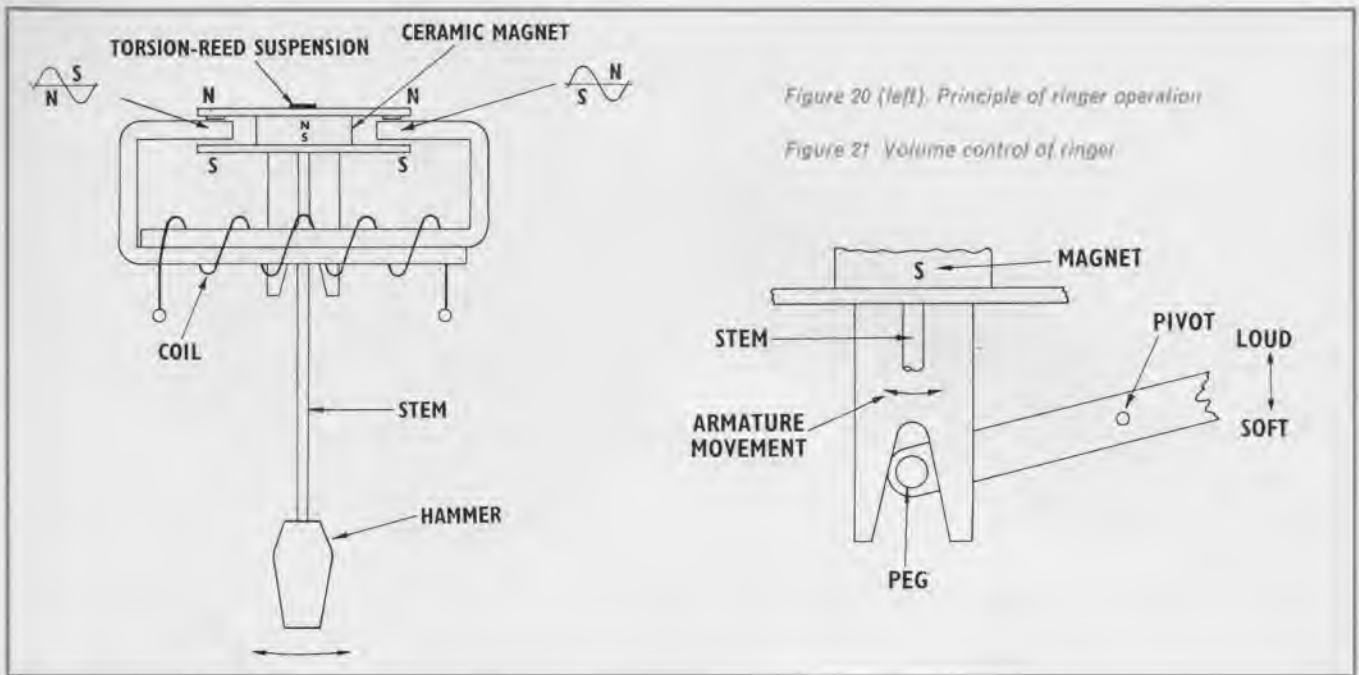


Figure 20 (left), Principle of ringer operation

Figure 21 Volume control of ringer

chosen for high sensitivity and good frequency response (figure 18).

BASE

The high-impact base is latticed with rib reinforcements and dish-shaped to provide a rigid construction. It has excellent insulating properties and, of course, does not corrode.

Slots are provided for keying the ringer mechanism directly to the base, for sound outlet, and convenient straight-out exit of the ringer volume-control lever at the side.

Moulded pillars with screw-fixing points support the two eccentrically-mounted ringer gongs. Notches, complementary to those in the instrument cover, allow passage of the line and handset cords and serve to hold them in position at the point of entry

The underside of the base includes four non-slip feet of the push-in type and two recessed screws, one for anchoring the clip-in ringer mechanism and the other for fixing the base to the cover (figure 19).

RINGER

The ringer combines simplicity of construction with a sound output which can be controlled by the subscriber according to requirements. Cost reduction is achieved by using one coil instead of the conventional two and incorporating it, together with a lightweight high-retentivity ceramic magnet, in a novel mechanism.

