11 HARMONICS

11.1 THE PHYSICAL BACKGROUND

It was seen in 10.2 that a wave travels twice the length of the string for each period. This means that the wavelength is twice the playing length of the string (i.e. finger to bridge). If there are waves of shorter length in this part of the string, and these are 1/2, 1/3, 1/4 or 1/5 of the 'natural' wavelength of double the length of the string, 'dead points' (nodes) will be formed, where the string is very nearly at rest. The number of these points will be 1, 2, 3 or 4, respectively, according to the size of the wavelength, when compared with the 'natural' wavelength. The shorter the wavelength, the more numerous the nodes. Fig. 11.1 is an attempt to illustrate what happens.

As has been discussed in 10.2, a wave top will travel down the length of a string, will meet the attachment point where it will be returned, upside down. Imagine then, a vibrating string containing three such waves which, together, fit exactly into the double length of the string. The waves are of similar shape; one and a half travelling to the left, while the other one and a half travel to the right on their way back from the attachment point. When in the position shown in fig. 11.1**a**, the effect of the waves travelling left will exactly balance the effect of the ones travelling right, so that the sum of these effects on the string will be zero (no visible amplitude).

A short time later, when the waves have moved a little bit further in their directions, the resultant effect on the string will be as shown in the right column of fig. 11.1 **b** and **c**. In **d** the waves are once more in a phase where the sum of their effects will be zero. A fifth situation is shown in **e**, where the sum again will be apparent on the string, while **f** shows a similar situation to the one we just had in **a**. A full cycle of the flageolet frequency is then completed.

Note that in the course of all this, there are two points on the string (beside the fixed points at each end) which have remained completely at rest. These are the two nodes occurring on a string which contains three equal (circulating) waves or pulses. If one wishes to play a harmonic with a wavelength of two thirds of the string length, one must bring the string to rest at one of the two points where nodes will be formed.

In the case of a double octave flageolet, where the wavelength is half the string length, there will be three nodes on the string. The middle node cannot be used by itself, however, as this would also permit waves with a wavelength of the **whole** length of the string to travel unhindered, i.e. a harmonic sounding an octave lower. In this case one of the two other nodes **must** be used, perhaps **combined with the middle one.**

