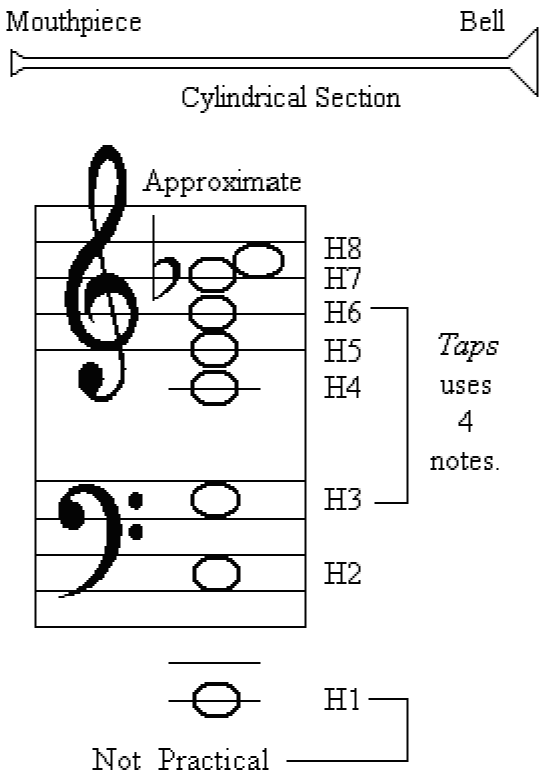
X. Brass

Early brass instruments were pipes of fixed lengths (see Fig. X-1). Today four very common brass instruments are found in the orchestra: the French horn, trumpet, trombone, and tuba. These each have a mouthpiece, cylindrical section, and bell end.

The trombone externally extends to increase length, while the trumpet uses valves to include more internal pipe sections in the resonance. The French horn and tuba likewise use valves. Focusing on the trombone and trumpet will give us an understanding of the two different methods employed by the brass instruments to obtain different pipe lengths for different notes.

Due to complicated effects, all harmonics are present for brass instruments; however, the fundamental is hard to access for typical use. For practical purposes, the player is restricted to the overtones (Fig. X-1) for a fixed-length pipe. Songs such as *Taps* were composed using just overtones for the older brass instruments.

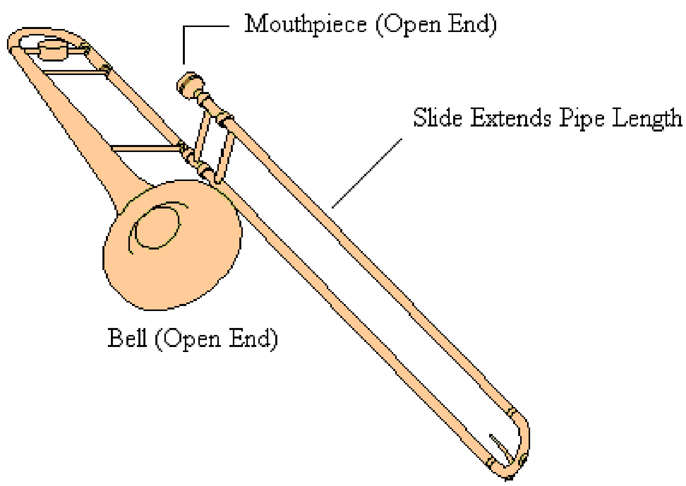
Fig. X-1. Early Horn.