As shown in figure 20, the magnet, which is unaffected by shock and vibration, forms the centre of the armature, being sandwiched between two flat mild-steel plates, whose ends overlap the pole-pieces extending from the coil core. The

armature is therefore capable of limited rotary movement about its centre and this motion is converted, by a stem attached to the armature, to sideways movement of a hammer which strikes the ringer gongs.

The armature mounts on a stainless-steel torsion plate instead of conventional bearing pivots. This new suspension arrangement not only assists accurate armature location and eliminates wear, but also enables the centre-stable assembly of armature, stem and hammer assembly to be resonated at the driving current frequency to provide maximum striking force at the gongs. The mounting of the armature is such that the required air gaps between it and the pole-pieces are automatically achieved on assembly, dispensing with the need for any re-adjustment during service.

Figure 20 also shows the interaction between permanent and alternating magnetic flux which drives the armature. As the polarity of the polepieces alternates between N and S, so each polepiece attracts the S and N tips of the armature respectively, causing oscillatory rotary movement of the armature at the frequency of the driving current.

The resonant frequency of the armature assembly is 21Hz, this is sufficiently close to the two common ringing frequencies of 16½ and 25Hz to cause adequate hammer movement at both these frequencies. Since the ringer gongs have a 3:2 fundamental-frequency ratio, a pleasant purposeful note (major fifth) results on hammer impact.

Effective ringing is obtained with as little as 10V at the line terminals of the



Figure 22. Desk terminal block

telephone. From a 75V 25Hz ringing supply six ringers may be operated in series at the end of a 1000Ω line loop with a single capacitor. A single ringer at the end of a 1000Ω line, fed from a 75V a.c. generator and 900Ω ringing-feed relay develops a sound pressure level of 95 phons (+21db ref 1 microbar) in a reverberant enclosure.

The volume control allows the loudness of the ringer to be continuously varied between loud and soft (figure 21). An extension to the armature contains a triangular cutout accommodating a movable peg attached to the volume-control lever. Movement of the lever causes the peg to advance towards the base or apex of the triangle, varying the clearance (between the peg and the sides of the cut-

TABLE 2. Current-feeding systems

Battery voltage (V)	Feed-bridge resistance (Ω)	Zero-line current (mA)
48 and 50	2 x 200 2 x 250	80 to 100
50 and 60	2 x 400 2 x 500	40 to 60
24 and 35	2 x 400 2 x 500	20 to 40

out) and hence the amplitude of armature movement. The minimum loudness setting still allows sufficient movement to ensure that the ringer is not completely silenced.

DESK BLOCK

The desk block (figure 22) is designed to be as unobtrusive as possible, yet practical for the installer. Technically, it is an example of the simplified moulding possibilities of properly chosen materials, which is, in this instance, polypropylene. Base, hinge, cover and fastener are moulded in one piece. By virtue of the material properties the hinge, a thin web section, will withstand practically unlimited flexing. The same applies to the snap-on fastener, which is readily released by a screwdriver blade inserted through a slot but defeats casual tampering.

The design allows quick replacement or removal of the telephone without interfering with local wiring, the line-cord connectors being simply pushed over or withdrawn from flat tags formed in each of four terminal inserts clipped to the base. Screw terminals with captive washers are employed for the connection of incoming cabling and provision for optional facilities, such as an extension ringer, is made by wire strapping threaded through slots in the moulding and trapped under the connection tags. The base of the desk block incorporates the instrument line-cord grip and has two holes for suitable fixing screws.

CORDS

The push-connected cords fitted to the new telephone are of slim, lightweight design, affording improved flexibility, good tensile strength and durability. They are cadmium-tinsel conductor cords insulated with PVC, of a grade sufficient to ensure adequate protection against damp and the risk of marring polished furniture surfaces. Cord-lead insulation is in various identification colours.

The line cord between the telephone and desk terminal block is straight and produced with 2, 3 or 4-way leads to cover standard and extra facility require-

ments (that is, extension ringer, operator recall or shared service). The handset cord is of the soft-pull coiled type which can be extended to a maximum of 4ft (1220 mm) with minimum effort and without affecting the stability of the telephone.

TRANSMISSION PERFORMANCE

The most important characteristic of a telephone—its speech-handling capacity—is the one most difficult to specify. The following brief explanation, applying to all telephones, is included to enlarge upon the problem of assessing telephone performance and to give the background to the performance figures quoted for the Plesseyphone.

