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Scaling Limitations

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Although pipes have been found to follow a fairly predictable pattern of behavior over a wide range of conditions, there are some conditions where the rules for the majority of pipes no longer apply.

It is the purpose of this article to point out these exceptions.

In small pipes (generally less than 1'' diameter) the air slit must be narrowed from 1/16'' to 1/32'' in order for these pipes to operate efficiently. Since the lip is so much closer to the source of the air stream in small pipes, such a flue reduction will guide the air precisely where it is needed.

Unlike large pipes, where reducing the flue requires increasing the pressure exponentially, no change in pressure will be required in small diameter pipes.

Although small diameter pipes are generally more efficient (capable of producing a given frequency and sound level using less air) than their larger counterparts, there are limits to this efficiency for two reasons:

First, the actual power available becomes so small, that even with a higher air to sound conversion efficiency, less sound will be produced.

Secondly, as pipes must maintain a relatively large diameter in the treble, in proportion to their length in order to operate efficiently, the scale of their mouths must be reduced.

This in itself would pose little problem, except when the mouth dimensions become progressively closer to the air slit dimensions. Practical minimum dimensions for the top pipe in a 2' stop are 1/4'' diameter with a minimum cut up of 1/20''.

The use of extremely large pipe scales at anything but high pressures also poses problems.

The main reason for this is that the scale of the mouth must be kept quite small in order for the pipe to operate efficiently. For reasons previously explained, satisfactory treble pipework could not be built for such scales at low pressures.

The pipe lengths required to produce a given note are also considerably shorter when dealing with large scale pipes with low mouth cut ups:

For example, in 1905 when George Audsley wrote *The Art of Organ Building* he knew that if the cut ups are held to 1/2'', a closed middle C pipe 1'' square would be 11-3/4'' long. A closed middle C pipe 2'' square would be only 9-3/4'' long, while a 'ridiculous' closed middle C pipe 4'' square would be a mere 5-5/8'' long, although Audsley could not explain a reason for this.

At the time of these writings, science had no satisfactory answers.

The Law of Physics which states that the wavelength of a closed pipe = 4 (L + .4d) and the wavelength of an open pipe = 2 (L + .8d) applies only to lengths of tubing without any flanges or restrictions of any kind.

The above formulas take only length and diameter into account, they make no account for such factors as the size of the mouth or ears on organ pipes.

It is now known that restricting a vibrating air column increases its inertive reactance, which causes it to vibrate at a lower frequency due to the viscous nature of air at high velocities. The formulas relating such factors are quite complicated and are beyond the scope of this article.

P.S.: For an approximation; if the diameter of a pipe is halved, its length and its cut up must be increased by 20% (approx.) to sound the same note at the same pressure and loudness as its larger scaled counterpart. □