The Playing Techniques of the Ophicleide and other Bass Horns

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1. The instruments

1.1 Nomenclature, archetypes, and construction materials

The term 'bass horn' refers to instruments of the tuba family which use tone holes to control pitch (including at least one keyed hole), but are not constructed in the 'S'-shape of the serpent. The majority of these instruments are constructed around a single 'U'- or 'V'-shaped bend, with one end connecting to the mouthpiece via a bocal, and the other connecting to or ending with an upward-pointing bell. The ophicleide has often been treated as distinct from other bass horns due to its close relationship to the keyed bugle family, but it also shares acoustic and organological similarities with many other forms of bass horn. The table below provides an overview of extant forms of bass horn, the given name(s) being determined by either their inventor or subsequent organologists.

Given name(s)	*Construction materials*		*Interfaces*	*Relative hole size*
	Body	*Bell*		
Serpent droit **(upright serpent);** ***Serpent à pavillon*****;** ***Basson russe (*****Russian bassoon, Russisches Fagott);** ***Cimbasso*** **(early);**[1] ***Serpent basson*** **(Fagott-Serpent)**	Wood	Metal (rarely wood), sometimes zoomorphic	6 holes, 1–6 keys	Small
Serpent Forveille	Metal and wood	Wood	6 holes, 3–5 keys	Small
English bass horn	Metal	Metal	6 holes, 3–4 keys	Small
Ophimonocleide	Wood (sometimes with metal tuning slide)	Metal or wood	6 holes, 1 key (for transposition)	Small
Chromatic bass horn **(early)**[2]	Wood	Metal	2 holes, 10 keys	Mixed
Serpent Coeffet	Wood	Wood	3 holes, 6 keys	Mixed
Hibernicon	Metal	Metal	8 keys	Large
Violoncell-Serpent	Wood	Wood	13 keys	Large
Tuba Dupré	Wood	Wood	6 keys	Large
Chromatic bass horn **(late);** ***Bass-Euphonium*****;**[3] ***Kontrahorn***	Wood	Metal	11 keys	Large
Serpent-Bombardon	Metal	Metal	10–11 keys	Large
Ophicleide	Metal	Metal	9–11 keys	Large

1 'Early' cimbassos refer to instruments organologically distinct from forms of valved ophicleide and valved bass trombone which have also historically and contemporarily been associated with the same name (→ TU 2.2.3).

2 'Early' chromatic bass horns refer to Gottfried Streitwolf's original 1820 design which combines finger holes with keyed holes, while 'late' chromatic bass horns refer to instruments which are associated with the same name (for example, from Gotthelf Finke (1846) and Jeremias Siering (ca. 1858)) that utilise exclusively keyed holes.

3 This form of chromatic bass horn should not be confused with the modern tuba family instrument of a similar name. At the time this instrument was invented (ca. 1855), the instrument known today as a euphonium was more commonly referred to as a 'Euphonion'.

The order of instruments in the above table is not chronological, nor does it represent any direct lineage of technical development. Nevertheless, those towards the top function in an acoustically similar manner to a serpent with keys (and are thus also commonly known as 'upright serpents'), while those towards the bottom demonstrate acoustic innovations which move themselves further away from the church serpent. For acoustic purposes, these differentiations manifest themselves primarily through relative tone hole size (→ 2.2, S 2.2). The use of tone holes covered by fingertips or keys of a similar size are designated 'small', while those covered with keys whose size is more proportional to the relative bore of the instrument are designated 'large'. 'Mixed' indicates a combination of both sizes. At the time of writing, further organological and historical data comparing these various forms of bass horn is being complied for analysis and publication.

The ophicleide is by far the most widespread form of bass horn accessible today through both large numbers of extant playable historical instruments and modern manufacturers of both replicas and new designs. As such, this guide will focus on the ophicleide, but will also include references to other bass horns where these differ significantly from either the serpent or the ophicleide. Ophicleides are described as being in C or B-flat (→ 2.1), with either 9, 10, or 11 keys (→ 1.2). The charts included here refer to an instrument in B-flat with 11 keys; for application to instruments with fewer keys (→ 1.2), ignore the columns referring to these keys. For application to instruments in C, transpose the pitches up by one tone, bearing in mind the individual resonant characteristics of each instrument (→ 2.2).

As with the serpent, all forms of bass horn feature a metal bocal connecting the mouthpiece to the instrument. Where the body or upper wing joint of the instrument is made of wood, the bocal requires a string and/or wax binding to ensure an air-tight seal; this is generally not necessary when this section of the body is constructed from metal. Similarly, metal mouthpieces—used universally with ophicleides and also sometimes with other bass horns—do not require a string binding with the bocal, although this is still necessary for mouthpieces made from wood or other natural fibres.

Upright serpents do not have a tuning slide, with physical intonation adjustment only possible through degrees of insertion of the bocal into the instrument (→ S 1.1), or in some unusual cases, through adjustment of other sections of the instrument.[4] Ophicleides with spiral-form bocals (often found with instruments in C) similarly do not have a tuning slide, whereas ophicleides with rounded rectangular bocals (more common with instruments in B-flat) do have a tuning slide built into the bocal. Upright serpents are commonly built in a modular construction, with the boot (bottom bend) of the instrument detachable from the wing joint (itself detachable from the bocal) and the bass joint (itself detachable from the bell). Other wooden bass horns (for example, chromatic bass horns) generally only have a detachable bell. Ophicleides and other all-metal bass horns are generally soldered together as one object, although some rare ophicleides have a detachable bell section.

4 Ophimonocleides have one open-standing key which can be used transpose the instrument by a semitone, and the bottom half of the instrument can slide closer or further away from the rest of the instrument as necessary to aid effectiveness of the tone holes in pitch modulation.

