# C-0: Technology and Practice Part 1

**John Fisher considers the performance parameters of the modern C-0 in this first of a three-part series on shell technology.**

The C-0, that mere 'container' for duplicated tape, is so often neglected or deliberately ignored. The more enlightened record companies — who have discovered the marketing value of improved duplicating stock such as chrome and of techniques such as *HX Pro* and *XDR* — can be persuaded with difficulty to pay a little extra for these 'hi-tech' features. But it is much more difficult to persuade them to pay more for high quality C-0s, as most duplicators are only too aware.

The C-0 protects the tape from dust, dirt and handling. Yet the C-0 is far more than a plastic container. It provides essential mechanical elements that complement those in the tape transport. It is the vital interface between the tape and the cassette mechanism. As such it is subject to considerable environmental and handling abuses in addition to the rigours of normal operation, particularly in the car cassette and headphone portable player.

Regardless of the merits of the new tape formulations, new tape heads and improvements in mechanical performance of tape transports, the C-0 is the final arbiter of whether (and how consistently) these improvements can be realised. It affects the frequency response and phase stability achieved in the replay machine; the hum levels achieved; the wow and the flutter; the mechanical noise; the quality of the wind and the problems of jamming; the battery consumption in portable replay units; and the 'playability' of the cassette when it has been left in a car in the sun or in freezing conditions overnight. The C-0 affects the variation in performance between differing replay tape transports. It also affects the longevity of a musicassette even if the cassette appears to perform well initially, reputations suffer if it jams after a little use.

Far from being a bit of plastic to be bought in at the lowest possible cost, the good C-0 is a vital, complex and precision element in the reproduction chain. Some duplicators (and just a few record companies) are increasingly aware of this. But the importance of C-0 quality is still too often overlooked in the quest to cut costs.

## Changing attitudes

However, there are signs that this attitude may be changing. 'Clear' cassettes are becoming a marketing feature. Now while the colour or transparency are of little or no intrinsic importance in terms of performance, this heightened consciousness of the C-0 may be important in improving the general standard of C-0s used — particularly if the C-0 is suddenly seen as a selling point. Why not 'high-tech' C-0's too? And by all means let them be transparent, if that is more appealing to the purchaser and lets him see what sort of C-0 he is getting for his money.

Regardless of the CD or R-DAT, the compact cassette has great potential. Technically, there is scope for further improvements in duplicating that enable very similar quality to be offered, using established technology — at an affordable price. The number of players and recorders in the field is vast, is still rapidly rising, so the market is a sure and very important one. Moreover, though the ability of cassette recorders to record is so often seen by the industry as a drawback, this very facility and their ease of operation makes them popular — and will continue to sustain the market for pre-recorded cassettes to play in these machines. In many countries, the musicassette outsells all other forms of recordings.

It is important for duplicators, record companies and purchasers alike to be continually aware (and where necessary, to be made aware) of the considerable importance of that humble C-0 in cassette duplication. This article will examine individual areas of performance and look at one important new means for the duplicator to assess and compare C-0s.

## The interface

In measuring or assessing the performace of a particular tape, loaded into a particular housing — or in the listener's perception of the quality of a recording — there are three separate but interacting factors which affect the result: the tape, the C-0 and the replay tape transport (assuming all is well with the duplicating).

It is one thing to look for low flutter, good HF response and low frictions; another to determine precisely the contribution of each component in the C-0 to the result. Sometimes the perceived performance of two replay machines will change with the tape/housing combination used; likewise the performance of tape/housing combinations may change ranking with the mechanism used for replay.

The domestic user can choose the best tape/cassette combination to record on *his* machine. The problem for the duplicator is to choose a tape that optimises electromagnetic parameters and a housing that performs well with that tapes on *all* replay machines.