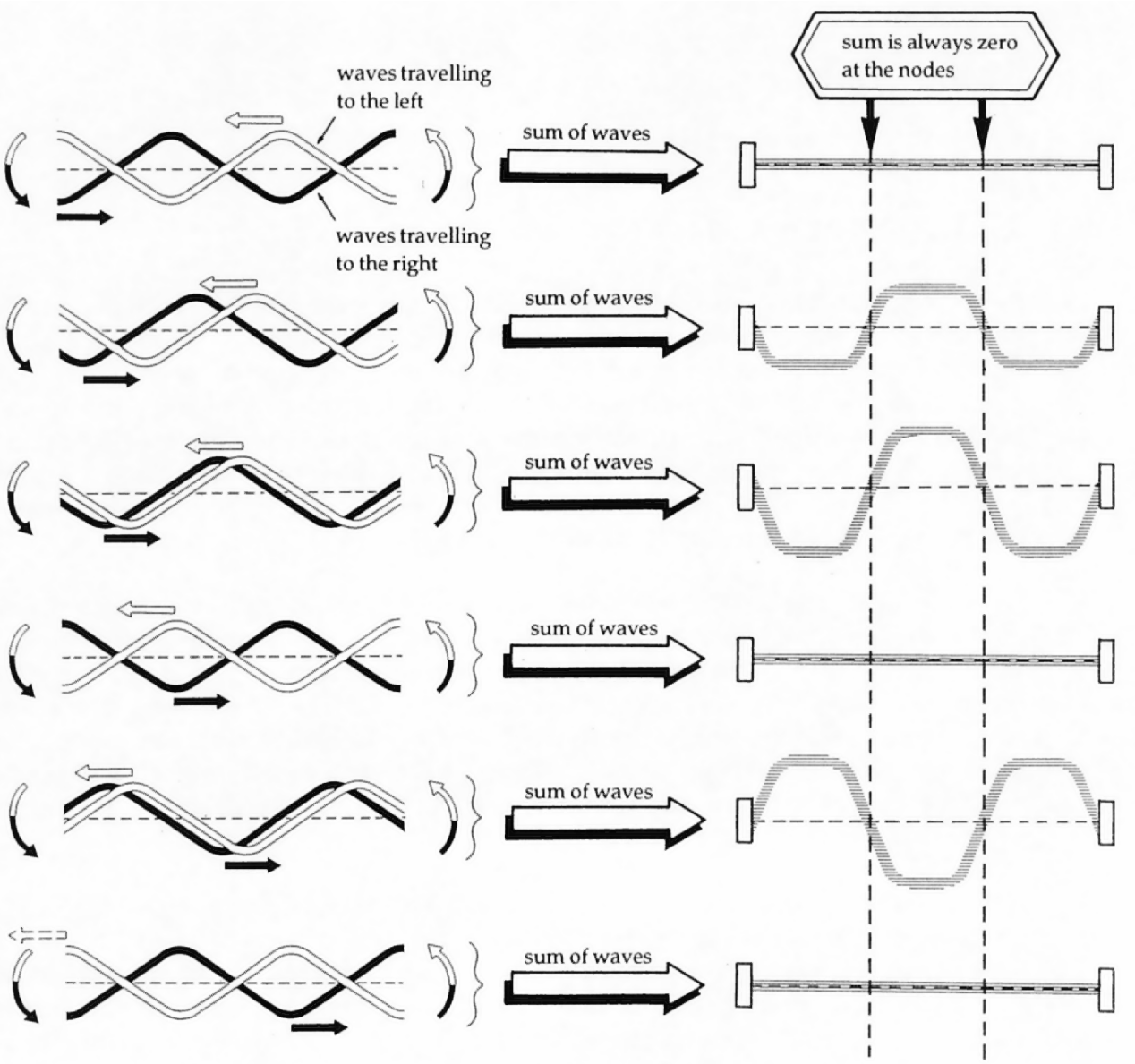


Fig. 11.1: When playing harmonics, several waves travel in each direction. The combination of these wave patterns produces nodes (zero points).

11.2 THE BOW'S CONTACT POINT FOR HARMONICS

It is not difficult to appreciate that when playing harmonics, it is of no use to bow at one of the nodes if one wants to activate the string in a pattern such as that shown in fig. 11.1. One can however choose any other point of contact, but it will generally be better to use one between the bridge and the nearest node to it. In order to find the position of this node, one must determine the point at which an ordinary note of the same pitch can be played either stopped (if the board is long enough), or as an 'Italian harmonic' (see 11.7). This applies to both natural and artificial harmonics.

This is particularly important when the harmonic is a high one (because the node may then lie well beyond the end of the fingerboard), or when playing pizzicato. A harmonic written as g'' (sounding g') on the G string, played by lightly damping the string (written ◇) at c', will have a node just where one usually plays jazz-pizzicato. This is useful to remember when having difficulty in getting a harmonic to speak (see Fig. 11.2).

It is, however, not sufficient merely to keep the bow away from the nodes. The rule still applies that the tone will be sharper with the bow nearer the bridge, or with the increased pressure (see 10.8). The latter will often be effective when trying to make a harmonic sound more like a normal note.

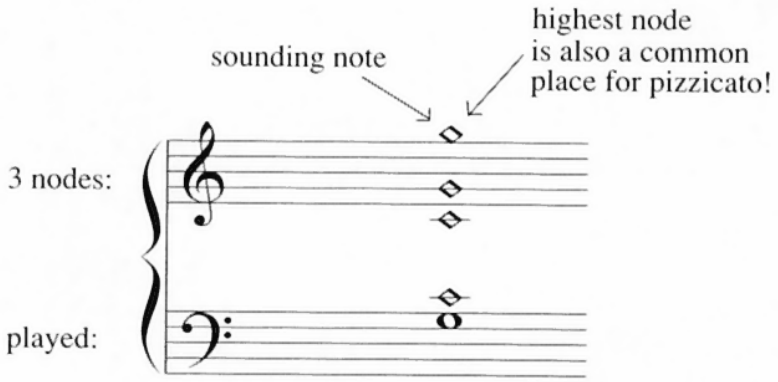


Fig. 11.2: Diagram showing nodes produced playing g'' on the G string.