1.2 Form factor, and key and hole placements

While more rarely-found bass horns such as the hibernicon, serpent Coeffet and violoncell-serpent employ unique tone hole combinations with bespoke fingering patterns, most bass horns fall into one of two categories. Upright serpents, English bass horns, and other small-holed bass horns follow the same principles as the serpent with keys (S → 2.3), although the exact combination, placement, and total number of keys can vary. Ophicleides and late chromatic bass horns, meanwhile, use their own, broadly standardised keys patterns. As with the serpent, all bass horns utilise two sets of tone and/or key holes, the left hand operating the upper set (closest to the bocal, before the bottom bend), and the right hand operating the lower set (closest to the bell, near to or at the bottom bend). Keys and holes are ordered from closest to the bell to closest to the bocal.

Small-hole bass horns (upright serpent, English bass horn, etc.)	
Key/finger hole, hole position	*Hand, finger*
Key 1, either	Left, thumb; or Left, little
Hole 1, front	Left, index
Hole 2, front	Left, middle
Hole 3, front	Left, ring
Key 2, front	Right, index; or Left, little
Hole 4, front	Right, index
Hole 5, front	Right, middle
Hole 6, front	Right, ring
Key 3, either	Right, little
Key 4, rear	Right, various; or Left, thumb

Ophicleide	
Key, hole position	*Hand, finger*
Key 1, front	Left, index
Key 2, front	Left, middle
Key 3, rear	Left, thumb
Key 4, front	Left, ring
Key 5, rear	Right, thumb
Key 6, side	Right, little
Key 7, front	Right, little
Key 8, front	Right, ring
Key 9, side	Right, ring
Key 10, side	Right, middle
Key 11, front	Right, index; or Left, palm

Ophicleides with 10 keys are generally missing either Key 7 or 9, while instruments with 9 keys are missing both. Double key mechanisms are often present with 10 and 11 key instruments, whereby depressing Key 7 automatically also opens Key 6, and depressing Key 9 automatically also opens Key 8, a feature which was developed to improve resonance and intonation (→ 2.2). Upright serpents and English bass horns with fewer keys are generally missing Keys 1 and/or 2.

1.3 Practical considerations and posture

Bass horns generally do not have water keys, although rarer models feature one built into the bocal. As such, in a similar manner to the serpent, care is required in order to avoid excessive build-up of moisture (→ S 1.2). This is especially true for those made of wood, which are also generally more fragile than their metal counterparts. Modular instruments use friction-fitted joints (sometimes with additional bindings), and so must be handled with care to avoid misalignment or disassembly.

All bass horns can be played both while seated and standing. Most instruments feature some form of supports mounted to the body for each hand (commonly allocated to the web of each thumb) and/or hooks for attaching to a harness system (those used with bassoons or baritone saxophones can often be adapted for use with an ophicleide or upright serpent). Many performers employ these harnesses while both seated and standing in order to minimise pressure on the hands in supporting the weight of the instrument while also overcoming some of the ergonomic limitations resulting from compromised tone-hole positioning.

2. Resonant characteristics and acoustic properties

2.1 Resonant frequencies and spectral components

Ophicleides are described as being in 8-ft C or 9-ft B-flat due to their fundamental pitches with no keys depressed being C2 and B-flat 1 respectively.[5] However, in order to produce a more resonant timbre, Key 1 is an open-standing key, and so when this key depressed and thus the full resonant length of the instrument is employed, the pitch is lowered by a semitone to B1 and A1 respectively (→ 2.4).[6] Upright serpents and English bass horns have a nominal resonant length of 8-ft C, however the lowest fundamental (with all holes closed) tends to be significantly flat (→ 2.3). Bass horns built to a modern pitch standard can also generally be used at lower pitches (for example, A=430Hz) by partially removing the bocal from the instrument (and, where available, extending the tuning slide), although this exacerbates the inconsistencies in intonation found between the employment of different tone holes (→ 2.2).

The purely conical bore of the ophicleide and minimal bell flare results in a similar cooperative regime of oscillation as found with the serpent (with resonant characteristics varying by individual instrument), although optimised size and placement of tone holes enables full functionality up to the fifth harmonic, with production of overtones generally possible up to the ninth harmonic.[7] Chart 1 presents the spectral content created by an ophicleide approximated to equally-tempered pitches to the nearest quarter-tone. A blank space indicates that there is no significant pitch difference (more than a quarter-tone) from the preceding hole combination, while additional numbers (for example, +2) indicate that extra key(s) need to be vented (→2.2) for production of this harmonic.

Upright serpents produce similar spectral content to that of a serpent with three keys (→ S Chart 1b). The narrower bore profile can result in higher overtones being harder to control with the lips than on the serpent (often limited to the fifth or sixth harmonic), while some instruments feature neighbouring holes bored into differing or occasionally multiple resonance pathways and/or extra keys in order to improve resonance and intonation in the lower register (→ 2.2, 2.3).

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5 Much more rarely found forms of the ophicleide are the quinticlave in 6.5-ft E-flat or 6-ft F, and the contrabass ophicleide in 13-ft E-flat or 12-ft F.

6 Some rarer forms of bass horn such as the chromatic bass horn, violoncell-serpent, and bass-euphonium extend this principle further, featuring two open-standing keys which can lower the fundamental pitch by one semitone each.

7 Some instrument and mouthpiece combinations enable production of additional overtones up to the twelfth harmonic, although these are very unstable and require extreme embouchure pressure (→ TU 5.3).

2.2 Tone hole acoustics

Ophicleide tone holes increase proportionally in size with the bore of the instrument, and thus have a significantly greater acoustic effect than the tone holes (both finger and key) on serpents (→ S 2.2). Key mechanisms also allow for placement of tone holes at acoustically optimised positions along the instrument's complete tube length rather than being limited to the distance between fingers. However, owing to their wide variety of sizes, the keys vary in their effectiveness at controlling both resonance and intonation. The smallest tone holes have the shortest resonant lengths and thus require significant control with lip musculature (→ 3.1), while the largest tone holes result in very limited pitch flexibility. Intonation is therefore most stable towards the middle of the instrument, with pitches requiring the largest holes and smallest holes tending to sound sharper and flatter than their theoretical spectral positions respectively. This differentiation is exaggerated when the overall tube length is extended to allow for employment at lower pitch standards.