For instance, the duplicator will have gone to great lengths to ensure, with the aid of open-reel standard test tapes, that the azimuth of the heads on the duplicator slaves is accurately set and therefore that the recorded azimuth on duplicated pancakes is accurate. But the *effective* azimuth may alter when used in any particular cassette housing, due to the effects of the C-0 itself in conjunction with the multitude of different


**Fig 1: Elements in the lower part of a compact cassette**

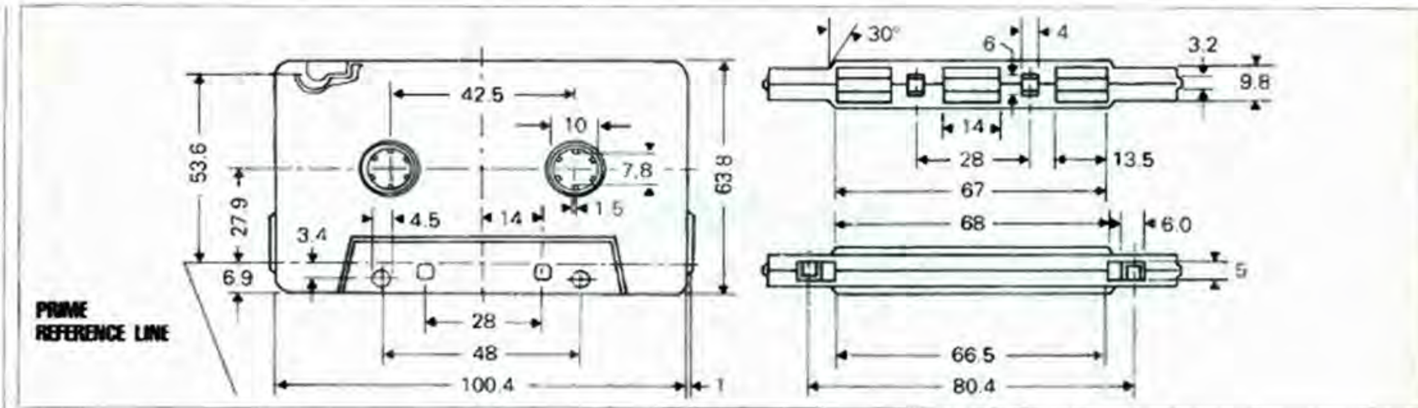


**Fig 2: Key measurements for C-0 performance**

transports that may be used.

Many of the causes of azimuth errors are also interrelated with causes of other performance errors. So before looking at ways of comparing C-0s in quasi-standardised transports, it is worth looking at the individual problem areas within the cassette housing itself (**Fig 1**).

## Components of the C-0

***Cassette shell.*** Most of the important dimensions of the compact cassette are defined in IEC94. Errors in these dimensions (**Fig 2**) can have a significant effect both on the performance of the finished cassette and its reliable handling. It is important therefore that the chosen C-0 conforms to specified dimensions as well as exhibiting other good qualities; this can affect the thickness of the plastics used in certain critical dimensions.

Dimensional errors can cause errors in the positioning of the cassette in the mechanism. They can also affect the ease of loading and unloading. The body of the cassette provides the reference plane for all critical dimensions and component positioning; it must therefore be very flat. There must be adequate stiffness and no localised shrinkage around areas of thicker plastic, such as at the point where fixed guides or other elements at right angles to the shell are joined to the shell.

For consistency in performance, the C-0 shell needs to be rigid and to sit firmly on the support points of the tape transport. Tilting of the cassette caused by dimensional errors at the support point (**Fig 3**) or twisting, will result in errors in the tape's path across the head; the cassette must be accurately dimensional within the specified area (**Fig 39**).

IEC94 allows a significant tolerance over the main support plane of the cassette shell and for the raised section around the head area; to minimise the effects of consequently tilting due to variations in tolerance between these two areas, the tolerance in the separation of these two planes should not exceed 0.1mm and should preferably be half that figure. Although recent recorder designs minimise the effects of such tolerances, cassettes must be capable of playing correctly in older transport designs.

The housing must not be weakened by the window: large, thick windows (or clear shells) may be preferable to small, flimsy ones.

Cassettes may be subject to wide temperature extremes when left in a car parked in the sun or in freezing conditions overnight: therefore the plastic of the housing must be dimensionally very stable over a wide temperature range and for prolonged periods. For example, for its own consumer cassettes BASF specifies tolerance of a temperature of +84°C for 24 hours.

Whether a cassette shell is screwed or welded is less important than whether it is well designed, well made and well assembled. Screwed designs, using five-point fastening, have the advantage that they can be opened in the event of the cassette being damaged or jamming; they can also be very rigid. A well made, sonically-welded shell can be equally rigid if the shell is correctly assembled prior to welding and if the weld is carried out evenly there may be less likelihood of distortion of the C-0.

