Chapter 1

An Introduction to Player-Voiced Aerophones

The Meaning of Sound

To a primitive man, sound is an awesome phenomenon[1] and the ability to interpret sound is an essential component of the ability to survive. If sound had this function then it was indeed, to man living with nature, the voice of nature, the universe and hence of his God. The stories of many peoples tell of the creation "In the beginning was the word." Equipped with his own vocal apparatus man could join in with this sonorous nature, to add his own dimension and, by imitation of nature to draw off her power. The voice must rank as the first of man's instruments, to be soon augmented by voice modifiers and simple idiophones.

Sound, however, is part of the order of things. It is only to be trifled with at the risk of crossing nature and the Gods and then at one‘s peril, and thus, forms of sound must be integrated into this fabric of existence. This integration constrains their form and limits their use both in time and in their availability to members of a particular society. The priest or shaman may be the guardian of the sacred instruments and perhaps too, the only permitted performer on these. He alone, by ritual cleansing or other rites, can commune with nature at this intimate level free from danger. In many societies, contact with the sacred instruments is forbidden to all but the initiated and seeing these or, in some cases hearing them can lead to death. This is the place of music in an archaic culture, something of value, integrated and awesome.

[1] This statement was challenged right at the beginning of the viva. How do I know this? The statement was rash and could have been phrased better

The Human Voice

The human animal, as do the majority of other members of the animal kingdom, generates sounds for most of the time while active. Some of these are involuntary, resulting from the processes of digestion, physical exertion etc. but others are deliberately produced to signal to members of the same and other species. In the human, these sounds have become specialised and highly developed into groups of languages mutually intelligible to the user of that specific form. The elements of sound available for the production of speech are generated by the movement of parts of the human anatomy, particularly the lungs, the larynx, the pharynx, the nose and the mouth. As a generator of sound the "voice organ" has three major units; a power supply (the lungs), an oscillator (the vocal folds), and the resonator (the vocal tract). The pressure of air stored in the lungs is increased by muscular tension and maintained at this pressure as a power source. On allowing this air to escape from the lungs, the vocal folds are alternately pushed back by the air flow, only to recover when the force extended by the laryngeal muscles exceeds that resulting from the air flow, i.e. the Bernoulli effect.[2] This oscillatory air flow then appears in the vocal tract as an oscillating air pressure or a sound source, having a frequency spectrum as shown in Figure 1.1[3].

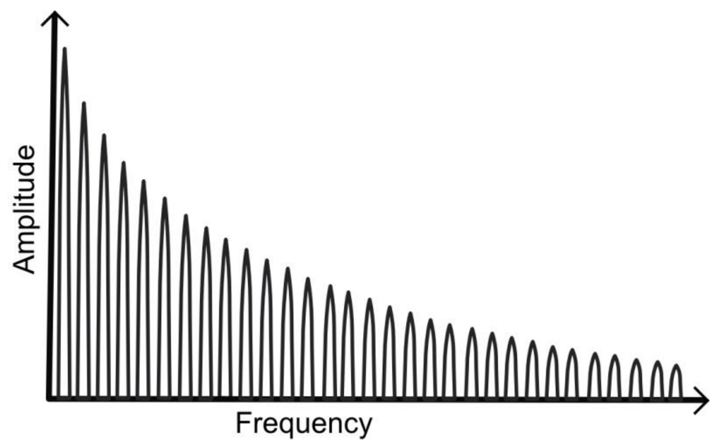

Figure 1.1

In this figure, the bass frequency can be seen with the successive higher frequencies decreased in amplitude uniformity with frequency at a rate of about 12 decibels per octave.

Passing into the vocal tract, the sound spectrum is modified by the physical properties of this resonator. Here a frequency-dependant effect causes some frequencies to be attenuated considerably, while others are less affected. Thus the radiated sound is a modified form of that generated by the vocal folds, with some frequencies attenuated, giving the radiated sound a characteristic tone-colour or frequency spectrum. Which of the frequencies originally generated are subsequently supressed depends upon the group of resonant frequencies of the vocal tract itself, known as formants. It is the nearness of a frequency to that of a formant which determines whether or not it will be attenuated, those coinciding with formants being only slightly affected, while those being midway between formants are considerably attenuated. See Figure. 1.2.

[2] Benade 1976, 365
[3] Sundberg 1977

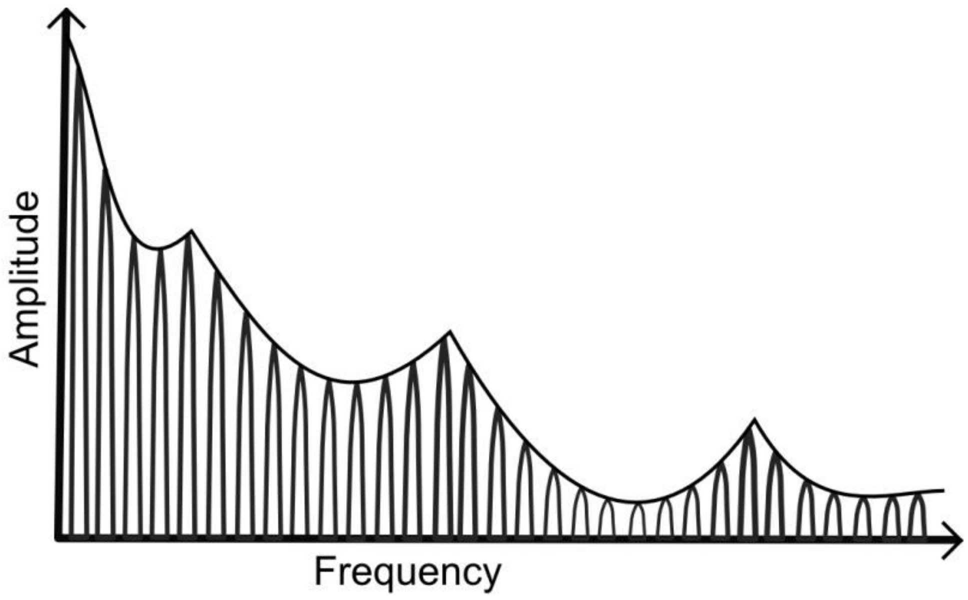

Figure 1.2

Three major parts of the vocal tract can be used to modify the spectrum of sound emitted, the jaw, the body of the tongue and the tip of the tongue. Manipulation of these, changes the formants of the vocal tract and hence the nature of the voiced sound.

Music was probably developed by use of the voice, as was speech itself, and one can only speculate on where and when the ability developed, to encode and decode emitted sound in such a way as to convey the delicate shades of meaning present in all known languages. However, the nature of the encoded signal remains generally uniform throughout the thousands of these languages, being generated principally by variation of the vocal tract characteristics and distinguishing one sound from another by changes in attack, duration, amplitude and tone-colour, along with a range of pitch changes. A number of languages change the meaning of words by pitch variation, especially in Africa.[4] It is by mechanisms such as these that player-voiced aerophones can be used to communicate. Personally, I have been unable to find references in other tone-language areas to such use of talking player-voiced aerophones. The possibility is worth bearing in mind, however. One reference to such a use of musical instruments is in Carrington's 'Talking Drums of Africa'.

When a developed language form has evolved, it attains its position in the culture as a medium of communication. As such, it may be used quite freely by all members of that society, in order to communicate. In many societies, however, different forms of speech develop which are used to express the possession of a specific role by the user of that form. Probably the most frequently-varied element of speech in this situation is that of pitch. Its range may be narrowed to produce a monotone speech or chant, or it may be widened to produce singing. Either modification differentiates it from everyday speech and, hence, identifies the user and his role. Thus the form used receives its powers from the perceived difference between "normal" speech and this specialised form and the value of the actual words used becomes of less importance.[5]

[4] Personal communication from JeremyMontagu.
[5] Jeremy Montagu commented in a personal communication that it is questionable whether the actual words of chants become less important when they are sung; the melody may be important but its function tends to be mnemonic – to help remember the words, which are the more important element. The tune of the chant may later substitute for the words but this is because the hearer remembers the words. For instance, in the use of the In Nomine or Dies Irae, the tunes only have an impact *because* the hearer remembers the words.

The Generation of "Musical" Sounds

Once the value of the language content of the sound produced in a ritual has declined sufficiently, the way is open for gross variation of the tone-colour of the sound to be practised.

Such modification of sound can be attained by abnormal use of the vocal tract, or by modification of the radiant energy once it has passed beyond the vocal apparatus. This may be achieved by placing the hand over the mouth, speaking into the cupped hand, or through a tubular or into a hollow object. When an object, such as a megaphone, is used in this way, the basic sound source remains the vocal folds, the emitted sound being modified both by the formants of the vocal tract and the regimes of oscillation of the air contained in the megaphone cavity.[6] While this device was not classified as a musical instrument by Hornbostel and Sachs (1914), in my opinion wrongly so, (see the section: Classification of the Instrument Group, below,) a variety of this was classified by them as "24 Ansingtrommeln" (Mirlitons). These are instruments in which a membrane is caused to vibrate sympathetically with the speaking or singing voice, thus modifying its tone-colour.