Ophicleide performance practice involves a technique known as 'venting' (commonly found in woodwind performance practice), whereby extra tone holes are opened in addition to those required for pitch production (in some cases produced automatically through double-key mechanisms (→ 1.2)). While Chart 1 demonstrates that, as with the serpent, spectral possibilities are generally weakened (and/or deviate further from equally-tempered pitches) as more holes are opened, this technique can be helpful in both enabling greater resonance and allowing more flexibility in intonation. Chart 2a combines the spectral content shown in Chart 1 with venting and the other techniques and technologies detailed below to create a practical chromatic fingering chart for an ophicleide in B-flat with 11 keys. Chart 2b similarly refers to an ophicleide in C with 10 keys (in this case, missing Key 7). As with the serpent, these charts are to be used as guides only; the key combination chosen will always depend to an extent on the individual instrument (→ 2.1), and the relative strength of the embouchure (→ 3.1, 3.2).

Upright serpents and English bass horns use chromatic fingering charts analogous to those used for a serpent with three keys (→ S Chart 2a), albeit with more variety in key combinations depending on the model (→ 2.3). On some upright serpents, ophimonocleides, and serpents Forveille, holes 4, 5, and/or 6 are often reversed, having been bored into the ascending rather than descending resonance pathway (or occasionally both) in order to extend the resultant acoustic distance between the holes. This leads the right-hand fingers to have different acoustic effects; for example, the index finger might now control hole 6. While the generally narrower bore of upright serpents means that relatively small tone holes (open and keyed) do have more of an acoustic effect that with S-shaped serpents, their effect is nevertheless considerably less than that resulting from the keyed tone holes of ophicleides or other bass horns with proportionally larger tone holes.

2.3 Keys

As with serpent, ophicleide keys are closed-standing (→ S 2.4), with the exception of Key 1, which is open-standing (→ 2.1). The keys are placed in positions such that can produce equally-tempered cumulative semitone displacements from the instrument's fundamental pitch. Key 1 increases the overall sounding length and therefore lowers the fundamental pitch by one semitone, while all the other keys shorten the sounding length, thereby each raising the fundamental pitch by one semitone in turn, as illustrated in the table below. The felt pads of ophicleide keys are covered with leather (or a synthetic substitute), while some manufacturers today use 'resonators' (commonly found on modern saxophone keys) to help adhere the leather to the pad and aid in resonance propagation.

Key 1	*No keys*	*Key 2*	*Key 3*	*Key 4*	*Key 5*	*Key 6*	*Key 7*	*Key 8*	*Key 9*	*Key 10*	*Key 11*
Ophicleide in B-flat											
A	B-flat	B	C	C-sharp	D	E-flat	E	F	F-sharp	G	A-flat
Ophicleide in C											
B	C	C-sharp	D	E-flat	E	F	F-sharp	G	A-flat	A	B-flat

Keys on upright serpents and other small-hole bass horns are also almost universally closed-standing,[8] being found generally in the same acoustic positions as on 'S'-shaped serpents with keys (→ S 2.4), but these vary according to the manufacturer. A common additional key operates a tone hole slightly beyond the sixth hole, before the C-sharp key. This is used primarily for production of the fundamental C1, as the usual hole combination for this pitch (all six holes closed) tends to be up to a semitone flat. This key can also be depressed to aid in the production of some higher harmonics, notably D2, A3, and F-sharp 4. In any case, the acoustic effect of keys on upright serpents and other small-hole bass horns should not be confused with the proportionally larger tone holes found on ophicleides and other larger-holed bass horns (→ 2.2).

2.4 Dynamic and timbre

The generally narrower bore of bass horns means that, while producing more secure intonation, they cannot produce the same extremely rich fundamental resonance that defines the timbre of the serpent.[9] However, their timbre is still notably 'darker' than that found with modern labrosones due to the lack of any cylindrical tubing (excluding the tuning slide found on some ophicleides in B-flat (→ 1.1)). The dynamic range of the ophicleide is objectively louder than that of the serpent (→ S 2.5), with a stronger resonance that is less reliant on room acoustics (B-flat ophicleides generally produce a slightly louder and 'brighter' sound than C ophicleides owing to their larger resonant chamber and wider minimum bore), particularly when fewer keys are depressed. Nevertheless, the maximum dynamic level is still objectively quieter than what is possible with modern labrosones, and extreme dynamic effects such as non-linear sound propagation are not possible. Chart 3 illustrates the subjective maximum and minimum volume levels possible with an ophicleide at various pitches alongside their respective longest possible durations in a single breath. Upright serpents and English bass horns have similar dynamic curves to a serpent, while models of bass horn with more acoustically optimised tone holes (→ 2.2) can produce levels of spectral enrichment closer to those produced by an ophicleide.

8 A notable exceptions is the transposition key of the ophimonocleide (→ 1.1).

9 The violoncell-serpent was perhaps the most overt attempt by a bass horn manufacturer to maintain the serpent's timbral characteristics while simultaneously improving intonation and ergonomics.

Ophicleide mouthpieces are funnel shaped, while bass horn mouthpieces tend to have a rounded backbore, and so both produce lip-reed sounds that are richer in fundamentals and other low spectral content that those produced using a traditional church serpent mouthpiece (→ S 2.5). As a result, the 'white noise' component of a bass horn's timbre is generally less present than with the serpent, but it is still more pronounced than with modern larosones, being notably audible at lower dynamic levels and/or when multiple tone holes are opened simultaneously (→ 3.5).