Trombones

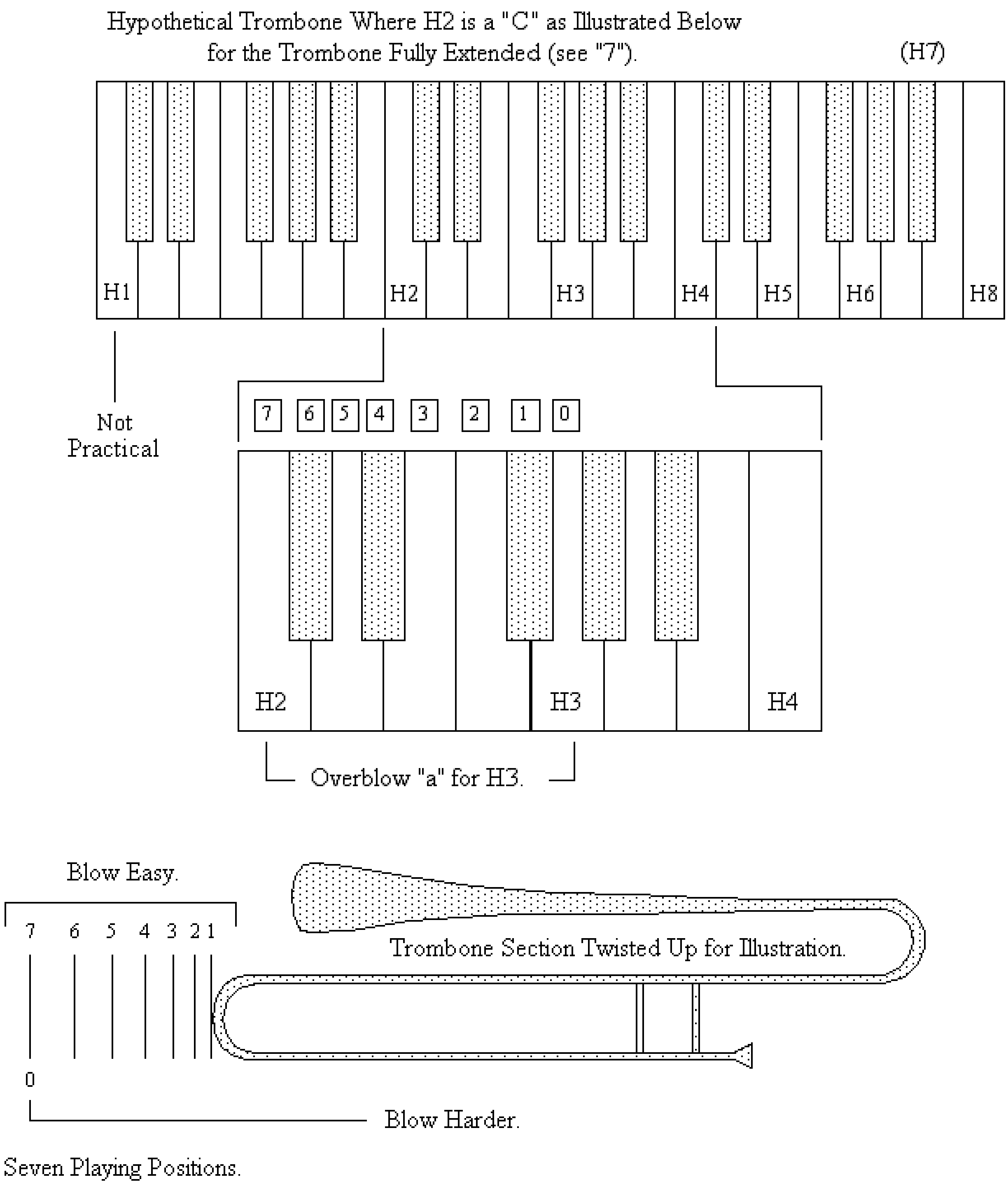
1. Trombone: The Physics. Fig. X-2 illustrates how the restriction to one set of overtones is removed in the trombone by the slide. Pipe length is adjustable to obtain more tones.

Fig. X-2. Trombone.