11.3 BOW SPEED

Bow speed for a harmonic must be the same as if the note were stopped. For example, if fig. 11.2 was bowed after an open D string, the resulting interval would be two octaves + a perfect fourth. Had the high G been stopped (at the same pitch), it would have required considerably more bow speed than the open D: when this G is played as a harmonic, the bow needs also to travel faster if the optimum sonority is to be obtained.

11.4 NOTATION AND EXECUTION

Great confusion exists in the notation of harmonics. The fact that the double bass sounds an octave lower than written makes for extra bewilderment. Sometimes harmonics are written at sounding pitch, and sometimes showing how they are to be executed.

1 **Interval:** String - ◇	2 **Interval:** String - ○	3 **Number of usable nodes**	4 **Alternatives:** String - ◇
Minor third	2 octaves + fifth	2	
Major third	2 octaves + maj. third	4	Maj. sixth, maj. tenth
Perfect fourth	2 octaves	2	
Perfect fifth	Octave + fifth	2	
Major sixth	2 octaves + maj. third	4	Maj. third, maj. tenth
Minor seventh	2 octaves + min. seventh	6	Flat min. third, Aug. fourth, Oct. + min. third, Oct. + min. seventh
Octave	Octave	1	–
Major tenth	2 octaves + maj. third	4	Maj. third, maj. sixth.

Fig. 11.4(i): Table of harmonics

The table in fig. 11.4(i) will help clarify matters. It applies both to **natural harmonics** (i.e., notes available on open strings) and **artificial harmonics** (the thumb stopped and a harmonic played with one of the fingers).

Column 1 gives the interval between the note produced by the string (without harmonic) and the point where it must be stopped to produce the harmonic.

Column 2 gives the interval between the string's pitch without harmonic and the pitch of the harmonic.

Column 3 gives the number of nodes which can be used to produce the harmonic. (This applies, in practice, only to natural harmonics.)

Column 4 gives other intervals (defined as in column 1) which can be used as alternatives to produce the same harmonic. (This also applies, in practice, only to natural harmonics, exept in pizzicato. See also 4.15.)

Let us use this table on some practical examples (see the example of notation in fig. 11.4(ii)). The lower note determines the length of the string, and shows us that we should here use the open D. The sign ◇ (called a 'diamond', and usually 'open' or 'white', irrespective of the time value of the note) shows the point at which the harmonic must be stopped. The interval between these two is a major third. Look this up in column 1, and read off column 2 which says that the interval between the open string (D) and the harmonic note, is two octaves + a major third, i.e. it will sound f''-sharp **on the instrument** (see **b**). Column 3 tells us that this harmonic can be played at four places on the open D string: namely, with ◇ on F-sharp , on B, on f'-sharp or f''-sharp (see **c**).

This last position is also where one would produce the same note by playing normally, which is really not so strange, since this is always one of the possibilities (although very seldom feasible in the case of artificial harmonics). Column 4 indicates two alternatives only, since two octaves + a major third (given in column 2) is taken for granted (see d).

To take another example (see example of notation 11.4(iii)): the lower note does not exist as an open string, so the harmonic has to be produced artificially. The thumb is placed firmly on e'-flat (on the G string because it is thinnest and will therefore sound best) - and the third finger laid lightly on a'-flat. The interval between these is a fourth (see **a**). We then find from the the table that the harmonic sounds two octaves above e'-flat; in fact: e'''-flat (see **b**). Columns 3 and 4 do not interest us, as this is an artificial harmonic (see **c** and **d**). In this case care must be taken to keep the bow near the bridge, because the highest note, e'''-flat, lies beyond the end of the fingerboard.

This harmonic could also have been played as shown in fig. 11.4(iv) i.e. as a harmonic at the fifth, with the thumb on a'-flat and the third finger on e''-flat. (Check this with the table!) A harmonic at the fifth often speaks easier; and **the same (artificial) harmonic, on the same string, will always need the same stretch** between the thumb and the damping finger, regardless of whether it is played as a harmonic at the fifth, fourth, third or any other interval! The context must therefore decide which possibility we choose to employ. We could also (with the same stretch) have used a harmonic at the major third with the thumb on B - or one at the minor third with the thumb on A-flat. The reason for the stretch always being the same (provided the same string) is that it is always a stretch of half the wavelength of e'''-flat on the instrument.