3. Sound production and articulation

3.1 Embouchure

The embouchure has a similarly important role in ophicleide lip-reed sound production as with the serpent (→ S 3.1). While the acoustically optimised key positions aid in overall intonation control (→ 2.2), the lack of any significant bell flare means that the acoustic structure of the instrument still provides minimal pitch stability relative to modern labrosones. This is especially the case when multiple keys are employed and/or the keys closer to the mouthpiece end of the instrument (Keys 9, 10, and/or 11) are opened. Upright serpents have a generally narrower bore and more significant bell flare, enabling greater 'slotting' between the embouchure and instrumental resonances, but this is still noticeably weaker than is found with modern labrosones, while the embouchure must also play a considerable role in counteracting the limited intonational capabilities of smaller tone holes. Overall, bass horn performance practice requires a comparable level of muscular support from the embouchure to the serpent, with similar resultant considerations required in terms of premature embouchure fatigue, intonation, and lip bending (→ 3.2).

3.2 Lip bending and factitious pitches

The ophicleide's chromatic key system means that modulation of lip resonance frequency does not have the same crucial role in performance practice as with the serpent. Nevertheless, the relatively weak cooperative regime of oscillation (→ 2.1) necessitates the use of lip bending for fine control of tuning, particularly to compensate for the compromised intonation control provided by the largest and smallest tone holes (→ 2.2), or when producing non-12-tone equal-temperament pitches. Chart 4 illustrates the potential lip-bending range of the spectral content in Chart 1, estimated to the nearest quarter-tone. Factitious 'pedal notes' are present an octave below the first fundamental, which can also be 'lipped' up, producing a range of B-flat 0–F2 on a B-flat ophicleide, and C1–G2 on a C ophicleide. As with the serpent, these are controlled in pitch by the lips, with key combinations primarily affecting timbre. Lip bending on upright serpents has a similar role as with 'S'-shaped serpents, although the generally narrower bore and wider flared bell mean that the overall range of potential lip bending is narrower as a result.

3.3 Legato, glissando, vibrato, and lip trills

Chart 4 illustrates that, despite lip bending being not as crucial for intonation control on the ophicleide as with the serpent, the harmonic structure of the instrument can nevertheless be significantly effected by the embouchure muscles. Legato gestures across harmonic series therefore still need to be treated with caution in ophicleide performance practice to avoid unintentional glissandos, particularly when executing rapid oscillations, when engaging keys closer to the mouthpiece end of the instrument (Keys 9, 10, and 11), and/or when involving the fundamental pitches. Lip trills (possible between adjacent fifth and sixth harmonics or higher (→ Chart 1)), glissando, and vibrato can all be otherwise executed in a similar manner to their production on the serpent (→ S 3.3).

3.4 Multiphonics, whistling, ingressive sound production, and articulation with the tongue, vocal tract, and other muscles

A similar harmonic structure to the serpent dictates that ophicleide multiphonics also rely heavily upon lip bending in determining their audible pitch content (→ 3.2), and are similarly fragile in nature, also varying significantly according to the individual instrument model and manufacturer. The acoustically-optimised key system does, however, mean that a wider variety of multiphonics are available, although the conical bore does limit these primarily to lower harmonic material, with higher multiphonics and/or those involving keys closer to the mouthpiece end of the instrument being particularly fragile in nature. The results of nascent experimentation has resulted in the work-in-progress presented in Chart 5, which (as with other labrosones) is limited by current performance and pedagogical practice as much as instrumental acoustics. Such experimentation has not yet been undertaken with upright serpents and other bass horns, although their narrower bore suggests that a greater range of higher multiphonics would be possible than with the serpent, although with less variation than found with the ophicleide.

Whistling and ingressive sound production on bass horns functions in a similar manner to production on the serpent (→ S 3.4). Articulation with the tongue, vocal tract, and other muscles also functions in a similar fashion (→ S 3.5), with the exception of slap tongue and other percussive articulations, which are considerably more differentiable in terms of pitch with an ophicleide due to the wider spacing of the tone holes.

3.5 Air noise (non-lip-reed) sound production

Air-noise production on the ophicleide and other bass horns functions in a fundamentally similar manner to production on the serpent (→ S 3.6). While the 'white noise' component to the sound is generally less prominent than with the serpent (→ 2.4), at all but the highest dynamic levels there is still a continually present air noise sound alongside lip-reed sound production, which is highly controllable when intentionally blended with or treated independently from lip-reed sound production. The acoustically-optimised positioning of ophicleide tone holes means that a wider range of pitch content is available in comparison with the serpent (and upright serpent), as listed in Chart 6 (regarding pitch content → TU 7.2.1), although this is once more only perceptible at low dynamics and without any filtration from closed formant shapes, while the perceived absolute pitch (primarily in terms of octave displacement) is broadly subjective (→ TU 9.4.2).

4. Instrumental mechanics and other options for sound generation and modulation

4.1 Key trills, tremolos, and timbral trills

The chromatic key mechanism of the ophicleide (→ 2.3) is significantly more effective in sonic modulation than the finger hole system of the serpents (both ‘S’-shaped and upright), and offers a comparable level of articulation possibilities to those provided by bodily mechanics (→ 3.1). Nevertheless, the combining factors of multiple large keys with the necessity of venting in order to produce a maximally resonant timbre (→ 2.2) limit the versatility of key articulation in comparison with valves. Trill gestures can be produced between any two neighbouring pitches in Chart 1, while timbral trills (*bisbigliando*) can be produced on any pitch with two or more possible key combinations (that is, at or above A3 on a B-flat ophicleide or B3 on a C ophicleide), although timbral modifications are likely to be more effective through modulation of the tongue and vocal tract (→ 3.4). Tremolos (oscillations over intervals larger than a semitone) work under the same limitations as with other labrosones (→ TU 10.1).