The role of a secondary external resonator may be further extended by utilising the resonance characteristics of its contained air, and exciting sympathetic resonances of this by singing through it at the appropriate pitch, the vocal folds remaining the generator of the pressure oscillations of the air column. However, while singing into the resonator at a frequency coincident with or close to the tube's resonant frequency, the vibration of the lips can be induced. Having noted this phenomenon, it is a short step to the use of lip-induced vibrations. These may be produced by tensing the lips using the buccinator muscles, and forcing air through them from the lungs and through the external resonator. By adjustment of the applied pressure and the tension of the muscles, the frequencies of vibration can be made to coincide with that of the resonator's characteristic frequencies or formants and a very strong resonance set up, this being the basic mechanism of trumpet or horn blowing. (See the section: The Acoustic Potential of Player-Voiced Aerophones, below) During this operation, a function similar to that performed by the vocal apparatus is being simulated, with the lips taking the part of the vocal folds and the resonator the part of the vocal tract.

A fundamental difference in the modes of operation of these exist, however, in that motion of the lips is reinforced by feedback from the upper partials in the tube's formants, thus facilitating their continued oscillation[7]. Nevertheless, when a sung note is superimposed on a lip-voiced note two complete generator/resonator combinations operate in series[8].

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[6] Collaer 1968 ,9, no. 6, provides an example of such a use.
[7] This phenomenon is covered in detail Campbell & Greated, The Musician's Guide to Acoustics, Oxford, 1998, p.308ff.
[8] As is done on the didgeridoo, when creating the sung tones while blowing.

The Development of Musical Instruments

Having developed the technique for producing sound from resonators external to the body, selection or development would take place to find or make objects that respond to the technique more readily. It is here where complications inevitably begin, as a development which enhances the ability of a megaphone to be sounded by the vocal folds, inhibits the range of harmonics that can be generated by means of the lips of the player. For sounds to be recognisable as words, the lips must have considerable freedom of movement to "mouth" these words. However, the production of the upper partials on a harmonic series requires the lips to vibrate at a high frequency with a resultant low amplitude, a condition best met by use of a small mouthpiece. Resulting from this conflict, a divergence of morphology takes place, with one group of instruments remaining suitable for use with the human voice alone, another for use with both the voice and the lips and the third group developing characteristics which enable an extended harmonic series to be sounded by use of the lips alone[9]. It seems reasonable to say that all of these groups may be described as musical instruments, although a whole spectrum of types exists with the dividing line between them being very unclear. However, if a broad view of the term "musical instruments" is accepted, the whole range of external lip and vocal-fold resonators are quite reasonably classified as such.[10]

The Player-Instrument Interface

The critical contact area between the player and the instrument is the aperture through which the vibrating column of air is introduced.

However, when a resonator is to be excited at one of its resonant frequencies by lip vibration, a seal between the lips and the instrument is essential as the pressure required to cause the lips to vibrate and create an air-flow through the tube would otherwise not be readily maintained by the lungs. The lips and facial parts are therefore restrained by this contact with the resonator and are unable to form identifiable words. Thus, development improving the lip vibrating characteristic of the tube impairs and, in the limit, destroys its ability to serve as a megaphone.

A tube with an aperture, equal to the tube diameter, of the order of 15-30 mm diameter and a metre or so long can be blown by a person with normally formed facial features, and fairly readily sounds the first characteristic frequency of that tube. This note will require little pressure to maintain a steady continuous note. But, in order to excite the tube at its next harmonic[11], the frequency of lip vibration must be doubled. This may be done by increasing the air flow through the lips considerably, by tensing the lip muscles and increasing the air flow by a much lesser amount or, more commonly, by a combination of these. The same effect can also be achieved by reducing the effective supporting diameter of the mouthpiece. This reduces the free area of lips available for

[9] The three being the megaphone, the variable tone-colour instruments (didgeridoo) and the trumpet/horn instruments.
[10] The use of the term *sound tools* which has emerged since the 1970's may well be more-suited to some of these forms.
[11] The term *partial* would, most-probably be better used here.

vibration, and hence reduces the vibrational amplitude and increases its frequency for a given air pressure. Such an organological change increases the ease with which the second harmonic can be played at the expense of ease in playing the first. Further reductions in size of the mouthpiece may result in an instrument upon which the first harmonic cannot be sounded at all. Thus, one of the key parameters in mouthpiece design is the range of frequencies over which the instrument is to be played

The Instrument Body

A trumpet or horn is made up of a matched mouthpiece/resonator combination joined together by an air-tight seal. The resonator part of the combination may be of the form of a cylindrical or conical tube or of a more complex shape, such as a hollowed-out anthropomorphic object.

One commonly-used external resonator that has been found in this study to have almost world-wide application is the hand. In questioning subjects from many different cultures, the "blowing of a raspberry" appears to be a virtually universal modern phenomenon. In doing this, the hand, being placed over the mouth, restricts the amplitude of vibration of the lips and raises their vibrational frequency. Presumably, this higher frequency sound output more closely resembles that produced by the bodily function simulated. Needless to say, this "raspberry" device, universally interpreted as it is as "rude" or offensive, remains the simplest instrument of this type in general use today!

An enormous variety of materials has been used to form the external resonators of instruments, among the commonest being animal horns, shells, hollowed wood/reeds and ivory. Analogues of these have been made in ceramics, wood and metal and simple tubes from sources such as sea-weed utilised. Many other materia1s, which are naturally of a horn or bell-like form, such as armadillo tails and gourds have been used to terminate tubular instruments, and flexible materials such as willow and birch bark have been formed into the appropriate shape to form a resonator. With the availability of metals, restrictions placed on morphology by the availability of naturally occurring shapes were replaced by those that were intrinsic to the technical processes utilised.

Tubular and conical instruments are undoubtedly the most common among the lip-voiced instruments, and can be sub-divided into end-blown and side-blown varieties. Both varieties are found in cylindrical and conical instruments, end-blown instruments generally being much more common than the side-blown variety.

Classification of The Instrument Group

In accepting that at least some of the group of instruments studied are "musical instruments" one is faced with a further problem of attaching a name to them which is clear, unambiguous and scientifically acceptable. Common parlance seems to present little problem in this respect, the term ‘brass instruments’ being generally used and understood outside the US and ‘brasswind’ within the US. However, in scientific circles a greater problem is experienced in devising a less ambiguous title.

In a recent book Anthony Baines[12] proposes a further term "labrosone" but this seems only to further the surplus of names for the instruments. That the group of instruments are aerophones, the air in the resonator vibrating, is generally accepted. Hornbostel[13] conditions this by adding "tubes blown with lip vibration." Bessaraboff[14] attaches the condition of lip excitation to produce the name lip-vibrated aerophones. This term, as has lip-reed and lip-voiced instruments, achieved wide general usage. While the instruments considered in this study are frequently lip-vibrated aerophones some, like the variable tone-colour group[15], have the further attribute of being suitable for the exploitation of vocal-fold generated sound. Even modern western orchestral instrument players are required by some composers to utilise facial parts other than the lips to generate an air- column modulation by use of the tongue to interrupt the air flow (so-called "flutter-tonguing."[16] These forms of sound generation would appear to be excluded by the term "lip-vibrated" and a suitable term would need to include those parts of the player used as sound generators. I, thus, propose the term 'player-voiced aerophones' (hereafter abbreviated to PVAs) which covers the use of the player's vocal apparatus as well as the lips and tongue in the generation of sound.

In the classification of instruments proposed by Hornbostel and Sachs in 1914 and since then generally accepted, the PVAs are classed under the heading "423. Trumpets," this having arisen from 4 = Aerophones.

4.2 Wind instruments proper; the vibrating air is confined within the instrument itself (Translation from Baines (1961, 27).

423 Trumpets; The air-stream passes through the player's vibrating lips, so gaining intermittant access to the air column which is to be made to vibrate.

[12] Baines 1976, 40. Interestingly, although he proposes the term labtosomes, his book is entitled "Brass Instruments, Their History and Development".
[13] Hornbostel 1914
[14] Bessaraboff 1941
[15] Didgeridoos, etc.
[16] I have discussed this with Jeremy Montagu who disagrees with this statement. However, I have not yet seen the function of the tongue described during flutter tonguing although its motion certainly does disturb the flow of air through the instrument

Their subdivision then continues.