Fig 11.4(ii)

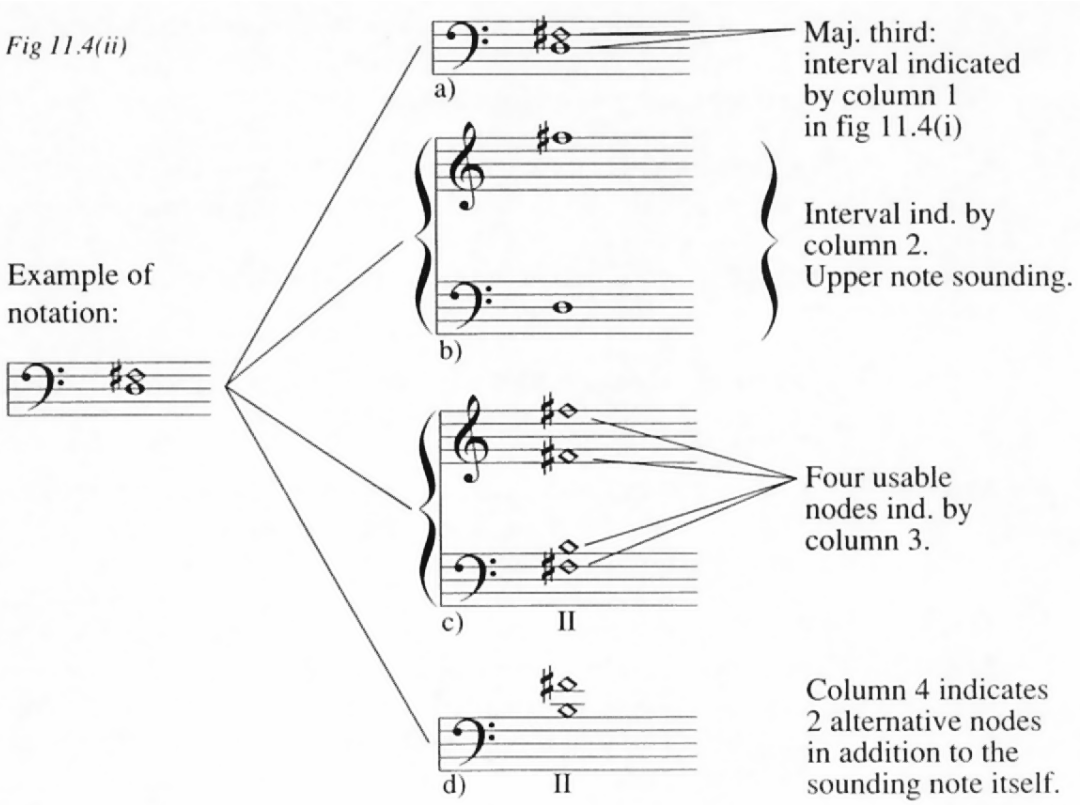


Fig. 11.4(iii)

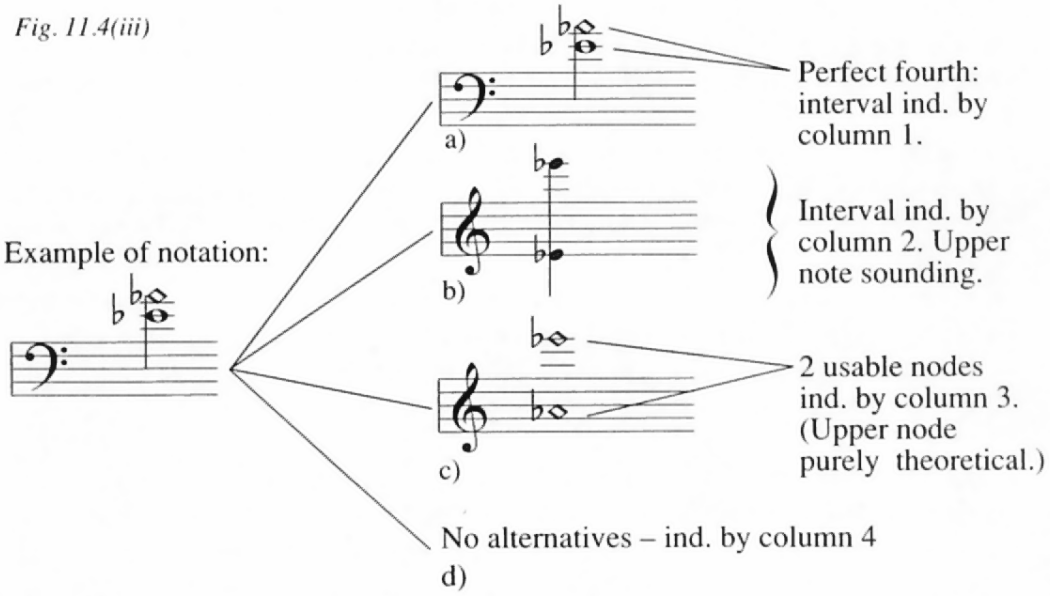


Fig. 11.4(iv)