Trill gestures are limited primarily by finger musculature; possibilities for rapid oscillation of individual keys varies from easy when involving the index or middle fingers (Keys 1, 2, 10, and 11) to difficult for the thumb or little finger (Keys 3, 5, 6, and 7).[10] These gestures are then further limited depending upon how many neighbouring keys of the same hand need to be depressed or oscillated simultaneously. For example, opposing fingers can be operated fairly individually, while the ring and little fingers share a tendon and therefore are very limited in their ability to move independently. The web of the thumb of both hands is also generally used to support the instrument (→ 1.3), which can limit the strength and flexibility of the thumbs themselves in key operation.[11] Trill gestures also create a significant percussive sound, especially when involving larger (left-hand) and/or multiple keys (→ 4.2), which is particularly limiting on the use of key trills for non-lip-reed sound generation such as air noises (→ 3.5) and vocalisations (→ 4.4) unless such a percussive accompaniment is desirable.

4.2 Use of keys alone

Opening ophicleide keys creates minimal noise, as the underside of the touchpieces are covered in cork to inhibit production of a metallic sound when hitting the instrument. However, a significant noise is produced when they are released and returned to their closed positions through a leaf spring.[12] As with the considerably quieter keys of serpents (both ‘S’-shaped and upright), these sounds increase proportionally in volume when multiple keys are operated simultaneously and/or in rapid succession, and can be at least partially mitigated by a controlled, slower release, which performers will automatically strive to produce whenever practically feasible. While generally quieter than lip-reed sounds, audible key noises are unavoidable when complex, rapid finger

[10] Double-key mechanisms are also generally limited in speed by the extra force required for depression (→ 1.2).

[11] This is particularly problematic with instruments that require multiple keys to be depressed by the thumb such as most chromatic bass horns.

[12] This situation is inverted for the normally-open Key 1, although this key normally requires a joint mechanism to operate the touchpiece, creating more mechanical noise (both when depressing and releasing) than the first-class levers employed by the other key mechanisms.

movement is required alongside quiet instrumental resonances, with particularly notable implications when using microphones (→ 4.4). An exaggerated effect can also be created by ‘flicking’ a key (opening and closing a key rapidly in one gesture). Flicking or loudly closing a key without lip-reed resonance creates a pitch which is determined by the same resonant series as air noises (→ Chart 6) although unlike with lip-reed playing, pitch differentiation here requires that all previous tone holes (closer to the bell) are additionally opened. The maximum perceived mechanical dynamic, produced by trilling or flicking all keys in rapid succession, is an objective *forte*.

4.3 Use of bocal and mouthpiece alone

Bocal and mouthpiece buzzing functions on the ophicleide in a similar manner to the serpent (→ S 4.3), and the pitch range varies according to the performer and their own mouthpiece and bocal. However, the longer resonant length of the ophicleide bocal means that clear modal resonances can be produced. For example, a typical B-flat ophicleide bocal can produce a fundamental of ca. B2 and harmonics 2-5 (ca. B3, F-sharp 4, B4, and D-sharp 5 respectively), as well as a factitious F-sharp 3 between the first and second harmonics, ‘pedal’ B1 (which can also be lipped up to B2 down to G-sharp 1), and ‘double pedal’ B0. A shorter-length tube can also be resonated by removing the tuning slide found as part of some rounded rectangular bocals. With the slide removed, pitches between ca. B1–B4 can be produced, although this shorter resonant length lacks such a strong cooperative mode of oscillation, and are thus these pitches are primarily determined by lipping rather than modal resonances.

4.4 Vocalisations, other uses of the body, and external equipment

The combination of ophicleide resonances with vocalisations or any other extraneous sounds functions as with the serpent (→ S 4.4), taking into consideration the comparatively louder dynamic range and ‘brighter’ timbre of the ophicleide’s lip-reed sound (→ 2.4), as well as the metallic body of the instrument. Any requirement of microphones at close range will need to account for the mechanical sound produced by the key mechanisms (→ 4.2), which, when amplified, can dominate any air noise or lip-reed sound. Physical movement with all bass horns is generally easier than with the serpent, as they were originally designed to be played while mobile.

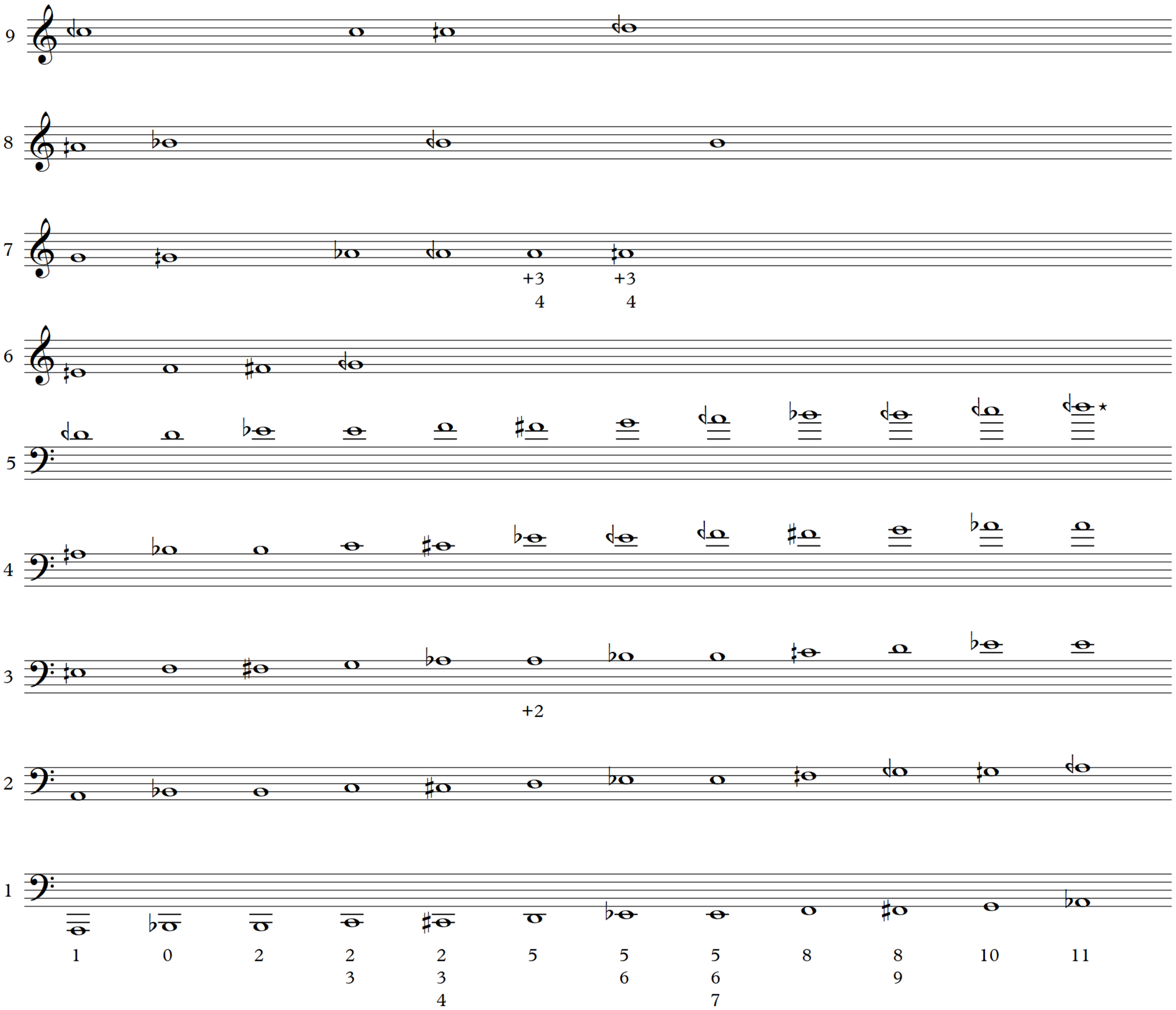
Other combinations with external equipment function in a similar manner to those with the serpent. While not as fragile or susceptible to damage by water, ophicleides still require greater levels of physical care compared with modern labrosones, as the brass used for construction is generally thinner and therefore more liable to denting or cracking. A baritone saxophone mouthpiece can create pitch material as shown in Chart 7, although further research is required into the use of reed mouthpieces with ophicleides and bass horns in order to determine the optimal mouthpiece size, as well as to develop any necessary adapters.[13]

