It is for this reason that the exercises in Chapters 4 and 5 are to be performed without vibrato. It is important to develop the physical aspects of flute playing without the mask of vibrato, which can obscure the basic sound making it difficult to measure the true quality of the tone.

**The Physical Means of Changing Registers**

The article *The Flute Embouchure and the Soda Straw* by Richard Hahn uses experiments with a soda straw and the embouchure of the flute to illustrate various properties of flute sound production. Hahn later incorporated the information in the article into his method book *Practical Hints on Playing the Flute*. The reader can easily use the following illustrations to help understand some of the underlying physical principles involved.

First, a soda straw should be flattened at one end so that the opening is an elongated oval. This end will be used to angle the air stream into the head joint of the flute. The flutist will blow into the other end and direct the air toward the opposite wall of the blowhole. The far wall of the embouchure hole should split the air so that approximately half of the air stream goes into the flute and half blows over it.

The first means of changing registers on the flute is simply to blow harder. The straw should remain at the same relative angle to the embouchure hole while the flutist blows harder to produce the next octave. Figure 3.19 shows the straw at the same angle

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for both high and low notes, while the force of the air stream is greater for the high octave.

Figure 3.19. Flute head joint with straw. The same angle of the air stream can produce both the fundamental and the octave higher. Simply blowing harder produces the higher octave.

The flutist will notice that this method of changing octaves is quite inefficient, as a great amount of additional force is required to change the octave. Fletcher states that the flutist has to blow four times harder to produce the next octave. The resulting sound is also rather blatant, tending toward sharpness. The flutist should try this method of changing octaves with the assembled flute while keeping the lips set in one position. The inefficiency of this method will immediately become apparent. The difficulty of obtaining a viable sound quality using this method of achieving notes in the higher registers will also become quite clear.

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Figure 3.20 demonstrates another means of achieving the higher octave. This means is through changing the angle of the air stream. Angling the air stream more across the blowhole will produce the higher octave. Again, the flutist should try this method of changing registers with the assembled flute using the lips directly. This method also proves to be very inefficient as it is nearly impossible to change the register solely through angling the air stream with the lips.

![Flute head joint with straw.](image)

The third means of changing octaves utilizes a less well-known property of acoustics. By moving the source of the air stream closer to the far wall of the embouchure hole, the upper partials of the sound can be produced. Mr. Aitken uses this principle to aid in the development of an automatic embouchure. Since the actual amount of distance that the lips need to move is so small, the flutist has great control over this mechanism and this becomes the most efficient of the three methods of changing octaves.

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The flutist can also set the lips at nearly the point where the next octave is achieved to aid flexibility, as the lips need only to move the minimum distance possible.

Figure 3.21 illustrates this principle. To demonstrate, the flutist uses the straw to blow the fundamental note of the head joint. The flutist should then move the straw closer to the far wall of the embouchure plate. After the straw moves forward somewhat, the next octave should sound. Further experimentation should reveal a point at which the straw can move an infinitesimal amount to change from the low octave to the high octave and back again. This should demonstrate to the flutist the very least amount of lip motion necessary to change registers. The straw on the left, which produces the fundamental note of the head joint, is covering approximately one–third of the embouchure hole. The straw on the right producing the higher octave is covering about one–half of the embouchure hole.

Figure 3.21. Flute head joint with straw. The decreased distance between the source of the air stream and the far wall of the embouchure plate produces the higher octave.
The simple means of reproducing this action with the lips is through the lowering of the upper lip into the lower lip. The downward pressure of the upper lip makes the lip opening smaller. This in turn builds air pressure behind the lower lip and pushes it, and the upper lip, forward. The lip movement will occur if the lower lip is relaxed and both lips are unencumbered by the teeth or the embouchure plate. This action decreases the distance to the far wall of the embouchure plate, allowing the upper partials to sound.

Figure 3.22 shows this principle translated into the actual movement of the lips. To produce the fundamental note, the lips cover approximately one-third of the embouchure hole in the photo on the left. In the photo on the right, the upper lip has moved down into the lower lip. The resulting build up of air pressure has pushed both lips forward to decrease the distance between the lips and the far wall of the embouchure plate and the higher octave sounds. The increased velocity of the air stream caused by the smaller lip opening also aids the production of the higher octave.

Figure 3.22. Flute head joint with lips. The lips move forward with increased air pressure to shorten the distance from the source of the air stream to the strike wall. This, in conjunction with the increased velocity of the air stream, produces the next octave.
Another point that Hahn makes in the article is that the tone color can be controlled with the size and shape of the lip opening of the embouchure. The flutist can use progressively smaller straws with progressively flatter tips to demonstrate this point. A larger, rounder tip opening will produce a sound devoid of upper partials, while a smaller wider opening will produce “an ‘edgy’ sound with many upper partials.”

Figure 3.23 shows a relatively large lip opening that was used to produce a low G. The resultant frequency spectrum, shown on the right, indicates a relatively muted harmonic texture marked especially by a large drop in the decibel level of the second partial.

Figure 3.23. Lip opening and frequency analysis of G₄. A relatively large lip opening for low G produced the frequency spectrum on the right.

Figure 3.24 shows the effect produced on the frequency spectrum by making the lip opening smaller. The most well defined effect is that the second partial becomes louder,

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8 Hahn, *The Flute Embouchure*, 49.
matching the volume level of the fundamental. The result of this change in tone color is that the listener will tend to hear a brighter sound.

Figure 3.24. Lip opening and frequency analysis of G4. Using a smaller lip opening for low G produced the frequency spectrum on the right. The most noticeable difference from the Figure 3.23 is the increased loudness of the second partial. This should result in a brighter sound.

This particular change of tone color brought about through a change only in the size of the lip opening can help the flutist play with a minimum of two tone colors. The less bright tone color achieved through the larger lip opening can be used by the flutist for a blending tone quality, while the brighter tone color achieved through making the lip opening smaller can be used for a more penetrating soloistic tone. Further experiments by the flutist using changes in the size and shape of the lip opening coupled with changes in the relative size of the opening of the vocal tract can help the flutist develop a palate of tone colors.