Example of notation:

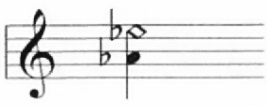


Fig. 11.4(v)

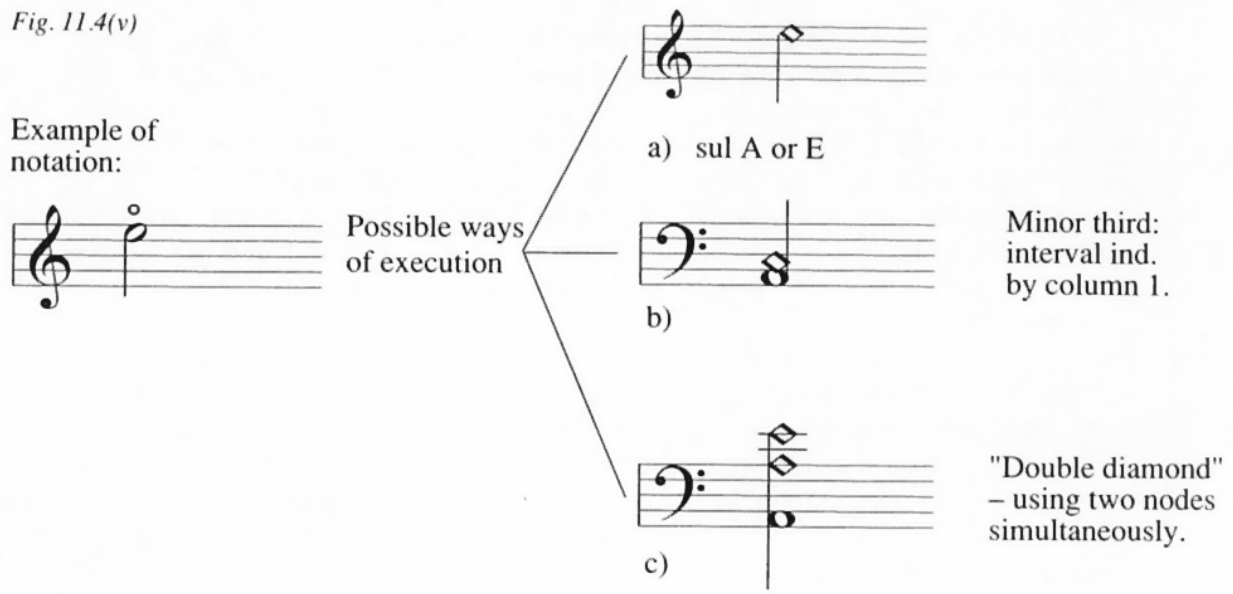


Fig. 11.4(vii)