In choosing between C-0s, it is worth bearing in mind that many blind people use the screw heads (or dummy screw heads, in the case of some welded designs), to identify which side is which — a small but invaluable feature for those so handicapped.

***Guide rollers.*** The guide rollers at the front corners of the C-0 play a very important role in the correct functioning of the cassette, affecting azimuth accuracy and azimuth/phase stability, flutter, winding characteristics and tape damage. Consequently, the guide rollers need to be precision made and accurately positioned.

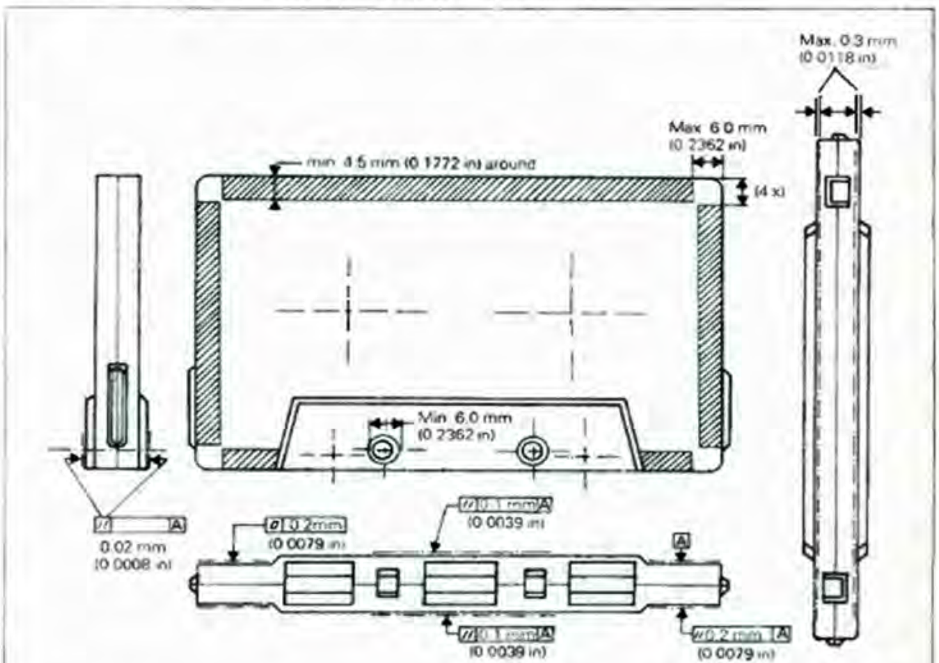


**Fig 3: Cassette support planes: the hatched areas must be parallel and provide the reference planes for critical components in the C-0**