423.1	Natural trumpets	Without extra devices to alter pitch
423.11	Conches	A conch shell serves as trumpet
423.111	End-blown	
423.111.1	Without mouthpiece	India
423.111.2	With mouthpiece	Japan (rappakai)
423.112	Side-blown	Oceania
423.12	Tubular trumpets	
423.121	End-blown trumpets	The mouth-hole faces the axis of the trumpet
423,121.1	End-blown straight trumpets	The tube is neither curved nor folded
423.112.11	Without mouthpiece	Some alphorns
423.121.12	With mouthpiece	Almost world-wide
423.121.2	End-blown horns	The tube is curved or folded
423.121.21	Without mouthpiece	Asia
423.121.22	With mouthpiece	Lurs
423.122	Side-blown trumpets	The embouchure is in the side of the tube
423.122.1	Side-blown straight trumpets	S. America
423.122.2	Side-blown horns	Africa
423.2	Chromatic trumpets with extra devices to modify the pitch	
423.21	Trumpets with fingerholes	Cornetti, key bugles

From this entry on, the remainder of their trumpet group of instruments are outside the scope of this study.

The major problem in categorising the instruments studied here arises from the variable tone-colour group. These are quite capable of being blown as straight-forward members of 423.111.1 "trumpets, natural, without mouthpiece" and utilising their first formant. However, as discussed above, they are considerably more versatile than this categorisation allows, and are not adequately covered by it. Neither is it as easy as simply creating a new sub-group to cater for them, as many instruments, for example, the Irish side-blown horns, have blowing apertures so large that they could function quite adequately as megaphones. In this case, the instrument would receive or be denied the title musical instrument depending on its use, and this might vary from time-to-time during a single performance.

Under the heading 423, the term 'trumpets' is qualified by a statement that the air stream passes through the player's 'vibrating' lips. In that a vibration is an alternation in movement at an unspecified frequency with an unspecified uniformity of repetition then speech itself involves the passage of air through the "vibrating" lips. One way of avoiding this problem is to define 423 Trumpets as dependant on lip-vibration re-enforced by the standing wave in an instrument cavity, i.e. by a feedback-induced vibration. However, as well as excluding the hunting horn from the category, this would also exclude the conventional trumpet or horn when played in its high register, see below, p. 21.[17].

A better solution to the problem would be to accept the megaphone as a PVA, i.e. a 'trumpet' under 423 as:

423. Instruments where an air' column is principally modulated by means of the facial and vocal parts of the player.

This would include the variable tone colour instruments as:

423,121.13 Trumpets, natural, tubular, end-blown, with mouthpiece suitable for use in a variable tone colour mode. Types include didgeridoo

425,122.21 Horn, natural tubular, side-blown with mouth- piece suitable for use in a variable tone-colour mode. Types include Irish Bronze-Age horns.

Establishing Sequences of Instruments

The instruments under study were all manufactured prior to c. 500 AD and are representatives of a sequence lasting several thousand years. Hence, one of the pre-requisites for study of such a sequence is the establishment of a chronological ordering of the material.

The major problem when attempting to define a chronological sequence of artefacts is that each item has attributes related to discrete sequences encompassing different

[17] see Section: Range of Sounds of Player-Voiced Aerophones

facets of the culture. Such facets include technological, aesthetic and the functional needs that led to the creation of that particular item. In the case of musical instruments, the functional factors in design are described in the term "organology," this covering the whole area of use of the instrument in the production of music. It is thus possible in any group of instruments that are fully representative of a developmental sequence to define three distinct sub-sequences viz: technological, aesthetic and organological. Such sequences, however, are not necessarily mutually exclusive and problems may arise in defining to which sequence a change belongs.

Each sequence consists of discrete steps that can be individually defined but are not necessarily exclusive, the steps possibly belonging to two or even three different sequences. A discrete technological step might be the joining of two tubes by use of brazing to replace casting-on. See Figure 1.3.

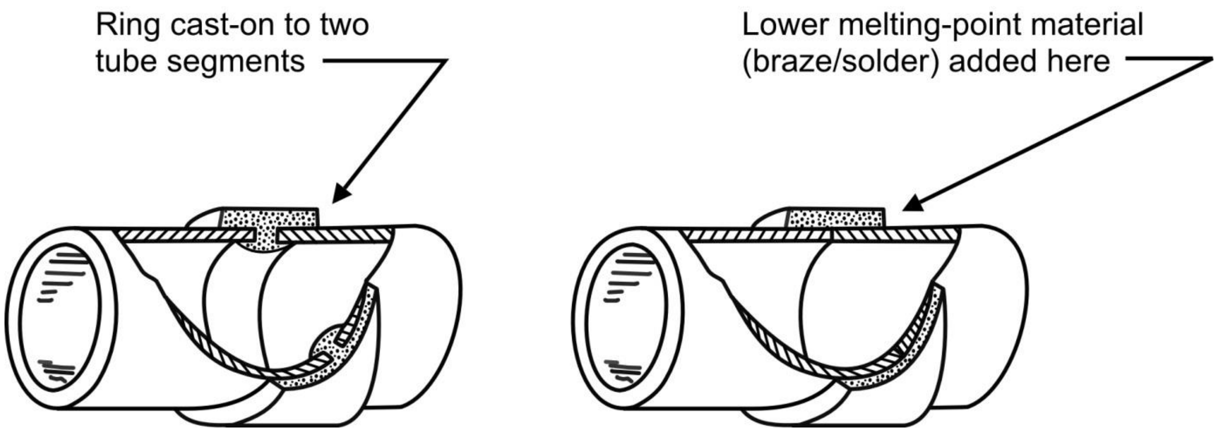

Figure 1.3

This step could produce a tube with the same aesthetic impact which was organologically identical.

An aesthetic step could be the introduction of extra decorative rings on a portion of instrument tube. This would require no new technology and organologically speaking would not change the instrument.

Having developed the technology for manufacture of a basic instrument, many organological changes could readily be introduced. In particular, so critical is the influence of mouthpiece in enabling a standing wave to be initiated and then controlled that many variations of mouthpiece morphology are seen. A change in the diameter of the mouthpiece throat for instance, would affect the ease with which the instrument's higher formants could be sounded without requiring new technology or affecting the aesthetic impact of the instrument.

Not all changes are peculiar to one sequence, however, and some affect all three; for instance the change from a "natural" mouthpiece i.e. a hole cut in a horn tip, to a metal mouth support or mouthpiece would be a change involving all three sequences.

Such sequences may be described as positive or negative depending on whether they represent increasing or decreasing sophistication of that particular facet of an instrument.[18] Developmental pressure would tend to create a positive gradient of

[18] The question of intentionality impacts strongly upon how one sees a step change of any type and this is the most-difficult of all features of ancient design change to get a grasp of: what did the designer/maker actually have in mind when they made that change.

development, increasing the technological, aesthetic or organological complexity of any particular item. A caveat is necessary when attempting to equate any sequence with chronological events as the gradient of any sequence may not remain positive and will certainly have a different slope in different areas. Thus, the interchange, or diffusion, of ideas between areas will affect the developmental gradient producing quantum jumps in development that, lacking a complete sequence of artefacts, cannot readily be detected.

The Diffusion of Ideas

When looking at early examples of instruments one is continually faced with the problem of deciding from where the ideas and technology came, i.e. were they indigenously developed or did elements of either design or technology come from elsewhere? However, it is not enough to cry "diffusion" and to state that "this" diffused from "here to here." Any artefact is made up of several, frequently many, design elements created by specific technological processes and, in the case of musical instruments, is required to perform its task in a highly specific way.

One degree of diffusion can be proposed, that of 100%. In this a manufacturer would move along with all his necessary tools, designs and equipment to an area where his products are equally desired by the market for the same purpose and the necessary raw materials are equally readily available. However, should any of these criteria not be met then the diffusion would be less than 100%.[19]

It might be better when talking of diffusion to speak of "maker" and "user" diffusion as clearly recognisable strains. In the first case the geographical move could still allow a complete transfer; if all the above criteria are met the most conservatively maintained elements of the artefact are those deriving from the technology applied in its manufacture.

In the second case, however, the functional aspects of an artefact would be better conserved even when a totally different technology is used to manufacture them. A further possibility is the diffusion of a design, "design diffusion," emphasising conservation of the aesthetic aspects of an artefact.

Thus, in the case of a musical instrument a maker would transfer the technology without necessarily understanding all the intricacies of design from an organological point-of-view. A player would tend to conserve the functional - in this case organological - features of an instrument, to some extent, at the expense of technological and aesthetic features. A ruler, shaman or priest for whom the instrument is played would be interested in the aesthetic and/or the musical impact of the instrument perhaps showing little interest in the technology employed in its manufacture.

[19] Close links between cultures, trading and otherwise, can serve to obfuscate technological/design relationships. We are told in ancient literature, for instance that the Etruscans produced many goods specifically for the Greek market and this leads to the needs to separate out the cultural aspects of an object and its source of manufacture.