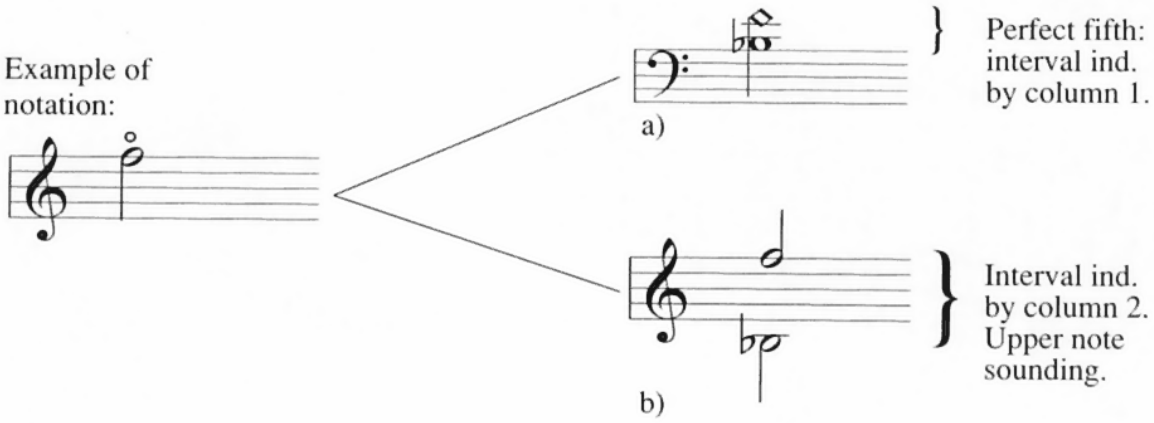
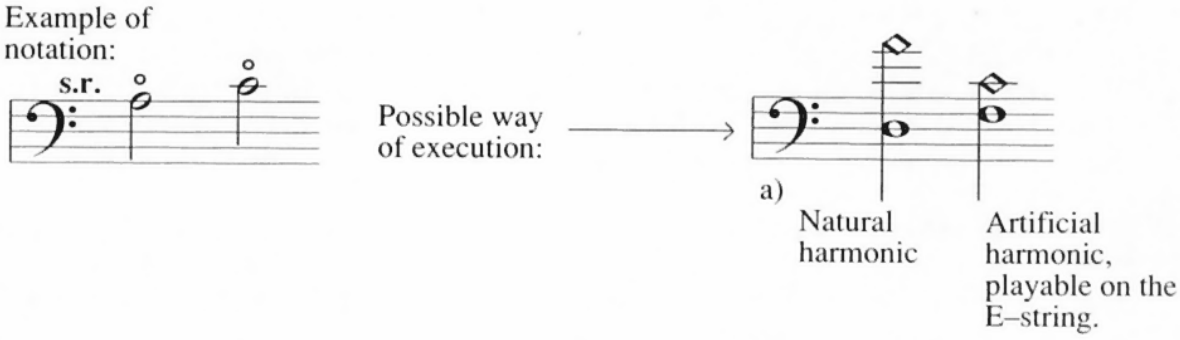


Fig. 11.4(viii)



In these examples we have shown a clear and unambiguous notation for harmonics. It expresses clearly how they are to be **executed.** Another method of notation is to put a circle over the note to be heard, implying that it is to be played as a harmonic. (N.B. open strings are also marked in this way!) Be on the lookout here, because if, in addition to the circle the note is marked "suono reale", "s.r.", "suono naturale", "s.n.", "real sound", "actual sound", etc., this means that the note **has not been transposed an octave for the instrument.** In other words, on the instrument it must be played an octave higher. On the other hand, if there is **only** a circle over the note, it is to be played as is usual on the instrument.

Consider a further example (fig. 11.4(v)). This note is marked only with a circle, without any other instructions, and may therefore be considered as transposed for the instrument. (Unfortunately, it sometimes happens that composers get a bit muddled over this.) The note exists as a natural harmonic on the A string (and also on the E string, where it is not so easy to execute). On the A string it can be played as a harmonic at the minor third (see column 1 of the table) or where it is written. The latter is easier to execute. It will however very often be more convenient to play this using two of the nodes (see **c**) where both the thumb on A **and** the third finger on e′ damp the string lightly. The result is like a harmonic at the fifth with the thumb firmly depressed on A, but this version is easier to play in tune - and also considerably easier to find than a harmonic at the minor third, with the diamond on C. Compared with playing this harmonic where it is written, the advantage is that one perhaps avoids getting resin on one's fingertips!