[13] It has been argued that the saxophone was developed by Adolph Sax after he experimented with reed mouthpieces on an ophicleide, a hypothesis demanding of further historical, acoustic, and performance-practice based research.

Charts

Unless otherwise specified, charts refer to an ophicleide in B-flat with 11 keys (→ 1.1)

Chart 1: Spectral content



* Key 10 depressed in addition to Key 11 creates a C-sharp 5

Chart 2a: Chromatic fingerings (B-flat ophicleide, 11 keys)

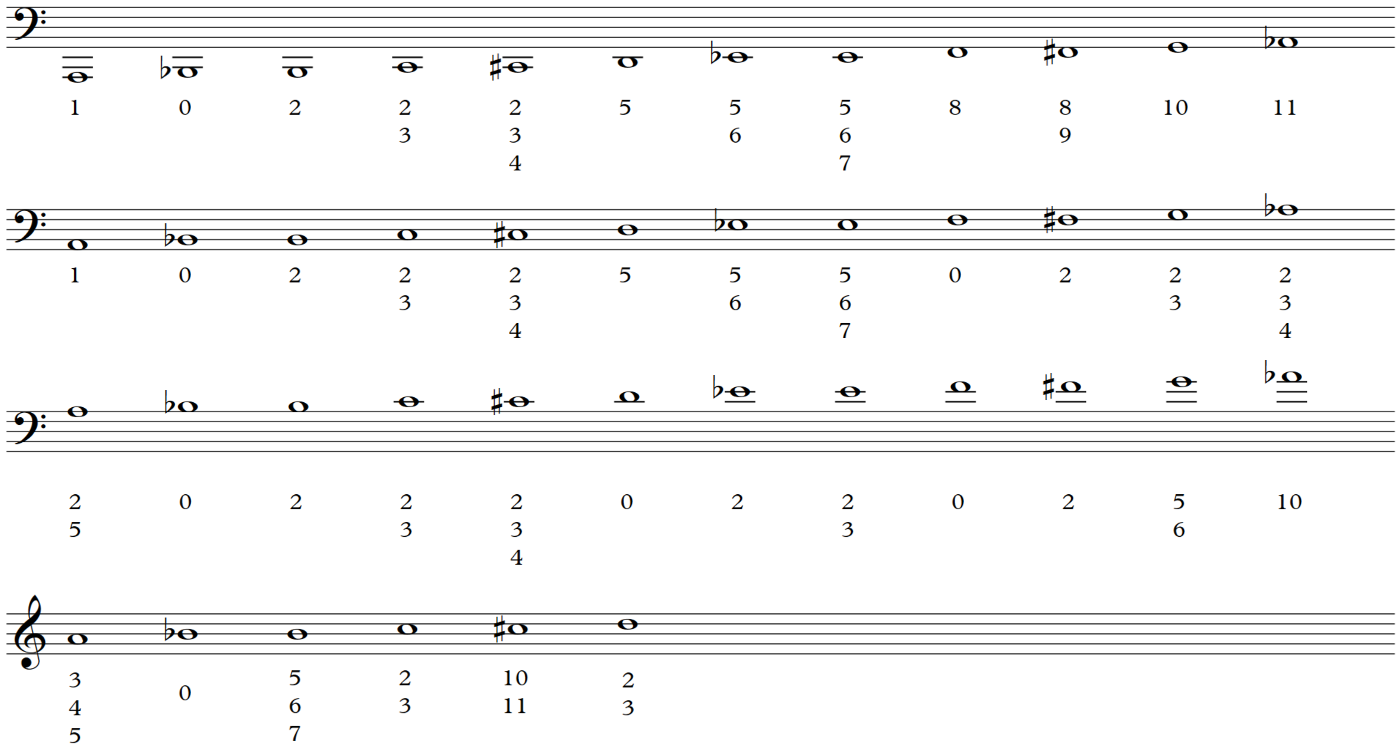


Chart 2b: Chromatic fingerings (C ophicleide, 10 keys)