In all the above cases, the transferee of information might perform the transfer of information more or less well. The maker who took with him the manufacturing technology may have lacked understanding of a part of the manufacturing process. His knowledge of clay preparation or the alloying of metals might have been defective, perhaps previously having been carried out by other members of a workshop. In a similar way, the "idea" of a horn-shaped metal tube with certain magic powers may have been all that was transferred, giving a very low level of design diffusion. Obviously, it is generally not possible to define the nature or degree of diffusion in a particular case as, to do this, the exact level of manufacturing technology and the nature of the artefact usage in both the donor and receptor societies would need to be accurately defined at the time of interchange. However, it is important to recognise the different facets of the diffusion of ideas in order to inter-relate the products of different societies in a more realistic way. In this study, therefore, where diffusion is considered to have taken place, the nature of this is conditioned by a pre-fix such as, maker, user or design, along with, where possible, some indication of the order of this diffusion.

Reconstruction of Ancient Music

No examples of musical notation exist for the instruments studied other than written descriptions of shofar calls for use in the temple and synagogues of ancient Israel. Thus, to reconstruct their music, use must first be made of all the material available, be it complete and fragmentary instruments, iconographic references or contemporary documentary accounts. From this a realistic attempt may be made to reconstruct the individual sounds that were components of this music. Herein however, lies a problem as any instruments being studied are likely to have evolved over centuries, perhaps even millenia as also would the performance techniques associated with them. The contemporary performer, would therefore, be heir to this knowledge and the product, therefore, of a school of performance. Obviously, it is not now possible to re-connect the traditional tie and it may be that the awareness of the problems inherent in re-creating a realistic performance is in itself a valuable asset. Clearly, the contemporary performer would possess expertise in the use of his instrument and, presumably, the necessary developed facial musculature associated with excitation of the instrument. It is, thus, apparent that, while some expertise in blowing would be of value, rigid training in a modern traditional school could render a performer quite unable to adapt to the different blowing technique required of a different instrument. Equally unsuitable for performing on such instruments is the outright amateur! Obvious as this statement may seem, several learned gatherings particularly where ancient instruments have been discussed have seen a speaker pick up an instrument and "have a go." Were such a test to be applied to the magnificent 17th and 18th century trumpets, our current view of these would be that they were little more than fancy bugles. No amateur would have dreamt that such an instrument would - or even could - have performed Bach's 2nd Brandenburg Concerto, for instance. A near approach to the authentic sound will only come from an awareness of the possibilities in performance technique allied with practice over a long period on accurate reproductions or the instruments themselves.[20]

Fortunately for studies of this type many instruments survive in what is presumably their original condition. These horns and trumpets, being of integral construction and made entirely of metal, have survived and give us the opportunity to recreate their sound.

The Acoustic Potential of Player-Voiced Aerophones

As discussed earlier, a megaphone, or simple external resonator modifies the tone-colour of the voice and, when used with lip vibration, modifies somewhat the buzzing of the lips. As the length of the air-column of this resonator is increased, the number of its characteristic frequencies of vibration, i.e. those frequencies at which its wave impedance brings about the establishment of standing wave patterns, progressively increase in number. However, with a straight tube, i.e. one with no conicity or flare, the sound that escapes from its end, to be heard by the listener, is nearly inaudible. This is due to the wave-impedance discontinuity at the open end of the bell where the tube diameter expands instantaneously to infinity, i.e. into the open air. The energy transfer from tube to open air is facilitated by the provision of a flare of the type generally seen on modern instruments or, to a much lesser extent by a bell disc (to an acoustician a "flanged termination.") In addition, this flare increases the effective length of the instrument as its increasing cross-section provides progressively greater impedance to wave propagation and hence increases the time for a wave to travel from the mouthpiece to the "bell-end" and back.

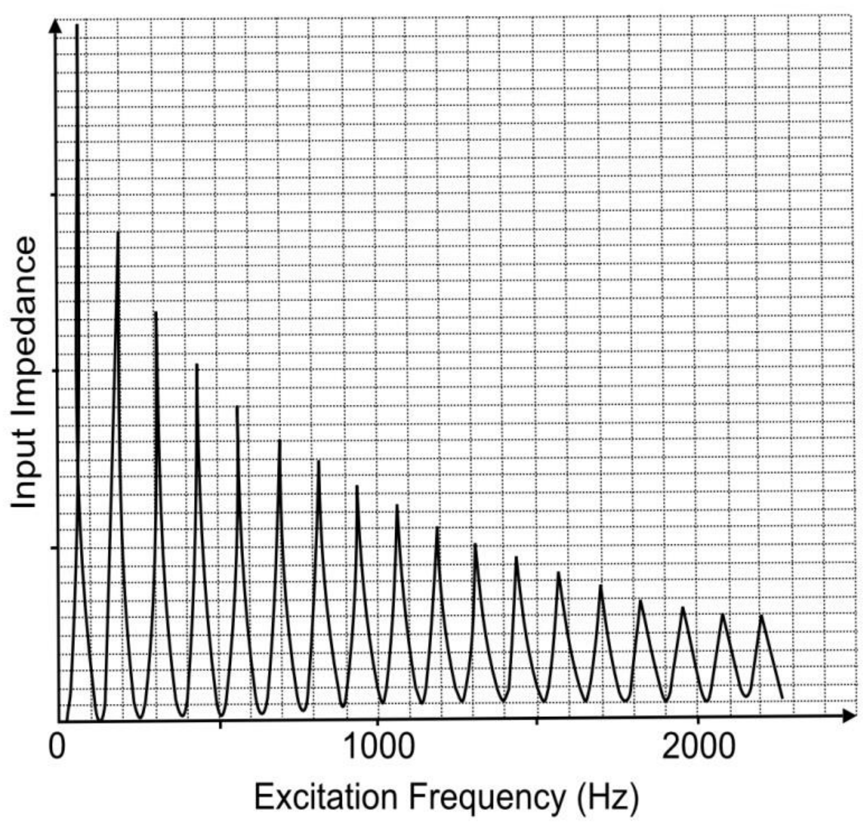

Figure 1.4

[20] Since this work originally suggested that the Bronze-age Irish Horns were possibly played as variable tone-colour instruments (à la didgeridoo) a school of performance on these has emerged, driven, in large part, by Simon and Maria O'Dwyer in Ireland.

The addition of a flare to an instrument, therefore, modifies the impedance curve from that Shown in Figure 1.4 to that in fig, 1.5[21] by shifting the resonance peaks towards lower frequencies as well as decreasing their amplitude because of the greater dissipation at the tube walls. Also, above about 1500 Hz the impedance curve has a very low amplitude.

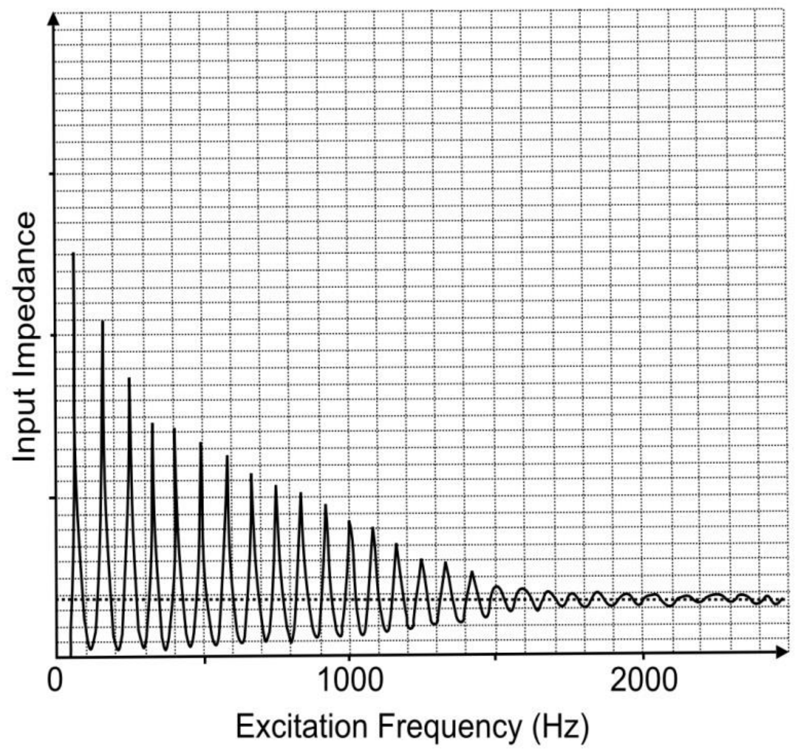

Figure 1.5

In spite of the presence of the standing waves, shown in Figure 1.4, however, the lips can only resonate readily at those characteristic frequencies to which higher formants are related harmonically.[22] Where the higher frequencies are not related in this way to the vibrational frequency of the lips, pressure waves arrive back at the lips out of phase with their motion. These waves then damp the lip movement and prevent vibration at that particular frequency. Thus in Figure 1.5, for instance, a player attempting to produce a 60 Hz tone would find this difficult to do, as its upper harmonics almost all fall near to dips in the resonance curve. Returning waves from these upper harmonics disrupt the lip vibration preventing the establishment of a steady standing wave. If, on the other hand, (s)he attempts to blow a note based on the 165 Hz resonance,they are aided by the 2nd, 4th and 8th harmonics that are reasonably well related harmonically and combine to form a well-defined regime of oscillation. Several other such tones could be played on this, a1though they would lack the brilliant tone of a trumpet even more than the 60Hz tone did.[23]