Assessment of telephone performance. Objective measurements of electro-acoustic conversion efficiency over a range of frequencies and line conditions can be made with reasonable accuracy and give some indication of performance, but are not easily equatable with the user's subjective assessment of the telephone's performance.

Subjective measurements offer an alternative assessment of performance which can give a more realistic rating to the telephone, provided the tests are conducted in such a way as to ensure accuracy and repeatability.

There are three main types of subjective measurement (1) volume, (2) articulation and (3) immediate appreciation. In volume rating the testing team balances the apparent loudness of the telephone against that of a standard reference telephone system, while articulation rating is based on the percentage of unconnected syllables correctly received. Immediate-appreciation tests rate the telephone on discrete levels of performance (for example very good, good, fair, poor and bad) based on the correct receipt of information contained in a telephone conversation.

All three methods require mathematical treatment of the results to obtain a figure of merit, but the first method—volume rating—requires less than the other two and is the only method having inter-

national recognition.

Volume-rating tests are carried out by the International Telephone and Telegraph Consultative Committee (CCITT) in their laboratories at Geneva. Sensitivities of a telephone relative to the standard system are indicated by the amount of attenuation inserted into or taken out of the standard system to equate its loudness to that of the test telephone. The results of these tests conducted by a team of testers, are known as reference equivalents, expressed in decibels (db) or decinepers and having a positive (+) sign if attenuation is added to the standard (indicating that the tested item is worse than the standard), and a negative sign if attenuation is removed (indicating better than standard). Although volume rating takes no account of articulation and is not highly accurate (± 3 db), it forms the most practicable method of measurement available at the present time.

The reference equivalents are only valid for the telephone when it is used with the exchange current-feeding system and the line defined in the measurement, although it is possible to calculate with reasonable accuracy the performance which would be achieved with other current feeds and lines. Exchange-battery feeds can be divided into three groups according to the maximum current which can be drawn from the battery. Table 2 compares battery voltage, feed-bridge resistance and maximum line current for the three groups.

The national sending and receiving reference-equivalent limits relative to the standard set by NOSFER (new European fundamental reference system) as agreed by the CCITT in June 1964 are sending, not greater than +20.8db, receiving, not greater than +12.2db.

These are positive values indicating a performance *lower* than the NOSFER standard. The combined reference equivalent (sending and receiving) is therefore $20.8 + 12.2 = 33$ db. An additional loss of 3db between international centres is allowed, making a total reference equivalent of +36db for an international call. In the national network the loss introduced between the local exchange and the international switching centre may be up to 4db for both sending and receiving, requiring the telephone instrument itself to be 4db better (in sending and receiving) than the national minimum standard.

The maximum reference equivalents allowable for a telephone instrument are therefore sending, not greater than +16.8db, receiving, not greater than +8.2db.

Plesseyphone transmission performance. The average performance (relative to the NOSFER datum) of five sample Plesseyphones submitted to the CCITT,

TABLE 3. Plesseyphone maximum line lengths at which CCITT standard is maintained

Exchange voltage and feed	Limit on 4lb/mile (0.4mm) cable			Limit on 6½lb/mile (0.5mm) cable		
	Miles	km	Ohms	Miles	km	Ohms
50V 2 x 200Ω	3.4	5.4	1500	4.8	7.7	1300
50V 2 x 400Ω	2.8	4.5	1250	4.1	6.5	1100
60V 2 x 500Ω	2.8	4.5	1250	4.1	6.5	1100
24V 2 x 400Ω	2.3	3.7	1250	3.3	5.3	900

and with the telephones connected via a 1000Ω loop comprising 3.7 miles of 6½lb/mile (5.9km or 0.5mm) cable to a 50V 2 x 200Ω feed bridge, was sending +13.0db, and receiving, +3.4db.

Comparing these results with the maximum reference equivalents quoted previously it can be seen that, under these conditions, the performance of the Plesseyphone is above the minimum standard by 3.8db for sending and 4.8db for receiving.

An alternative measure of telephone performance is the length of cable over which the CCITT standard is just maintained. Like Reference Equivalent this depends on both the gauge of the cable and the type of feed bridge. Table 3 shows the maximum lengths of 4lb/mile (0.4mm)

and 6½lb/mile (0.5mm) cable, with various battery feeds, at which the CCITT standard is maintained. A 2db allowance has been made for production tolerances.