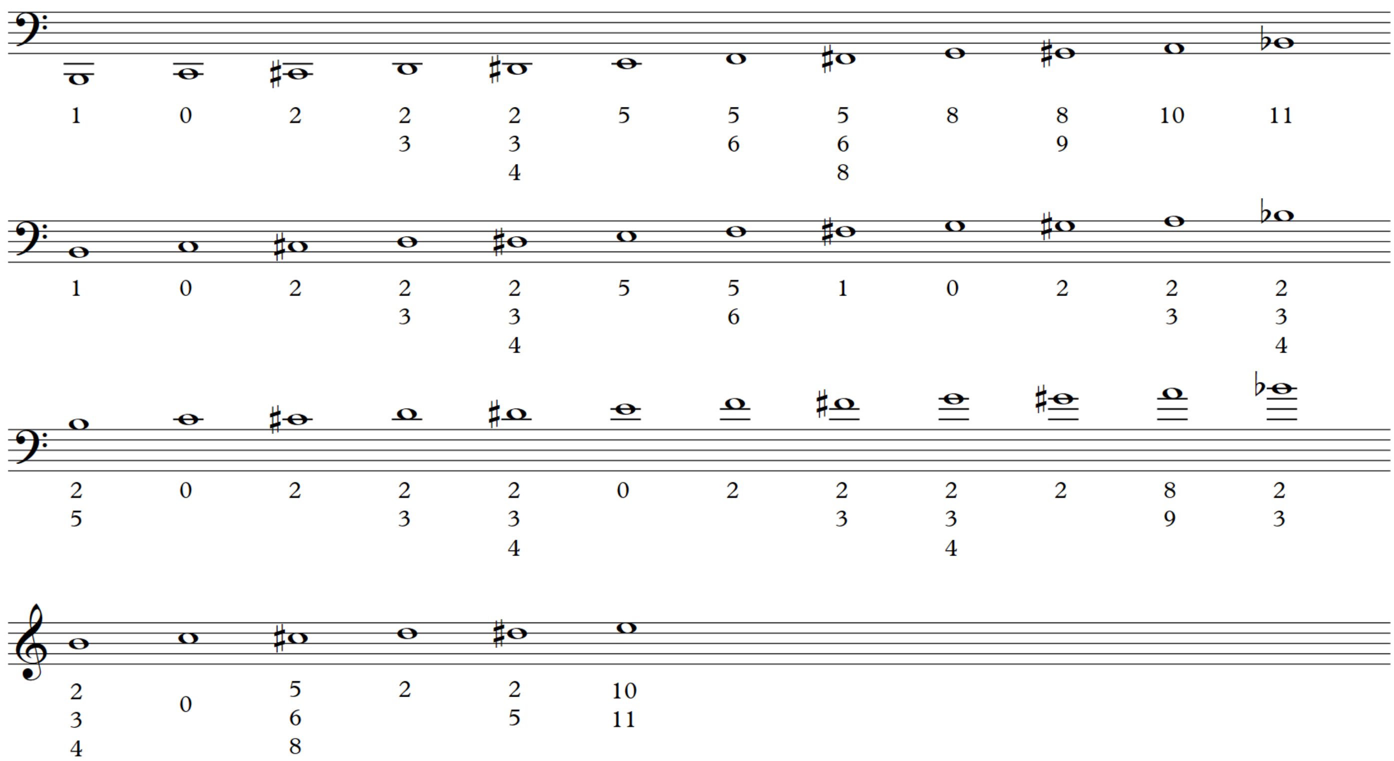


Chart 3: Dynamic curves and durations

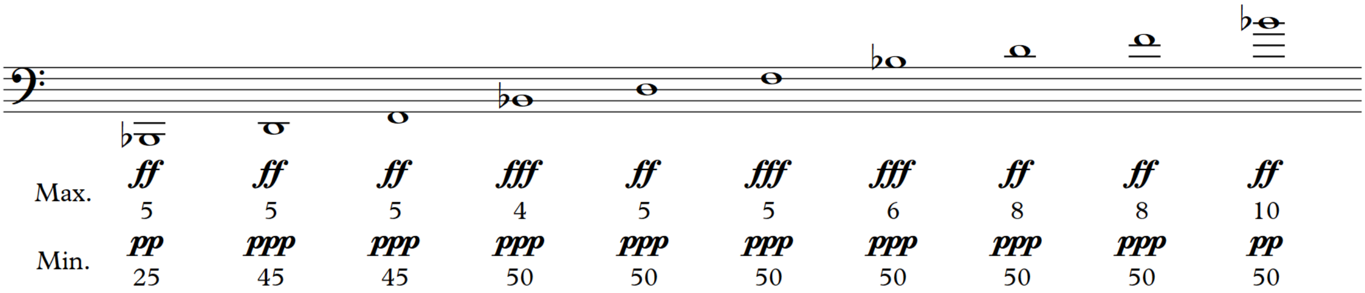


Chart 4: Lip bending ranges

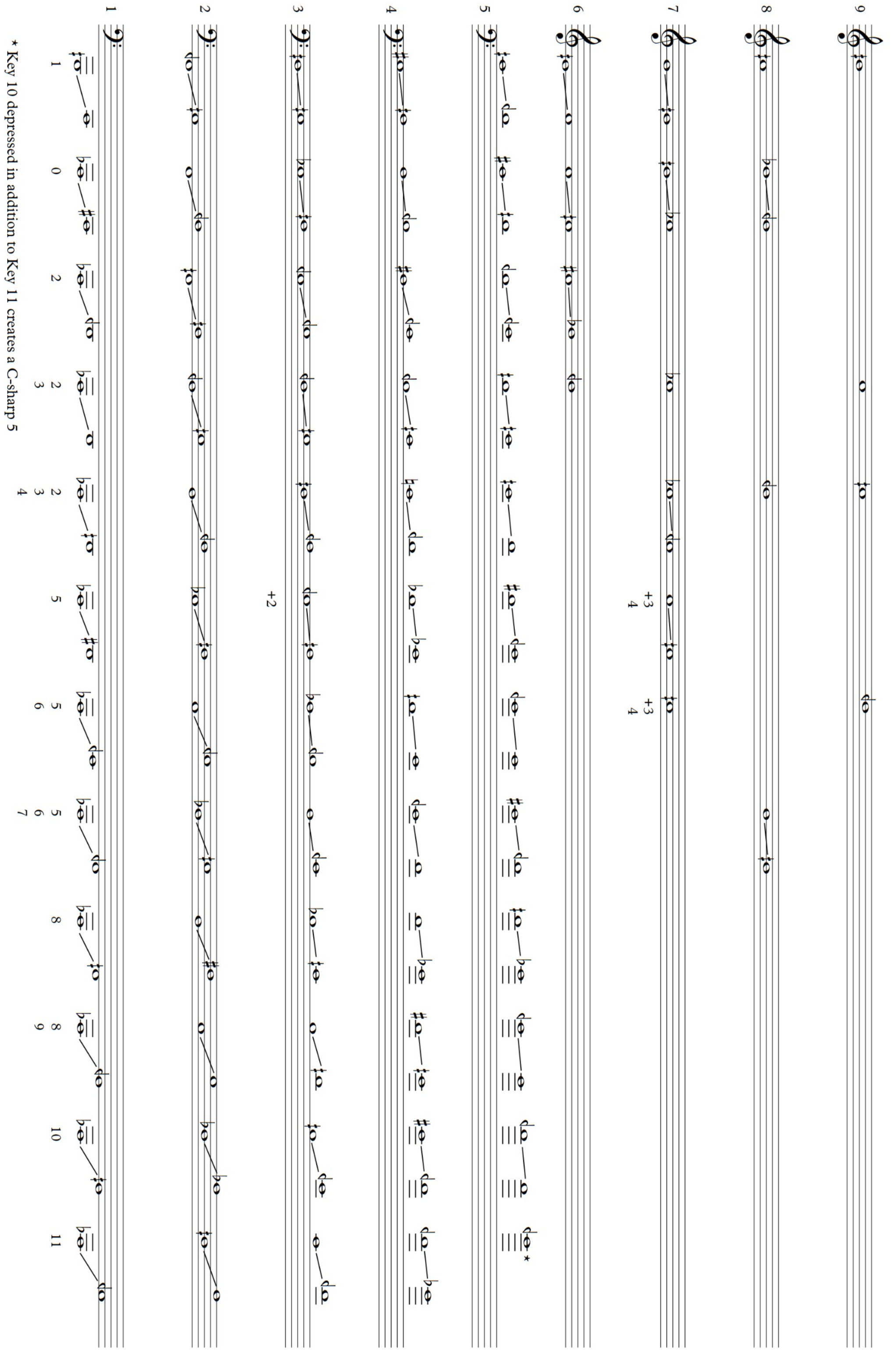


Chart 5: Multiphonics

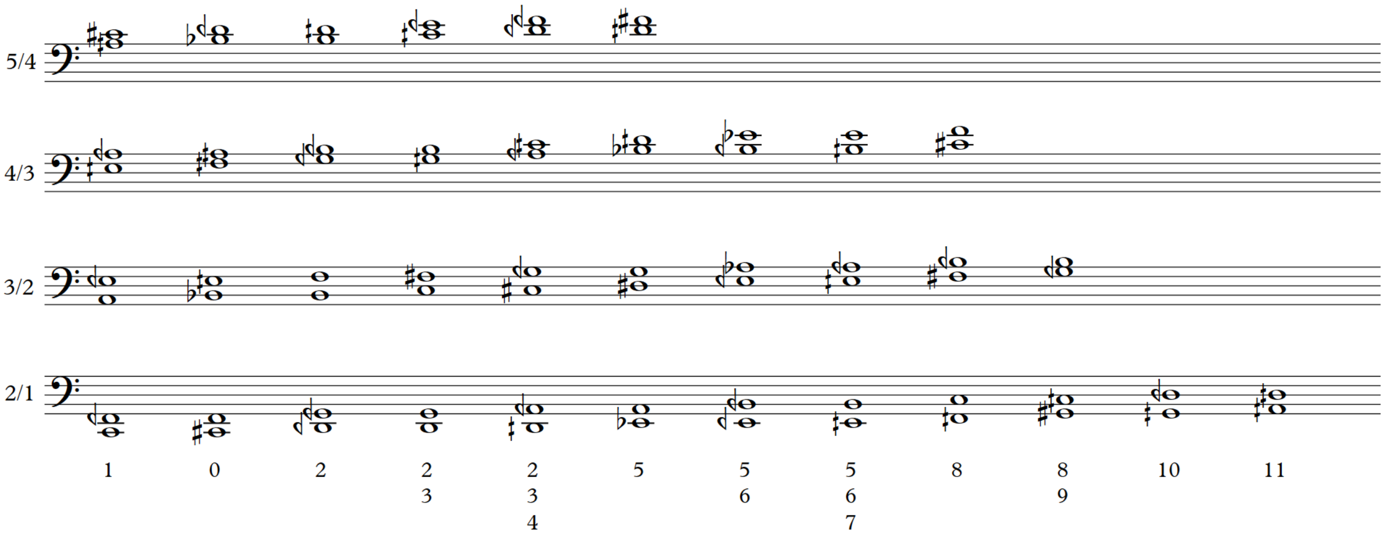


Chart 6: Air noise and key flick pitch content

* N.B. Key flick pitches require all of the previous tone holes (closer to the bell) to be opened. For example, flicking Key 6 only produces an E quarter-sharp when Keys 2, 3, 4, and 5 are already depressed (but not Key 1, which is an open-standing key).

Chart 7: Spectral content with baritone saxophone mouthpiece