The Mouthpiece

Many of the instruments considered in this study lack developed mouthpieces of the type that modern instruments have. On some of these, the edge of the tube is simply radiused to cushion the lips, on others the rim of the tube is rolled back to form a rim such as on the Tutankhamen instruments (My refs, SD201/2) On others,

[21] From Benade, 1976, Fig.20.4
[22] The term 'harmonically' should be interpreted here as referring to frequencies which are integer multiples of the fundamental frequency and carries no implication of cultural interpretation.
[23] This aspect of the acoustics of brass instruments, particularly with respect to the function of the mouthpiece, is covered in detail Campbell & Greated, The Musician's Guide to Acoustics, Oxford, 1998, p.308ff.

particularly the bronze-age Irish horns, for example those from Drumbest (My refs, SD16A and 16B), the tube ending opens out to form a larger diameter rim to give support to the lips. None of these instruments can be said to have true mouthpieces and in this study these have been referred to as mouthsupports. The acoustic effect of the addition of a mouthsupport to an instrument is negligible, its main function being to cushion the lips. However, a true mouthpiece has its own acoustic characteristics which, when combined with a length of tubing, produces an overall acoustic effect different from either of its two component parts.

In fact, when combined with a pipe alone, a modern trumpet mouthpiece has little effect at low frequencies, the impedance of the combination being virtually that of the pipe alone. At higher frequencies, however, the wave impedance increases up to about 850 Hz and thereafter decreases steadily until above 3500 Hz where it is actually lower than the wave impedance of the tube alone. The nature of this phenomenon leads one to suspect that the mouthpiece has a characteristic frequency at about 850 Hz. This can be verified by smacking the mouthpiece with the palm of the hand when it produces a tone at 850 Hz. Known as the "popping frequency" of a mouthpiece, this exerts a considerable influence on the mouthpiece/instrument combination giving rise to a peak response at this frequency.[24] This is illustrated in Figure 1.6. Thus, the combination of a mouthpiece with a suitable contoured tube produces the acoustic performance that one expects of a modern instrument and was arrived at as long ago as the Scandinavian Late Bronze-Age (See Chapter 4.)

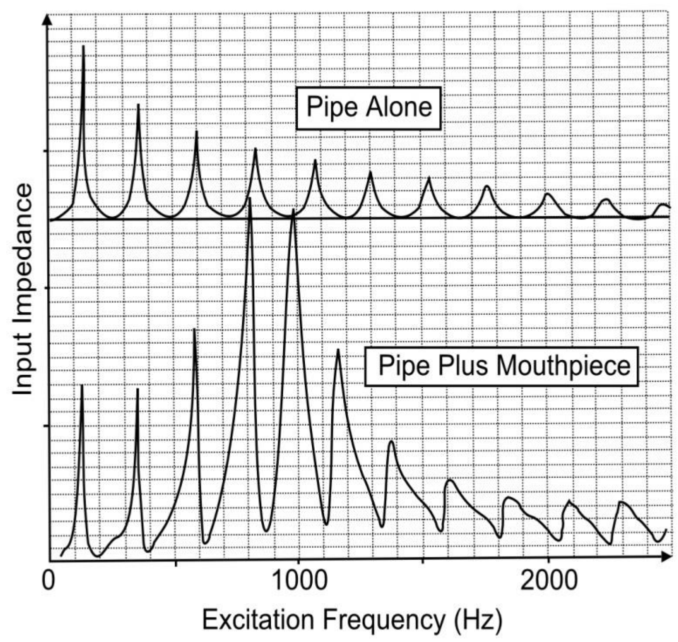

Figure 1.6: Input Impedance of a Cylindrical Tube

The Range of Sounds of Player-Voiced Aerophones

Having no detail of ancient performance techniques, other than those of the Hebrews[25], we can only guess what range of formants were actually used during performance. It is known that during the Baroque period the trumpets of the period were played — and were designed to be played - up to the 20th harmonic.[26] However,

[24] Benade, 1976, 401
[25] In fact, we have only modern interpretations of the ancient calls which were used, no concrete references surviving from ancient times.
[26] Jeremy Montagu comments on this statement that Baroque trumpet parts have occasional excursions up to the 24th harmonic and that the resonance curve of a modern b-flat trumpet (which is essentially a cornet with a wider mouthpiece) is not relevant to Baroque trumpet parts which were designed for a tube two thirds or more cylindrical and a mouthpiece with a hemispherical cup with sharp edges to the throat.

such high frequencies are clearly very difficult to attain even on specially designed instruments. Figure 1.7 shows the resonance curve of a modern Bb trumpet, along with the regimes of oscillation for the notes written G5, C6 and E6.

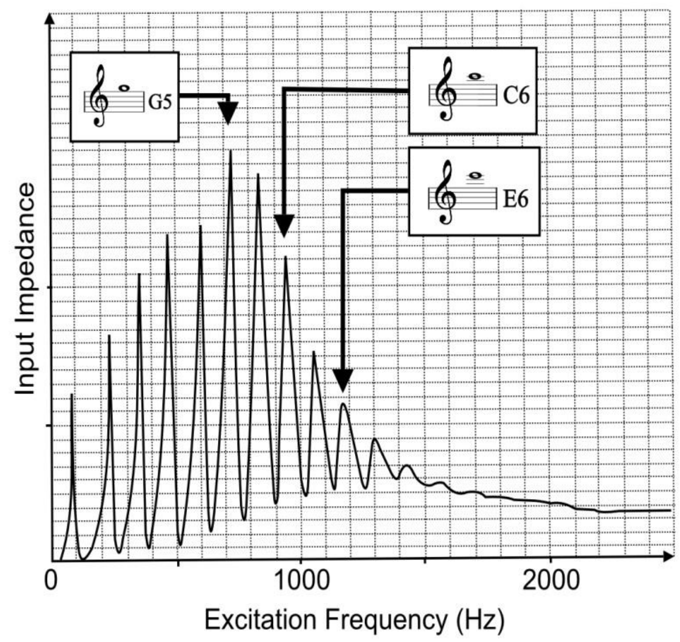

Figure 1.7: The Resonance Curve of a B-flat Trumpet

In this figure it can be seen that, when playing G5, Lip vibration is aided by the large standing wave associated with the 6th tall peak plus a marginal contribution from the G6 peak. The same is true, for C6 although, in this case the peak associated with C7 itself is minute. This complication in pitching the note, i.e. adjusting the lips' vibrational frequency appropriately, is additional to that of getting adequate tension in the lips to cause them to vibrate at this frequency. When blowing E6, however, no higher frequency wave assists the lips and their vibration is maintained solely by Bernoulli forces. At this level, then, the instrument ceases to act as a conventional PVA and becomes analogous in operation to a megaphone. Admittedly the lips remain the source of excitation but they are acting essentially independently of the tube itself as do the vocal folds on a megaphone.

The Effective Lengths of Instruments

A cylindrical tube when blown as a PVA behaves as a closed tube, hence, giving modes of vibration in which the frequencies are in the relationship 1:3:5 etc. Thus, a piece of cylindrical tubing about 12 mm bore and 1.27 m long would produce the notes shown in Figure 1.8.

Figure 1.8: The Notes Produced by a Cylindrical Tube

These are also shown in Figure 1.9, column (a) where they are displayed on a frequency scale, on which is superimposed a musical staff.[27]

[27] Adapted from Backus, 1970, fig. 2

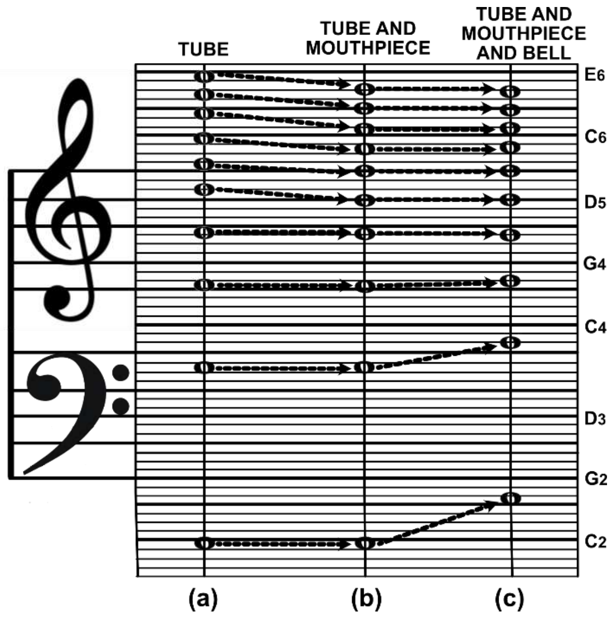

Figure 1.9: The Evolution of a Trumpet

When a mouthpiece is added to this tube it lengthens it; the effective increase at low frequencies being the length of tube which contains the same volume of enclosed air as the mouthpiece itself. Thus, Fig, 1.9, col.(b) shows the notes produced on this tube when shortened to bring the first harmonic back to the original frequency. (ln the actual case quoted, the mouthpiece had a volume of 6.5cc, this being equivalent to a 57mm length of 12 mm bore diameter tube.) However, the mouthpiece has a greater effect on the higher harmonics, depressing them to a greater extent than the lower ones, as shown in Figure 1.9, col.(b).