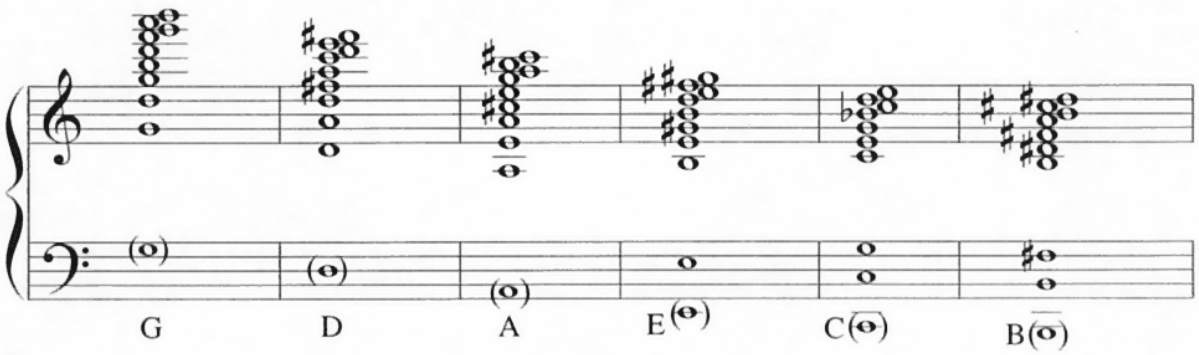


Fig. 11.4(vi): Table of natural (open strings) harmonics.

The natural harmonics on the open strings must be memorised. They are shown in fig. 11.4(vi), and are the same as the overtone-series of each open string. Consider fig. 11.4(vii). This f″, cannot be played as a natural harmonic. A useful way of finding it as an artificial harmonic (at the fifth) is: reckon an octave downwards, to f′, and place the third finger lightly at that point, reckon a further fifth downwards (to B-flat) and put the thumb firmly down there. Do all this on the highest string on which the stretch can be managed. (In this case most probably the A string.) The execution is then as shown in **a**.

The first note in fig. 11.4(viii) is marked with the abbreviation "s.r." as well as the circle (s.r. = "suono reale", or the plural "suoni reali", which means 'real sound'). This means that we must reckon it, on the instrument, as an octave higher, i.e. a′. This note exists as a natural harmonic, both on the D string and the A (cf. fig. 11.4(vi)).

The last note c' must also be "suono reale", since this is marked for the note before. So we have to think c" on the instrument - and find it as an artificial harmonic at the fifth (unless we have a low C string, in which case we can play it as a natural harmonic). Place the third finger lightly on c' and the thumb firmly on F - on the E string. This is just about the lowest artificial harmonic which can be played by a hand of normal size on a four-stringed instrument. We can, however, play B (suono reale) as a natural harmonic, so that with a four-stringed instrument tuned in the normal 'orchestra tuning', we can play harmonics chromatically from that note and upwards. (Tell your composer friends!)

In the examples above, the notation has been unambiguous. However, it often happens that harmonics are written only with a diamond ◇ without specifying which string they are to be played. In such cases one can usually assume that they are harmonics at the minor or major third, or the fourth or fifth, and this will determine the string. Unfortunately it does sometimes happen that the diamond is intended to indicate a harmonic at the octave, or the major sixth, thus introducing an element of uncertainty! If the sign ◇ is employed, the string should be specified by one means or another, either by writing I, II, III or IV string beneath or beside the note; or by letters G, D, A or E (sometimes sul G, sul D, etc.). The disadvantage of this method of notation is that there will often be doubt about the time values of the notes, as the diamond most often has a white ('open') head.

11.5 EXERCISE IN HARMONICS

Fig. 11.5 (page 112) is a harmonic exercise which introduces awkward string crossings. In each bar one finger can remain on the string. Notice the use of the thumb on c'" (on the D string with a diamond on c") and the first finger on e'" (on the D string with a diamond on e"). It is very often convenient to play these notes in this way (the Dragonetti concerto is one example). N.B.: the hand is kept in position the whole time; the thumb **alone** is moved backwards for the harmonic c'".

Also transpose this exercise to the lower strings and notice that the harmonics of the thicker strings speak more easily if they are fingered a bit from the side.

11.6 INTONATION

Natural harmonics are as a rule in tune - contrary to what players often think. There are however several reasons why they can sound too low, in practice:

– The harmonic sounding two octaves + a major third above the open string sounds in **just intonation** and therefore often conflicts with equal-temperament instruments like the piano. The difference between a major third in equal temperament and in just intonation, in a major triad, is equal to the difference between a = 440 Hz and a = 436.5 Hz, and can be painfully noticeable. If the accompaniment is a piano part containing the same note as this harmonic (at two octaves + a major third), the result can often be considerably improved by omitting it in the piano.