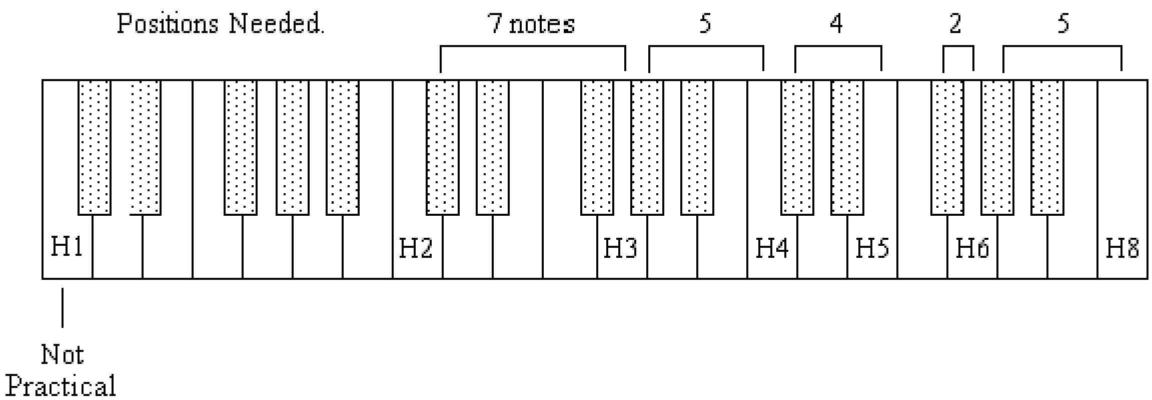
2. Trombone: Producing the Musical Tones in the Scale. We have transposed the harmonics to fall on convenient notes in Fig. X-3. We choose H2 to be a "C" for the fully extended trombone. The length is reduced to fill in the notes of the chromatic scale between H2 and H3 indicated on the keyboard of Fig. X-3.

Fig. X-3. Trombone Playing Positions.



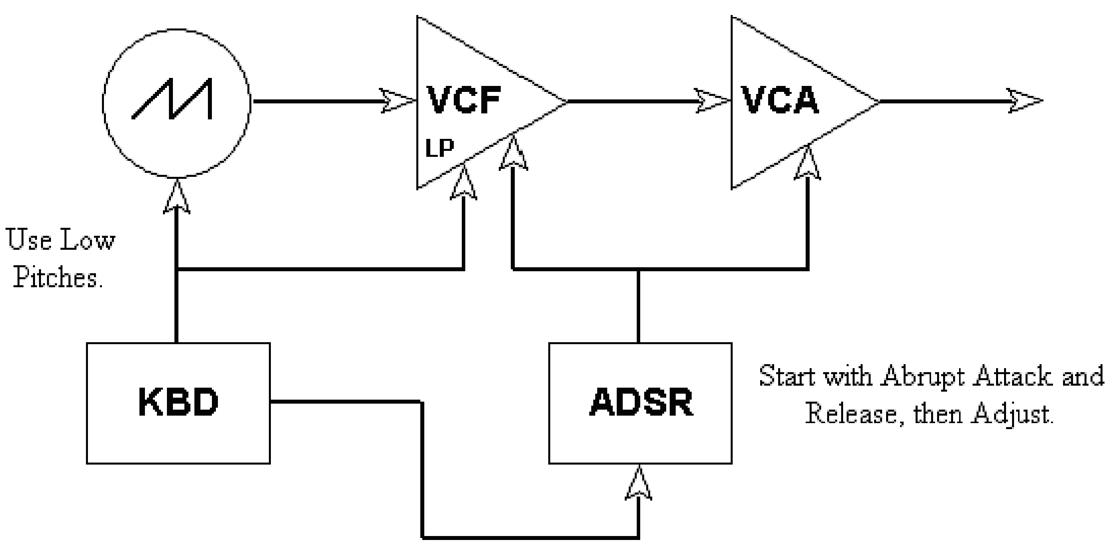
3. Trombone: Extending Musical Range. In Fig. X-3 the extended positions increase the pipe length by our equal-tempered 6%-"interest" amount. This drops the tone a half step each time. Note how the increments in length grow from position 1 to 7. This is gaining "interest on interest." Think of the 7 positions as the capability to achieve 7 half steps. By blowing harder into the trombone, harmonic jumps are achieved. The playing positions are used to fill in the half steps from harmonic to harmonic. Fig. X-4 indicates how the number of half steps decreases as you go higher. Note that H7 is avoided. The trombone can reach 3 octaves in this way. The real trombone starts on an "E_2," not a "C."

Fig. X-4. “Hypothetical” Trombone (H2 on “C” for Position 7) Extending Its Range.



4. Trombone: Synthesis. To synthesize a trombone-like sound we choose the "raspy" ramp wave (see Fig. X-5). The ADSR shapes the filter and the VCA. The timbral change gives a characteristic brass "vah-rump" sound. The ADSR is varied to get the desired effect. The lower harmonics are emphasized due to the low-pass filter.