When a flared bell is added to the combination, this further modifies the harmonics but, in this case, affects the lower ones to a greater degree than the upper ones. Thus if the tube length is again "corrected", this time to leave the upper harmonic unchanged, the notes shown on Figure 1.9, col(c) are obtained. In this the higher modes of resonance are in the ratio 1:2:3:4, i.e. those expected of a "natural" instrument, such as the modern bugle.

Many instruments in the archaeological record have achieved this transition from a simple sound generator to a generator of harmonically[28] related sounds, albeit in an empirical way. Nevertheless, many instruments can produce this harmonic series and cou1d,thus, be played in ways that utilise this phenomenon for harmonic purposes.[29]

Effect of Cone Angle on Conical Instruments

Conically-bored tubes do not suffer from the lack of a harmonic relationship between their formants as do cylindrical tubes. However, in the limit, a conical tube degenerates, on the one hand, to a parallel tube and, on the other, to a flat disc. One must, therefore consider the magnitude of cone angle, when speaking of conical instruments, this being an important parameter controlling the acoustic performance of a tube.

In a paper of 1975, Smith and Mercer examined the acoustic performance of cones, analysing their formants and relating these to the dimensions of the cones. These were excited in their study by means of a bassoon reed and the tubes were designed with a

[28] Harmonic, it has to added, to a western ear. This comment should be similarly read as applying to othe such references in this chapter.
[29] This would probably be better expressed as 'for purposes of polyphonic performance'.

range of semi-vertical angles (α) from 22.7 millirad (mrad) to 6.5 mrad. See Figure 1.10.

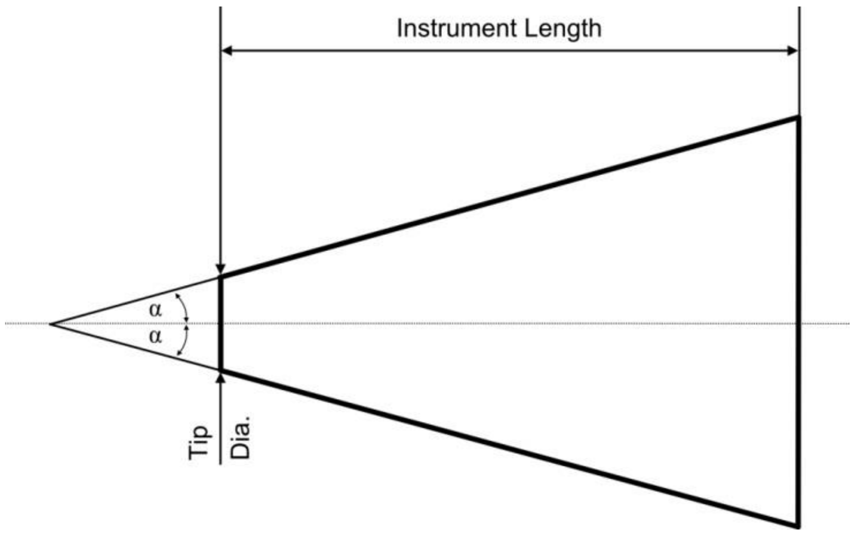

Figure 1.10: An Instrument's Semi-vertical Angle

Their lengths were chosen such that they all had the same fundamental frequency of 200 Hz.

In preliminary work they found that the cones with α greater than 22.7 mrad produced a "coarse and penetrating" tone, concluding that the cone angle was too great to allow reflection of the wave to occur inside the horn. The narrower cones, somewhat less than 6.5 mrad, (actual value not stated) were unstable and hence represented cases where the cone was degenerating to a cylinder, with the resulting change in acoustic performance,

Modern conical instruments have a wide range of values of α, that for the Alphorn being of the order of 6.5 mrad.

MUSICAL OCTAVE NOTATION

Throughout this study, the musical octave notation used is that proposed by the Acoustical Society of America and adopted by the USA Standards Association. This is outlined on Figure 1.11. It starts at the C with a frequency of 16.352 Hz (about the lower level of hearing) and designates this C_0. The octaves above this are then designated C_1, C_2, C_3 etc. All notes in the octave above C_0 are given the subscript 0, all those above C_1 given the subscript 1, etc. In terms of ease in reproducing and interpreting this was considered the optimum system to use in the present study.

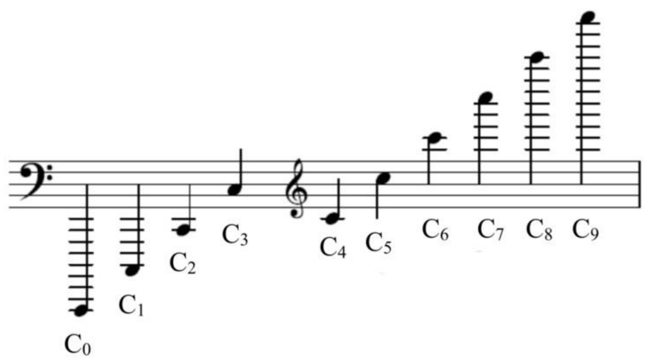

Figure 1.11

The Sounds of Player-Voiced Aerophones

Throughout the long history of PVAs, an enormous variety of forms was used, some in a naturally-occurring form and some manufactured. Probably the most commonly-used type is that of the animal horn, as in this, nature provides a convenient, conical, form which needs only to be provided with means of blowing to produce a playable instrument. To do this, part of the tip may be removed, and a mouthpiece carved from the solid material remaining. From this an instrument, such as the shofar, capable of sounding about three notes can be made, although a longer, narrower horn such as that from an antelope could produce an instrument with more playable notes. Such a horn could also be provided with fingerholes, as on the two Scandinavian Iron-Age instruments (my refs: SD271 and 272), providing more closely—spaced notes capable of use to play simple melodies. Instruments of this type led to the medieval cornett and, finally, the ophicleide. Modern Swedish fingerhole horns also use hand-stopping (the placing of the hand in the bell) to achieve changes in pitch and we do not know if such was the case in the past as the practice leaves no archaeological record. As a group these instruments produce what may best be described as a mellow ("horn-like!") tone, and have a very restricted range.

To increase their musical possibilities, the horn part of the instrument was extended by the use of a simple reed, bamboo, or similar long, tubular, object. The actual form of the material used, particularly its diameter, was of great consequence, for a long large-diameter tube would produce an instrument with few formants that could be played, the upper ones being incapable of being excited. (for example, the Irish Bronze-Age horns). These higher notes would be made playable by the use of a smaller bore tube (tube-yard) which would give the lips greater support (for example, the Greek salpinx, early Lurs such as Gullåkra).

With the ability to manufacture in metal, the restriction of form, to those which occur naturally, is removed. Thus, the tube yard can be made to have both a small tip diameter to suit the requirements of the lips and a large exit diameter to suit the entry diameter of the horn (Bell-yard). Such is the form taken by the later lurs. A further accommodation in metal can also be made to suit the lips, i.e. the provision of a mouthpiece in the modern accepted terminology. This is a device that provides some form of smoothly-formed rim which supports the lips: a cup, spherical or conical in form which leads into the throat, a small diameter constriction which, in turn leads into a back-bore or, in many of those instruments which have an integral mouthpiece, into the tube-yard. (for example, the Scandinavian Lurs).

Such instruments as the lurs (See Chapter 4) and the Celtic Lituus (See Chapter 6) lacked little more than the flare to give them a form that would be acceptable today. Their performance, therefore, is comparable with modern valveless or so-called "natural" instruments, the nearest modern analogy to the same forms of the lurs being a horn, and that to the Celtic Lituus a bugle. With their range of playable notes, 13 or so on the lurs and around 5 on the Celtic Lituus, one would be able to perform something like an l8th century natural horn player on the lur and like a modern bugle player on the Celtic Lituus.

A range of end-blown instruments also emerged from simple straight tubes and it is possible that these, by the addition of some form of bell, could converge with the group that began with the animal horn, and then added the bell. Having thus converged, no evidence would remain of their ancestry.

