An Acoustical Problem

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I have recently been helping a colleague, Roger Blench, with organological research and we conducted an experiment the other day, the results of which have foxed us so badly that we would welcome any explanation that anyone can produce.

As is well known, a reed-blown cylindrical tube produces a pitch close to that of a stopped flute of the same length and overblows odd-numbered harmonics (3rd, 5th, 7th, etc, starting with the one that is a twelfth above the fundamental), whereas a reed-blown conical tube produces a fundamental pitch most of an octave higher (the precise difference, due to the theoretical completion of the cone, is not, so far as we know, relevant to this problem) and overblows all the harmonics,. starting with the one an octave above the fundamental. In this context, reed-blown covers double reeds, as on the oboe, single reeds, as on the clarinet, and the human lips, as on trumpets; so far as we know, nobody has experimented with free reeds, as used on mouthorgans and on pipes with fingerholes in Malaysia, in this connexion as yet. The principles of this behaviour were established by James MacGillivray in a paper read to the Joint Congress of the International Association of Music Libraries and the Galpin Society at Cambridge in 1959, arid published in *Music Libraries and Instruments* (Hinrichsen, 1961).

We had been discussing instruments such as the hose-pipe trumpet, an instrument commonly used by lecturers to show how easily one can make a trumpet, and we started wondering how and why a seven foot length of cylindrical hose-pipe would produce the same pitches as a seven foot classical trumpet, which is partly cylindrical and partly conical, and why a four foot six length of cylindrical hose-pipe produced the same pitches as a four foot six conical bugle. We wondered whether the generally accepted idea, that the human lips exercise greater control than a reed, was true. As a result, we conducted some experiments and we have found that this generally accepted idea is not true.

Up to a certain length of tubing, the theory holds good in practice, but after a certain point it no longer does so. We have not yet established the precise points, which depend upon the bore:length ratio, but our results so far are as follows.

With a tube 7 mm in diameter, which just accepts an oboe staple, a tube 28.7cm long behaves as expected (conical tubes overblow octaves, cylindrical tubes overblow twelfths). With a tube (all tubes henceforth are cylindrical) 72cm long, a cylindrical tube behaves as though it were conical, when blown with the same oboe reed. At this gauge it was too narrow to blow by any other means. With a hose-pipe about 2cm in diameter, a length 78cm long behaves as a cylindrical tube whether it is driven by a clarinet mouthpiece or the player's lips. A l14cm length of the same hose-pipe behaves as a conical tube, whether it is clarinetted or trumpeted. With an aluminium tube 2 cm in diameter, a 48cm length behaves as though it were cylindrical; with a 2.5cm diameter aluminium tube, a 205cm length behaves as though it were conical. With a length of cylindrical plastic drain-pipe 3cm in diameter, a 120cm length behaves as though it were cylindrical, a 225cm length behaves as though it were conical. These rather random lengths and diameters are simply the bits of tubing that I had around the house; obviously we need to cut off bits, a cm or less at a bite, to see at what point for each bore diameter the change-over in acoustical behaviour comes; if possible we ought to try to construct long conical tubes to see whether anything even funnier happens (though the existence of bassoons and pre-tuning-slide horns suggests that they behave as expected). The question we ask you is: Why do long cylindrical tubes behave as though they were conical? A few other questions arise, too. Why do all these tubes, when struck with a flat hand on the end (ie as stamping-tubes), produce the same pitch as when they are blown? I.e., is a stamping tube an aerophone and not an idiophone?

Why do the aluminium tubes we used, when struck as though they were tubular bells, produce the same pitch as when they are blown? I.e. is a tubular bell an aerophone and not an idiophone?

Another that occurs to me only as I write, is how do the Leblanc great-bass clarinets behave? My memory, admittedly from a long time ago since I blew one, is that their bore:length ratio should make them, according to these experiments, overblow octaves and not twelfths; do they? And if not, why not?

We do not particularly like upsetting accepted acoustical theory; if you can prove us wrong, please do so, and if you can't, please tell us why this is happening.