– The harmonic at two octaves + a minor seventh always sounds flat, and should be avoided for long notes, when playing with accompaniment. All the other harmonics

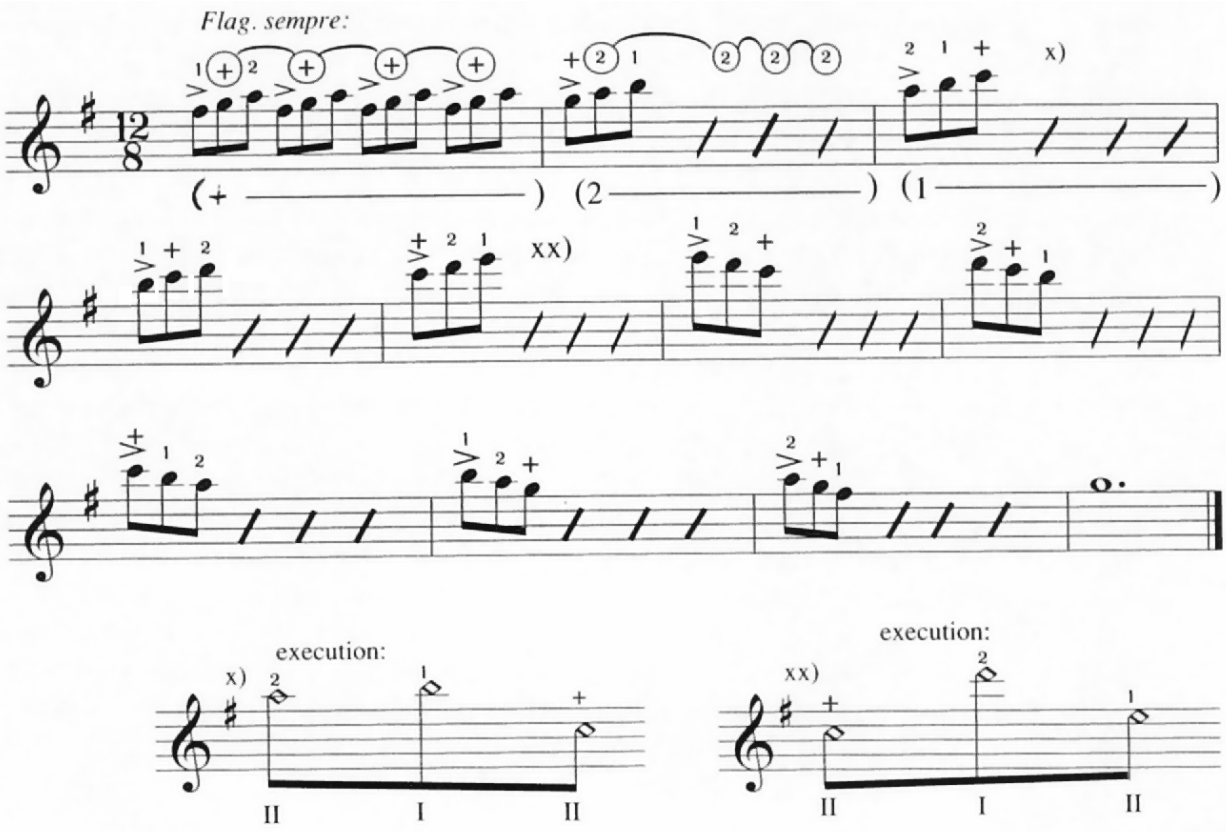


Fig. 11.5: Exercise in harmonics.

are 'correct' and go perfectly well with accompaniment, whether of equal temperament or just intonation.

– If one tunes the instrument by open strings (instead of harmonics), one often tunes too low, because the open strings are rather unstable and can easily be forced upwards in pitch. The harmonics are more stable.

– When playing with other stringed instruments, one's harmonics may well sound flat, because other players sometimes press the pitch upwards by degrees. In such cases it will pay to anticipate, and to tune rather sharper, beforehand. If this proves insufficient once can press the string slightly at the node (preferably sideways), so as to tighten it, and thus raise the pitch.

11.7 ITALIAN HARMONICS

An 'Italian Harmonic' is not in fact a harmonic at all, a note produced by an old technique designed for playing other notes that lie off fingerboard. The playing finger presses the string **firmly to the side** instead of onto the board. The thumb can quite well lie on the string in the usual way, as the string will have no nodes and will vibrate only between the bridge and the playing finger. See fig. 11.7. Vibrato should be used to avoid dullness of tone.

Fig. 11.7: Hand position when playing "Italian Harmonics"