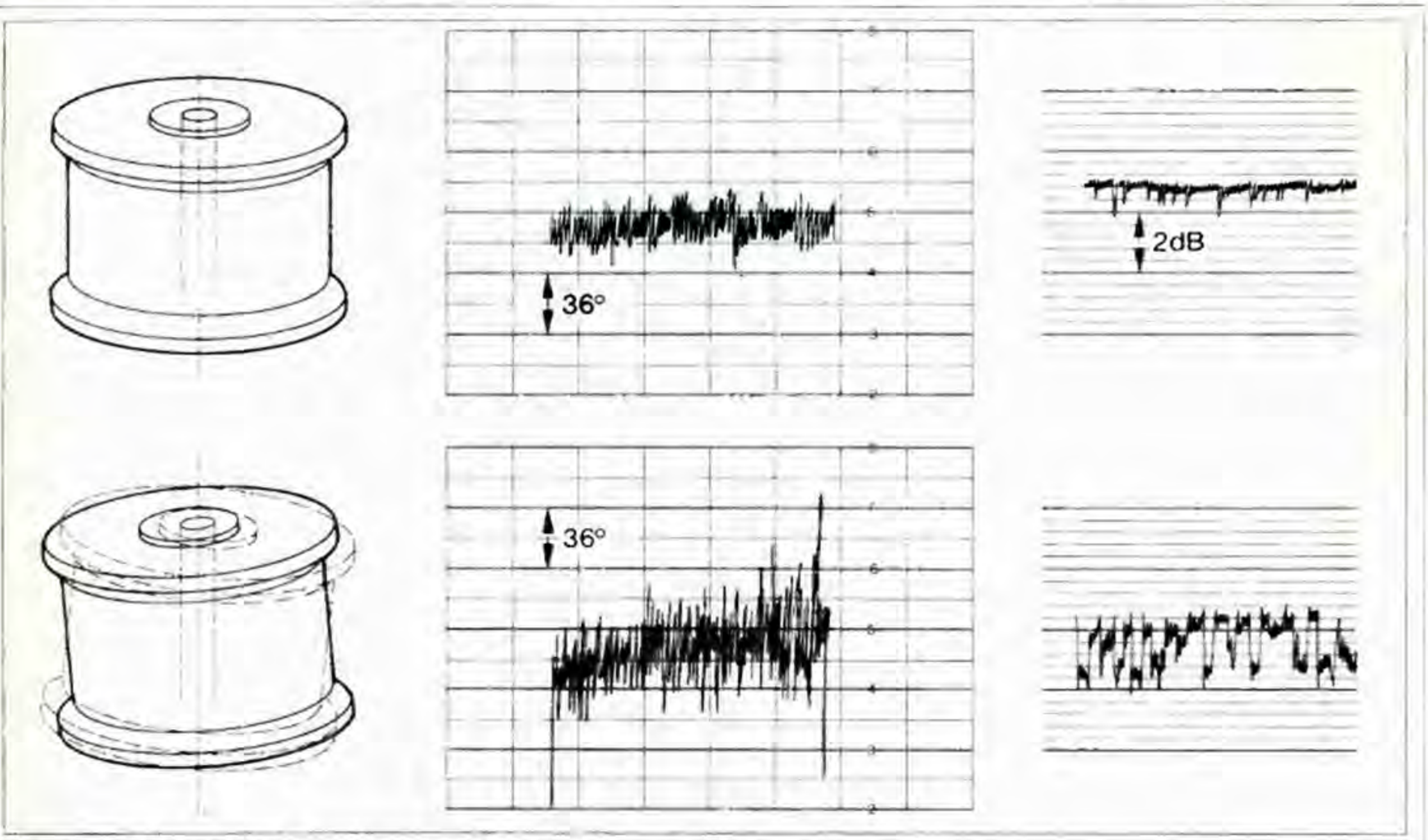


**Fig 4: Influence of different rollers on phase and level uniformity — replay 10 kHz**

Guide rollers must run true, be round and run concentric with their axles; eccentricity can be significant problem with cheap rollers, causing short-term azimuth fluctuation and in extreme cases contributing to wow. Total eccentricity should be less than 0.04 to 0.05 mm.

To avoid HF loss and phase jitter, the axles and bearings should be accurate to better than .015mm and must remain at right angles to the shell and tape path, regardless of tape tension. True running must be maintained during fast wind at rotational speeds of 100 rps, without wear.

Rollers must be cylindrical across their faces between the flanges, not tapered or barrelled, to avoid distorting the tape, bad running and azimuth problems. Coincity, or difference in diameter between the two ends of the contact surface of the roller, should not exceed about 0.03mm. There must be no moulding seams within the area that contacts the tape, nor moulding 'pips' in the flanges; either can cause tape damage and cyclical speed variations.

Roundness and true running will be affected by the method of construction of the rollers — solid, spoked, symmetrical or asymmetrical — as well as by the plastic material and method of production: how they are made is less important than good, reliable results in practice. While solid rollers are less prone to the distortions introduced by spoked construction, they may suffer from uneven shrinkage of the thicker plastic material and may consequently vary in performance more than spoked types.

The accuracy, profile and spacing of the flanges affects weave and edge damage to the tape, and hence both effective azimuth and head contact. Flanges should be correctly spaced, to guide the tape without intruding into the tape path and distorting it. Wobble, angular play and excessive vertical play of the roller on the axle contribute to bad winding, mechanical noise during wind, tape damage and phase instability **(Fig 4)**. However, some perceptible vertical play of the roller on the axle is necessary in order to allow the roller to move up or down enough to allow correction of the tape path if there is a small error in the seating of the cassette. This allows the tape to run between the flanges without their intruding into the tape path.

The axles on which the roller guides run must be exactly at right angles to the shell, to avoid introducing deflection of the tape path. Rollers with metal axles are frequently regarded as being more accurate than rollers with plastic axles. However recent BASF research suggests that accurately moulded 2 mm diameter plastic axles, in a suitably stable shell material, can give more accurate running than 1 mm steel pins. Because of the greater stability of the plastic axles with regard to the shell, the perpendicularity can be better than with metal pins and the influence of the axle on the tape path is reduced; provided the right materials are used for both the axles and roller, there need be no increase in friction and no stiction.