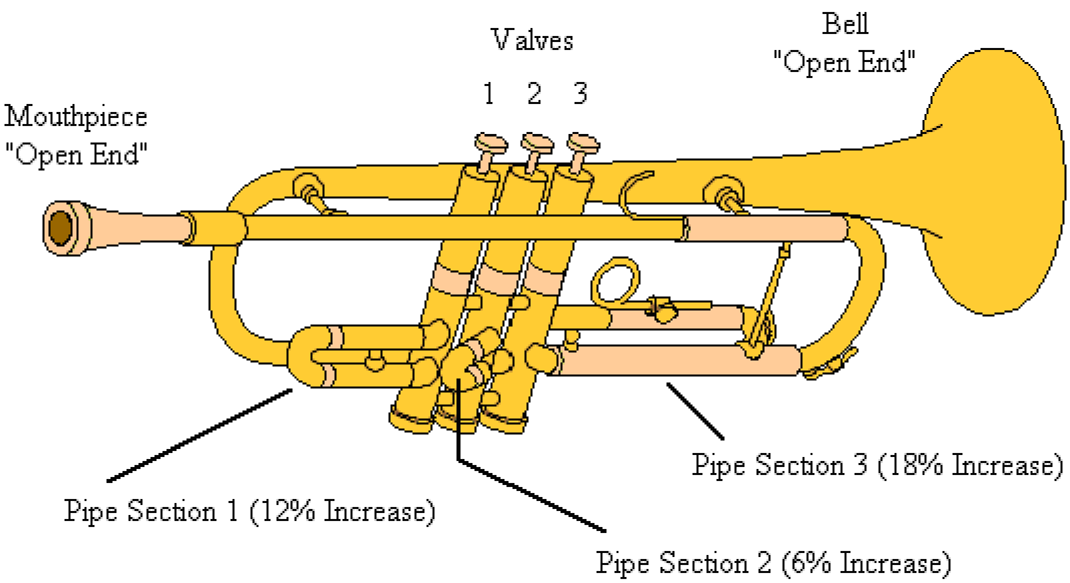
Fig. X-5. Synthesizing a Trombone-Like Sound (Staccato Effect)



Trumpets

1. Trumpet: The Physics. The trumpet uses valves to increase the length of the pipe. Pressing a valve increases the internal pipe length (see Fig. X-6). When no valves are pressed, the trumpet has its minimum or base length. Valve 1, when pushed down, allows a pipe section to join the internal path, which increases the base length by approximately 12%. The three valves provide increases of 6%, 12%, and 18%. These are multiples of our "interest rate" of 6%. They allow for frequency changes of a half step, whole step, and whole + half step respectively. Note that the smallest percentage increase goes with valve 2, the one in the center.

Fig. X-6. Trumpet.