The use of lighter-gauge cable, where the distance between the telephone and the exchange allows it, results in worthwhile savings in cable costs. Alternatively, the use of heavier-gauge cables allows the area served by an exchange to be enlarged. For example, by using 10lb/mile cable instead of 6½lb/mile (that is 0.6mm instead of 0.5mm), the 4.8 mile (7.7km) limit would be extended to 6.6 miles (10.5km).

The increased sensitivity of telephones developed during the last two decades can result in excessive volume on short lines,

as established in an investigation by Williams and Wilson (Proc IEE, 106B 1959, p 361). Apart from causing discomfort to the telephone user, excessively high signal levels can overload amplifiers and increase the risk of crosstalk. There are therefore both maximum and minimum limits on loudness, and these define a preferred range of performance. Relat-



Figure 24. Plesseyphone with prototype key plinth for extension plans

ive to NOSFER, the preferred range of combined (send-plus-receive) sensitivity is from +5db down to +25db. To keep within this range the sensitivity of the telephone requires to be reduced on short lines. Manually-preset attenuation can be introduced, but this is unsatisfactory for PBX telephones which may be connected via a short line to the PBX and a long line to the public exchange.

The attenuation introduced by the Plesseyphone regulator is dependent on line current through the telephone. Since line current is an inverse function of line resistance, the regulator automatically takes account of both length and gauge of cable. Figure 23 shows the beneficial effect of regulation on the Plesseyphone performance, with the send-plus-receive sensitivity on zero line modified to the preferred upper limit of +5db.

RELATED DEVELOPMENTS

Because telephone design is a continuous process, related developments are already in progress to expand the scope of the Plesseyphone in user facilities and application. The unit construction of the new telephone facilitates this task since modifications can be made without disturbing the telephone as a whole, typical examples being the inclusion of a simplified transmission unit for PAX installations and an in-built handset amplifier for noisy locations and hard-of-hearing subscribers. A principal project leading to other variants is the development of multi-key switching units. These will serve to provide facilities for the more complicated extension plans and will be accommodated in various add-on key plinths of the type shown in prototype form in figure 24.

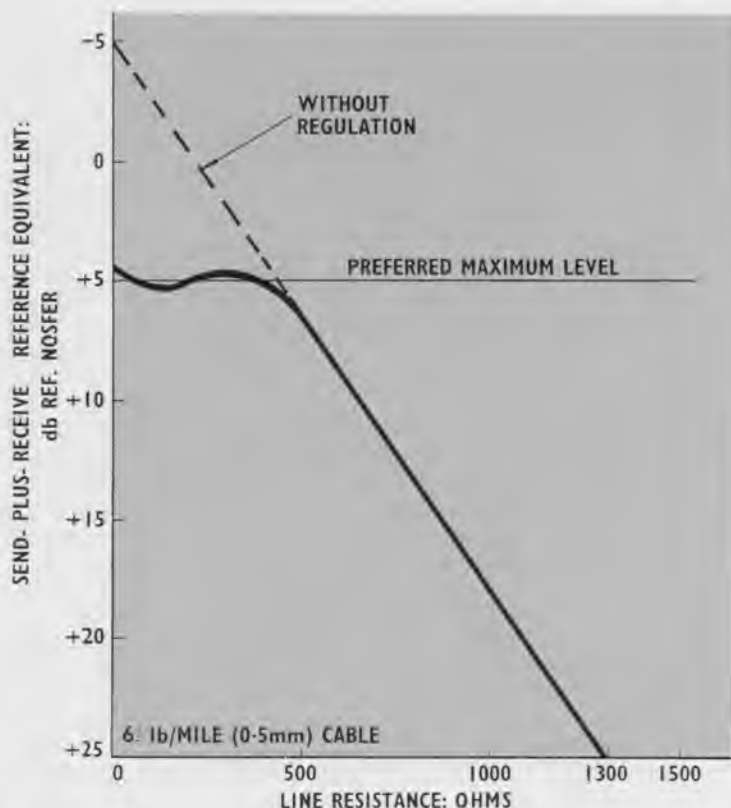


Figure 23. Regulated overall (send-plus-receive) performance