As with all the plastic elements, temperatures stability of the plastics used must be good to ensure smooth running.

In some cassettes, roller A **(Fig 5)** is replaced by a fixed post or skid guide; because of the long wrap, this may add substantially to the friction and stiction — and therefore flutter — but is a cheap solution to avoiding the errors caused by eccentric or badly moulded rollers, provided the skid itself is very accurately moulded.

Bad rollers (or bad skids) will repeatedly distort the tape, causing damage and inferior performance.

***Pin and stay guides.*** The two moulded plastic pin guides on either side of the replay or record/play head **(Fig 5, H, L)** have been found to have the most influence on replay azimuth. The guide pins, usually moulded plastic but sometimes inserted metal pins, need to be perfectly cylindrical and must not taper or bulge. They must be exactly at right angles to the C-0 housing, as any error in azimuth or zenith of these pins causes an azimuth error **(Fig 6)**; deflection of the pin, measured across the width of the tape path, should be less than 0.015 mm.

There is also some influence on azimuth due to the stay guides B, F, M and N; their zenith have a lesser effect on the accuracy of the tape path and a deflection of up to 0.025 mm across the tape width is acceptable.

In addition, all these guides may introduce ►

friction and stiction with the chosen tape, affecting flutter and smooth winding, and their behaviour will depend on the shell material used. Badly moulded guides may damage the surface or edge of the tape and accumulate oxide. Surface damage and the build up of oxide around the tape path may cause dropouts and HF loss; edge damage may cause flutter, dropout on one channel (left) and ultimately jamming due to poor bad winding.

***Foils.*** The thin plastic foils that line the C-0 prevent the tape rubbing on the plastic housing of the cassette shell and can contribute to smooth, jam-free running.

Foil design varies: they may be flat, dished or shaped, or embossed. Generally the flatter foils give lower flutter, while the more strongly shaped foils give enhanced tape guidance during fast loading, but at the expense of flutter. The form of the foil also contributes to runnning noise: flat foils tend to result in a noisy wind, since the hub on which the tape winds is more free to move up and down. The worst case is where the shape of the foil differs in the two halves of the C-0, due either to production tolerances or the effect of temperature fluctuations. This can contribute to bad winding.

Foils may have a lubricated coating to ensure low friction and good winding, and some conductive coatings may help reduce the build-up of static. The worst types of foil may offer none of these qualities, may warp with temperature change and contribute to bad running.

***Hubs.*** The tape is wound on 22 mm diameter hubs and builds up to a diameter of over 50 mm. Hubs should have about 1 mm of play within the housing to allow their correct seating on the winding centres of the take-up and rewind drives. The hubs must be truly round and accurately concentric to minimise wow, offer low friction in contact with the C-0 shell, and provide good anchorage for the tape with no wow-inducing bulge at the anchor point. Over-large apertures at the centre of the hubs may result in sloppy winding; undersize apertures may cause difficulty in insertion and consequent distortion of the cassette.

Hubs generally have little effect on azimuth, but badly moulded hubs can contribute to wow & flutter, and to noise during fast winding.

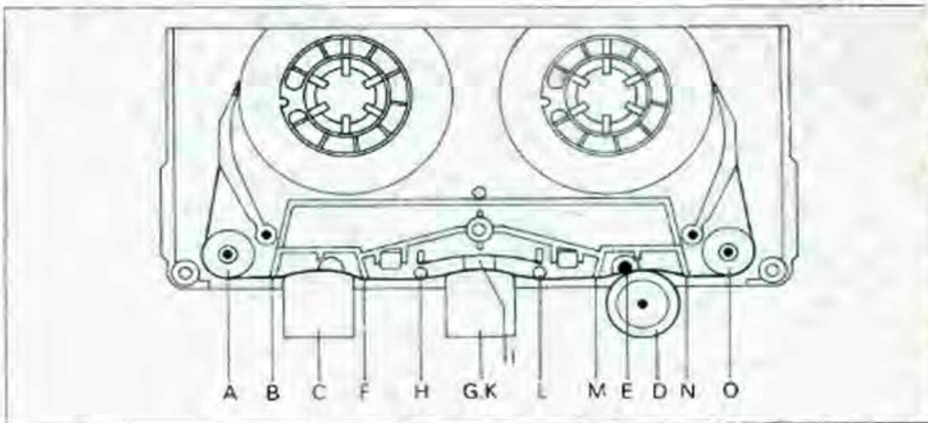


**Fig 5: Tape path and C-0 components. A = left roller and axle; B/F = left stay guides; C = erase head; D = pinch wheel; E = capstan; G/K = record/play head(s); H/L = pin guides; I = pressure pad and spring; M/N = right stay guides; O = right roller and axle.**