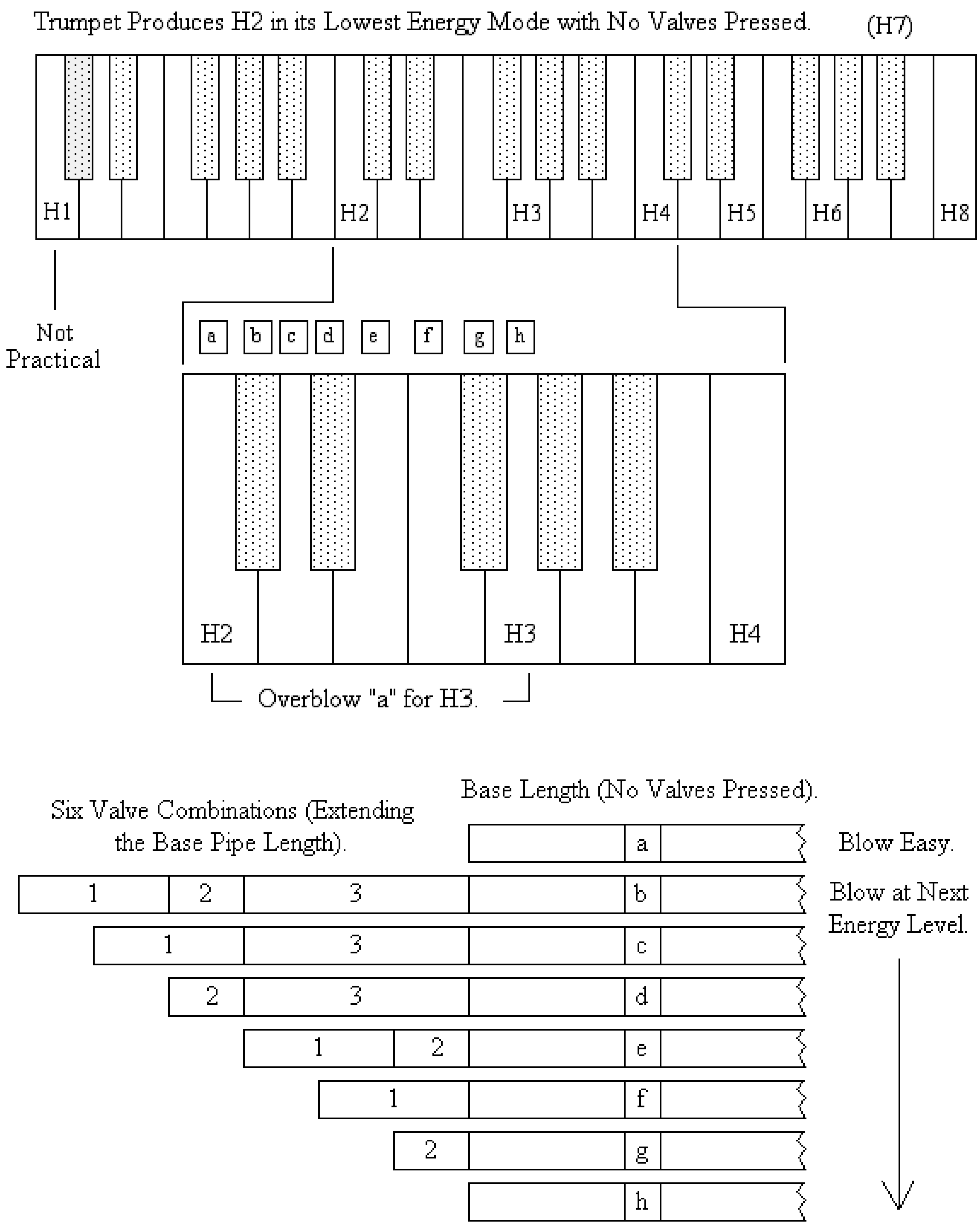


Why 3 valves? We know from the trombone that a base length can give us H2 and H3. So we need 6 additional playing positions to fill in the gap between H2 and H3. To reach these 6 half steps going down from H3, we need to increase the base length by (forgetting little extra gains by the "interest-on-interest" effect) 6%, 12%, 18%, 24%, 30%, and 36%.

The little additional percentages needed by the gain of "interest-on-interest" effect can be compensated by blowing technique. How can we obtain these 6 percentages with the minimum number of building blocks? The answer is 3, choosing as units 6%, 12%, and 18%. You get 24% by adding the 6%-unit to the 18%-unit, 30% by combing the 12%-unit with the 18% unit, 36% by adding all three units: 6% + 12% + 18% = 36%. This is a very elegant application of basic mathematics and physics to instrument design. In practice, the 18%-unit is saved until you need 24%. To achieve 18%, the 6%-unit is combined with the 12%-unit. It gives a better match due to the ways the precise percentages are chosen in order to minimize the "interest-on-interest problem."

2. Trumpet: Producing the Musical Tones in the Scale. The trumpet has 7 basic playing positions, like its cousin the trombone, to span the notes from H2 to H3. See Fig. X-7. The H2 on the keyboard corresponds to base length rather than full "extended" length as it did earlier for the trombone. We do this because Fig. X-7 is an actual trumpet.