Variable Tone-Colour Instruments

Several instruments have remained as simple tubes, developing neither mouthpiece nor bell-yards, and their origins can thus be recognised. Generally-speaking, these instruments are of a fairly large diameter and, lacking a developed mouthpiece, are used as simple instruments to sound their lowest playable tone and a second formant. In societies with poorly-developed technology, these instruments may well form an important part of the total instrumental range available and, in the case of Australian Aboriginals, were the only musical instruments other than idiophones, which they possessed.[30] This aboriginal instrument, the didjeridu, is a very simple hollow wooden tube modified only at the mouth-support end. Here, the jagged material, left by the insects that hollowed out the wood, is smoothed to a slightly-flared form. This hole is then lined with wax which can be manipulated with the fingers to form an oval aperture to suit the lips of the players. On an experimental instrument, made in metal during this study[31], the mouthpiece was made to suit an experienced player of this instrument. The final optimum dimensions of this were 40 x 25mm, although it was found that he could play almost as well with a mouth aperture considerably larger than this.

On these instruments, the lips are relatively free from restriction to vibrate and, being able to do so at large amplitude can generate low frequencies. In addition, other than the Buccinator muscles can be used to control the Orbicularis Oris muscles. See Figure 1.12.[32]

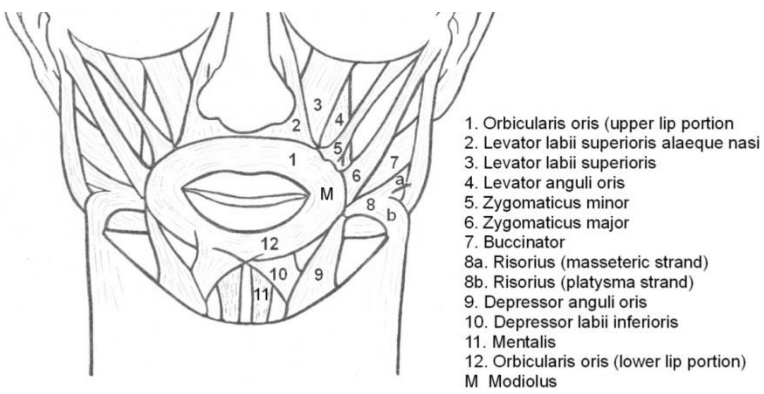

Figure 1.12:Scheme of Musculature of Embouchure

This allows control inputs to be introduced around this muscle, creating a situation where the fundamental frequency of vibration can be maintained, while harmonics are introduced by controlling specific parts of the Orbicularis Oris muscles separately.

[30] A plate of a First Australian playing the didgeridu was removed at this point as it is now felt to be inappropriate and not to advance the argument further.
[31] This was a slide didgeridoo made by the author for the Artist Rolf Harris who needed and instrument he could tune in order to fit in with orchestras instead of them having to tune to him. Possibly the first-ever, chromatic didgeridoo.
[32] Figure 1.12 is adapted from Porter, 1967, fig. 3.

For instance, on an experimental side-blown instrument made for this study, the first formant F3 was produced with a very relaxed embouchure and very low applied pressure. On slight tensing of the mentalis muscles, the lower lip is tightened slightly, resulting in an audible modification in tone-colour by the addition of an A4 into the spectrum. Then when the Mentalis muscles are relaxed and the Depressor labii inferioris muscles tensed slightly the A4 disappears and a C4 appears in the spectrum.

Thus, when the cycle of : relaxed - tensed Mentalis - tensed Depressor - relaxed, is repeated, the characteristic hollow beat of the didjeridu is generated. Only when the blowing aperture of an instrument is large enough, however, can such a sound be produced, the smaller aperture restricting lip movement.

The tone colour can be further enhanced by means of tones generated by the vocal folds and "spoken" through the instrument. Such sounds may be used in a sustained way to enhance the tone colour generally, to inject regular rhythm into the performance or to create special highlights with loud interjections.

An additional feature of modern didgeridoo playing is the use of circular breathing, i.e., the sustaining of the note by means of controlled breathing in through the nose while continuing to blow out through the mouth.[33] When doing this, the cheeks are used as a reservoir in much the same way as bagpipes use the air bag for a constant supply of air. By use of this technique, the instrument can be used as a drone to accompany singing or chanting, at the same time providing rhythm by varying the tone-colour of the sound.

Thus, with variable tone-colour instruments it is difficult to define the individual instrument sound in isolation from the performance. The sound that emerges from the bell of such an instrument contains its own, very characteristic, mixture of harmony and rhythm. As now used, the didgeridu lays down a basic sound pattern to which is added rhythmic accompaniment; with simple idiophones, the performer frequently tapping the instrument itself and adding the sung component. (Jones, 1967, 23ff.)

Side-Blown Player-Voiced Aerophones

A further usage of the animal horn to produce musical instruments is seen on side-blown instruments. On these, an aperture is cut downstream of the tip so that, when blown the instrument lies across the face of the player from right to left (a right-hand instrument) or vice-versa. For ease of playing, the blowing apertures of these instruments are frequently built up to form a mouth-support and, hence, the instruments are often made of material that has a thicker section at the tip such as ivory. Other materials are also used to build instruments up from separate parts, such as gourds and other organic material.

[33] It might be apposite to mention, at this point, that the didgeridoo and its mode of playing were both relatively rare when this was written in the 70s. If someone in the UK had heard of the instrument, it was almost certainly through the efforts of one Rolf Harris entertainer/artist and not as a result of their ethnographic studies or membership of a hippie circle.

Because of their short length and rapidly-opening bore, the archaeological side-blown instruments generally only allow one note to be produced. However, very long side-blown horns of wood are not uncommon in the ethnographic record.

Some instruments, particularly those of instruments where a hole bored through the tip which allows a second tone to be produced by opening and closing this. This is also used along with hand-stopping in Africa.

Shell Instruments

One other material commonly used for both end and side-blown instruments is the shell from marine gasteropods, such as Turitella, Concha and Triton. The living cavity of these shells is in the form of a cone which spirals around a central axis. Thus, to convert such a shell into a musical instrument, an entry has to be made into this cavity either at the tip, for an end-blown instrument, or the side, for a side-blown one. These instruments are still widely used throughout the world and hand-stopping to increase their range is widely used.

Ensemble Playing using Player-Voiced Aerophones

A general association with PVAs are idiophones of various types. These are used to this day in Australia and are reported generally in other ethnographic work. In Australia, the didjeridu player frequently uses the instrument itself as an idiophone, and a similar situation obtains where rattle plates and similar devices are fixed to instruments, such as the lurs. (See Chapter 4)

By their nature, PVAs are not suitable for playing melodic lines unless their length is such that their upper formants are reasonably close together, as on the Baroque instruments. (See Baines, 1976, 27 for discussion on this point). Their potential is, of course, increased where two instruments play together and, as with most other instrument types, a common pattern of usage is for two instruments to be played together. Thus, as the upper and lower formants of conical PVAs have a frequency relationship, of integers 1, 2, 3, 4, 5 etc. there will be octave correspondences at 1:2:4, etc. and it seems likely that these would have been exploited, leading to polyphonic music being performed almost naturally. In fact, when two such instruments play together, it is harder to play in unison than to play polyphonically.

Of all instruments, the PVAs as a group might be said to be most naturally polyphonic. When sounding their first five playable tones, they produce all the notes of what we, in the western musical tradition, see as a major chord based on their lowest formant. See Figure 1.13. Thus, any difference between two players in terms of notes played would result in a composite tonal output which was richer in the spectrum of sound and may have been exploited as increasing the quality of the performance produced.[34]

[34] This section has been re-written slightly to remove references to the ‘harmonic’ nature of the first five formants of a conical instrument.

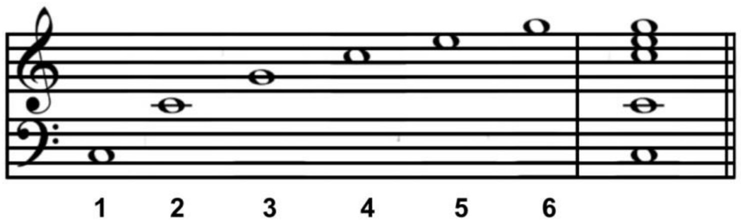

Figure 1.13: The First Six Formants of a Conical PVA expressed in Moderm Musical Notation

Several authors have considered that, for instance, the lurs were played polyphonically, others that they were used to answer each other, and yet others that they simply played in unison.[35] However, recent studies in musical usage throughout the world has revealed that many geographical areas can be found where polyphony is used. Collaer[36] calls these areas of zones of natural polyphony and recognises several of these which he considers to be independent of each other.[37] Thus, instruments such as the lurs could well have been used melodically, with a polyphonic or duet accompaniment as on the record made by the Danish National Museum. (Side 1, track 1; Side 2, track 6).

Side-blown instruments are, generally restricted in range to one or two notes. This second note when it is available, is frequently obtained by the use of a hole bored through the tip of the instrument which can readily be covered by the thumb or finger. The opening of this hole allows air to flow through the section of tube between the mouthpiece and the tip and, on the instrument studied, raised the note of the horn by about a fifth. Thus, a rapid alternation of pitch of the horn can be achieved by opening and closing this hole.