***Other guidance devices.*** Certain cassettes, notably those from BASF, carry additional guidance mechanisms to those specified in IEC94. In the case of the BASF Security Mechanism (SM), they take the form of moulded plastic devices (tusks) to control the tape wind and guide it from hub to guide-roller and back again (**Fig 5**); the aim is a better wind and tape handling.

Some additional slight friction is induced by SM, but the effect is generally negligible (except possibly with very low power battery equipment) and it is claimed that the benefits outweigh this slight disadvantage. Such devices have not been widely used in C-0s for bulk-duplicated cassettes, presumably on cost grounds.

***Pressure pads.*** The pressure pad must extend across the full width of the tape and overlap on both sides, to ensure even pressure and reliable head contact. The pad must be long enough to press on both gaps of a dual record-and-play head; older-style 3 mm pads are inadequate for modern high quality machines.

The pad is usually of special close-textured felt, about 5×6 mm, mounted on a berryllium bronze spring. Sometimes the pad is of foam plastic and the spring of plastic: neither are generally very satisfactory except on grounds of price. Felt pads must be free from projecting fibres, foam pads must not exhibit a tendency to stiction. The spring should be non-magnetic, wide enough to provide a stable mounting for the pressure pad.

Excessive pressure from the spring will cause excessive friction/striction and poor flutter performance. Too little pressure results in unreliable head contact. With the pad in contact with the head, a force of 0.5 to 1.5 g/mm$^2$ is specified.

Though the effect of the pad and spring on azimuth is less than that of the guide pins on either side of the head, it does influence the tape path as well as head contact, and needs to be accurately positioned. Incidentally, the effects of bad pads on azimuth and head contact are less apparent on double-capstan replay machines than on single capstan types — a point to remember with regard to quality check machines.

***Screen.*** Behind the pressure pad is a screen to protect the replay head from magnetic radiation and provide some electrostatic screening. A good screen will provide 15 to 20 dB of mains hum reduction, a poor screen is only cosmetic.

Part two will examine the C-0 and azimuth, with details of the new BASF azimuth *Template Cassette.*

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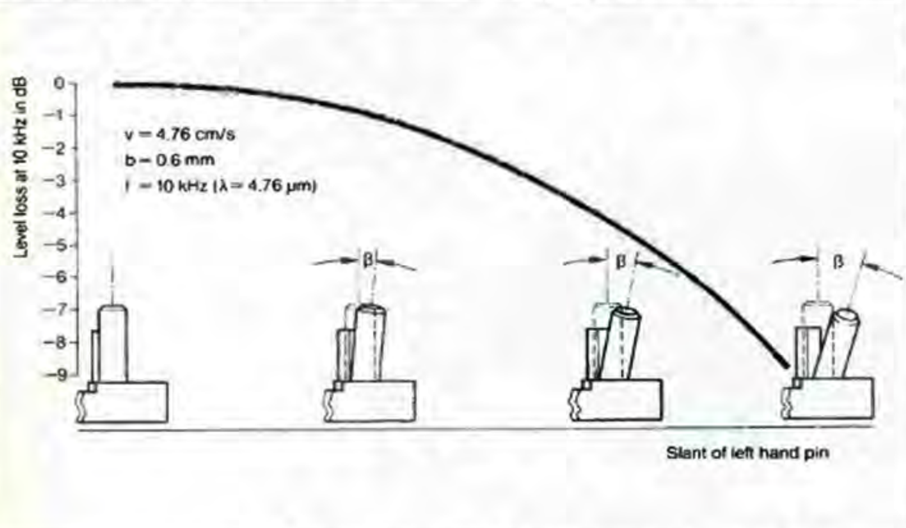


**Fig 6: Relationship between the deviation of the lefthand pin from the vertical position (angle of error β enlarged approx 10 times) and the loss in level at 10 kHz in dB.**