However, in spite of this versatility, the instrument only has a range of two notes, and is not of much use as a melodic instrument. To overcome this limitation, several societies have developed a group technique where a number of side-blown instruments are used, each having a different basic note.

The Uses of Player-Voiced Aerophones

The societies which utilised the instruments studied here are very different from modern western society; music plays many parts in any society, but in the simpler non-industrial ones is generally better-integrated with day-to—day life, both sacred and secular. Of Australian aboriginal music Ellis[38] says:

> *"There are three distinct groups..... The first and largest group consists of the sacred and secret ceremonies. These songs have no connection with pure entertainment but are songs which can only be performed in a particular place and for a specified purpose....*
>
> *The second type of music is the semi-sacred of which there is a large amount.... (These songs) were sung at the initiation ceremony of a young boy, and were performed by the men while the women danced.*

[35] See Oldeberg, 1947, 5-11 for a summary of these.
[36] Collaer, 1968, 5.
[37] Collaer, 1968, op. cit. map 2.
[38] Ellis, 1964, 5.

The third type is the non-sacred or pure-entertainment music. The songs comprising this group are the only form of Australian aboriginal music that can be performed by any person, man, women or child - any time, and at any place."

In the case of aboriginal music, the didjeridu is, of course, their only blown aerophone and is, naturally, subject to the restrictions of the music of which it is part. This is equally true of the other PVAs used in other societies where they may perform alone or as part of an ensemble using other instruments. However, in most societies there are uses to which PVAs are put which are particular to this group alone. This arises from the characteristics of these instruments, in that they are generally robust, compared with other musical instruments, and that their sound is loud, clear and capable of travelling over a great distance. The uses specific to PVAs can be grouped under the headings: Ritual, Military, Musical, Social and Industrial. These headings are not mutually exclusive as there is considerable overlap between them but they characterise the major uses to which different societies have put PVAs.

RITUAL USES

Religious

In these, the folk memory appears to maintain the more ancient view of the instrument sound as the voice of their God. Later, this may be interpreted as speaking to God or contain such symbolism as the remembrance by Israel of the ram sacrificed by Abraham instead of his son.[39] Later still the blowing of the shofar was "invested..... with the faculty of raising awe and devotion in the heart and soul of the people. Furthermore, the sounding of the shofar was to remind man of his duties to God."[40] Instruments were used in funeral processions in the Roman world where, "The procession, led by flute players, lituus player and horn-blowers is an elaboration of the Journey to Hades on late Etruscan urns".[41]

As a signalling instrument in religious practice, PVAs serve to call the faithful to prayer and to mark the progress of religious acts such as in the Roman sacrifice where cornu players frequently attended. Again, here, their voice may serve a symbolic purpose but it is also possible that they serve an altogether more practical purpose - that of covering the cries of the animal to be sacrificed.[42] Both in the Lustration. of the troops and Suovetaurilia, cornua and litui were used both in procession and during sacrifices performed at that time.

Civic, State and Ceremonial

In these uses, the specific character of PVAs is utilised, principally for the sounding of fanfares and similar musical forms that have become associated with the pomp and ceremony of civic and royal occasions. It is probably the characteristic tone-colour

[39] Sendrey, 1969, 545.
[40] Sendrey, 1969, 545.
[41] Ryberg, 1955, 56 foot-note.
[42] Ryberg, 1955, pl. XLIII.

of the PVAs, along with their impressive appearance when made in a straight form, from precious metals, that has given them this role which they now fill almost world-wide.

In civic life, in Roman times, the bucina called together the elders to meet "Buccina cogebat priscos ad verba Quirites".[43] In Britain, however, a property seems to have been attached to the particular instrument which was used, this generally being a horn. These Burghmote Horns are kept within the civic building, to be blown on occasions to which the instrument added authority. Such assemblies were often called *Hornblowen*.[44]

Symbolic

In their use as Burghmote horns a degree of symbolism is seen, but with the practice of Cornage or Horn Tenure this is taken to a much higher degree. In such a practice, the ownership of an estate was symbolised by the ownership of a horn. Thus, the willing of such a horn was the willing of the estate and was held in law to be so.[45]

Military

Signalling

The major military use for PVAs in the ancient world is in signalling, both to keep time in marching and to give orders on the battlefield. Egyptian iconographic references are the first to demonstrate the use for timekeeping (IC 51, c. 1500BC), and this practice seems to have been continuous to the present day. Of their use to give orders, the Roman documentary references give the earliest detail (DR 72) although it is quite likely that such use was made of these instruments at a much earlier date. Again usage of PVAs to perform this function is continuous, the bugle being the common modern instrument used.

Psychological.

The Celts[46] seem to have made use of their instrument, the carnyx, to strike terror into the opposing army. They used instruments in enormous numbers to obtain a vast and terrifying volume of sound. (See Chapter 6)

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43 Propertius DR175.
44 Bridge, 1904, 158.
45 Bridge, 1904, 92.
46 I would now use the term *Native Iron Peoples* to refer to this population, as the major references are Roman and, principally to the Gallic areas.

Musical

Artistic Performance

Instruments are used extensively today in performance for an audience. This is not so generally true in simpler societies, where music as most other social actions, involves the whole community, as it presumably did in ancient societies. However, iconographic references give many indications that groups of musicians played before the royalty of Ancient Egypt (e.g. IC164), and specific references are made to the prowess of particular performers such as Hosy. In ancient Israel, music "was looked upon as a necessity in every day's life, enjoying equal rights with the other two primitive professions, as a beautifying and enriching complement of human existence".[47] It was thus regarded as equal in status to the work of the herdsman and the metal forger.[48]

Of course, music also played a part in the theatre as an accompaniment. Here, PVAs were used together and with other instruments, as depicted on the two mosaics from Zliten (IC12 and IC 40). On these a tubicen and two cornicines, along with a hydraulis, are accompanying the butchery of a gladiatoral combat. (Plate 2.5 (b).

SOCIAL

Personal Entertainment

Enjoyment of an individual when playing his instrument was, no doubt, as great as that enjoyed by an individual today and, the same must have applied to the group in rehearsal. Similarly, the social occasion, when accompanied by a group would have benefited equally. However, the PVAs, generally, are loud instruments, and it was in the arena, as mentioned above, and in the hunt, that they were extensively used. Several iconographic references depict their use such as on IC140 from a tomb at Marisa.

INDUSTRIAL

Control Devices

Several uses of PVAs are described in connection with the employment of the players. One documentary reference, for instance, tells of the use of horns by shepherds and of the knowledge that the animals gained of the calls. In hunting for food, instruments were used to signal calls identifying danger or the presence of prey. Calls were also used in a quasi-military role to co-ordinate the efforts of a large number of workers such as in the moving of the colossal bull at Nineveh (IC10).

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[47] Sendrey, 1969, 60.
[48] The Bible, Gen. IV:20 – 22.

The Cataloguing of Data on Instruments

During the course of this study it has been necessary to locate references to PVAs of various types. Considerable difficulty has been experienced in this task, as many authors refer to instruments without giving any location for these or adequate cross-reference to allow the instruments to be found. In books such as Behn's "Musikleben im Altertum und Fruhen Mittelalter" (Behn, 1954), which must rank as the classic study of ancient instruments, the greatest difficulty has been experienced in locating all the material cited. In fact, some of this has not yet been located. It was decided, therefore, that a major part of this study would be the creation of a comprehensive catalogue which could form the basis for future studies, giving ready access to the material located during this particular work and facilitating the grafting-on of future knowledge onto this data base[49].

This catalogue, which is included in the study as Appendix 1, is sub—divided as outlined below:-

Specimen Detail

All extant instruments and fragments are catalogued under this heading, and given a reference number prefixed by "SD." In the case of the Irish horns the catalogue numbers assigned in John Coles article, 'Irish Bronze Age Horns and their Relations with Northern Europe[50], are adopted, simply being prefixed by "SD." As Coles catalogued these on find-spot. i.e. assigned the same reference number to all those from a particular find, individual instruments are differentiated by means of a suffix - A, B, C etc. In this respect this listing differs from others in the catalogue, but as this paper is well established as a standard on these horns and the assignment of numbers is a purely arbitrary exercise, the maintenance of this difference was felt to be acceptable. In the case of the Lurs, the numbers assigned to these by Broholm[51] were changed from 1 to 55 to 101 to 155, prefixed and used thus.

Iconographic Reference

All pictorial representations, e.g. reliefs, rock carvings wall paintings etc. are catalogued under this heading and given a reference number prefixed by "IC."

Documentary Reference

All ancient contemporary documentary references to PVAs are catalogued under this heading and given a reference number prefixed by "DR."

[49] This catalogue is now available at: http://www.hornandtrumpet.com
[50] Coles 1965, 549 ff.
[51] Broholm 1949, p. 12 ff.

Specimen Representation

All representations, e.g. statues, are catalogued under this heading and given a reference number pre- fixed by "SR."