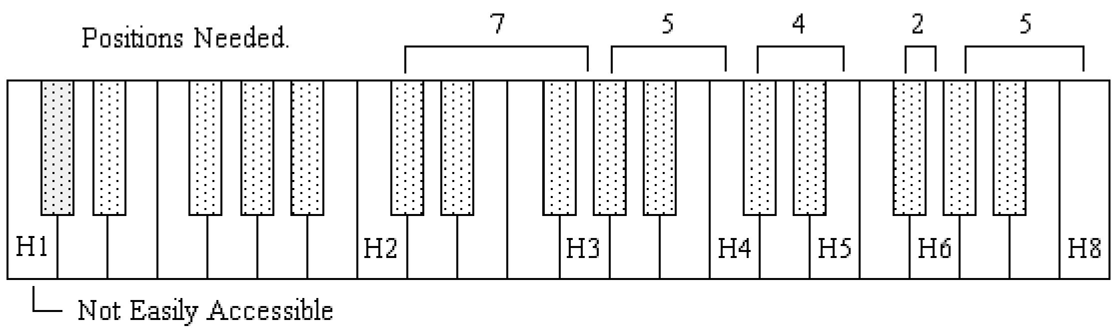
Fig. X-7. Trumpet Playing Positions.



3. Trumpet: Extending Musical Range. Blow the trumpet with no valves pressed (position "0") hard enough to obtain H3 (see Fig. X-8). Now press all 3 valves (1-2-3) to lower the tone 6 half steps (which is roughly a 36% increase in length, 6% per half step). This gives the note to the immediate right of H2 in Fig. X-8.

Proceed to decrease pipe length by 6% each time to raise the pitch note by note to H3. Fig. X-7 gives these valve configurations, which decrease the length by 6% each time: 1-3 (total pipe length is 30% beyond base length), 2-3 (24%), 1-2 (18%), 1 (12%), 2 (6%), and 0 (0%). Now blow harder to get H4 (no valves used). You have skipped the tones between H3 and H4. So we need to drop 4 half steps to get to the note immediately right of H3. This is 4 x 6% = 24% (increase in length), valve configuration 2-3. We then proceed with 6% decreases in length to march up to H4. These are 1-2 (18%), 1 (12%), 2 (6%), and 0 (0%). Blow even harder with no valves and get H5. To get the 4 notes from the note after H4 to H5, we just need 1-2 (18%), 1 (12%), 2 (6%), and 0 (%). Then, blow harder to get H6. Can you figure out which configurations are next. If so, you know how to play the trumpet theoretically!

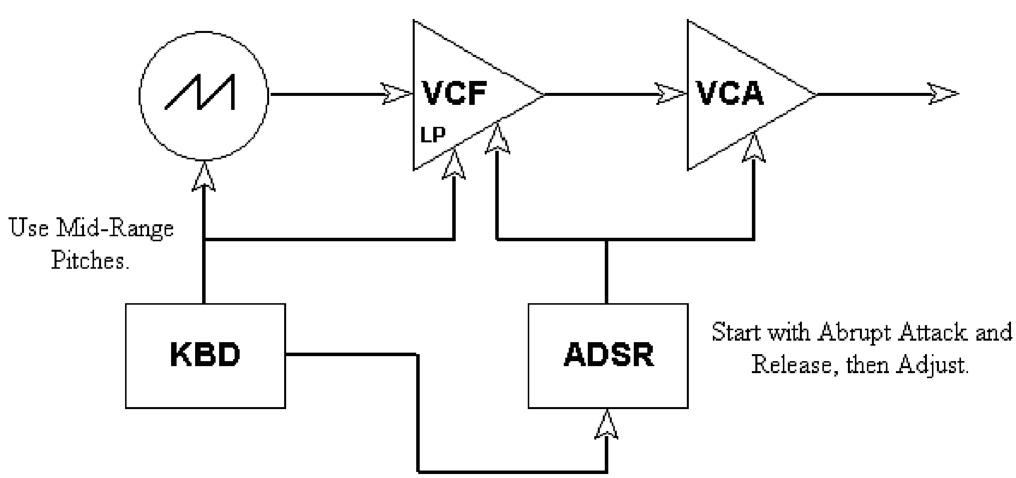
Fig. X-8. Extending the Trumpet's Range by Overtones and Values.



4. Trumpet: Synthesis. The arrangement (Fig. X-9) is the same as that for the trombone except we use mid-range pitches.

We obtain lower harmonics by employing the low-pass (LP) filter. Remember that the ramp wave is rich in harmonics.

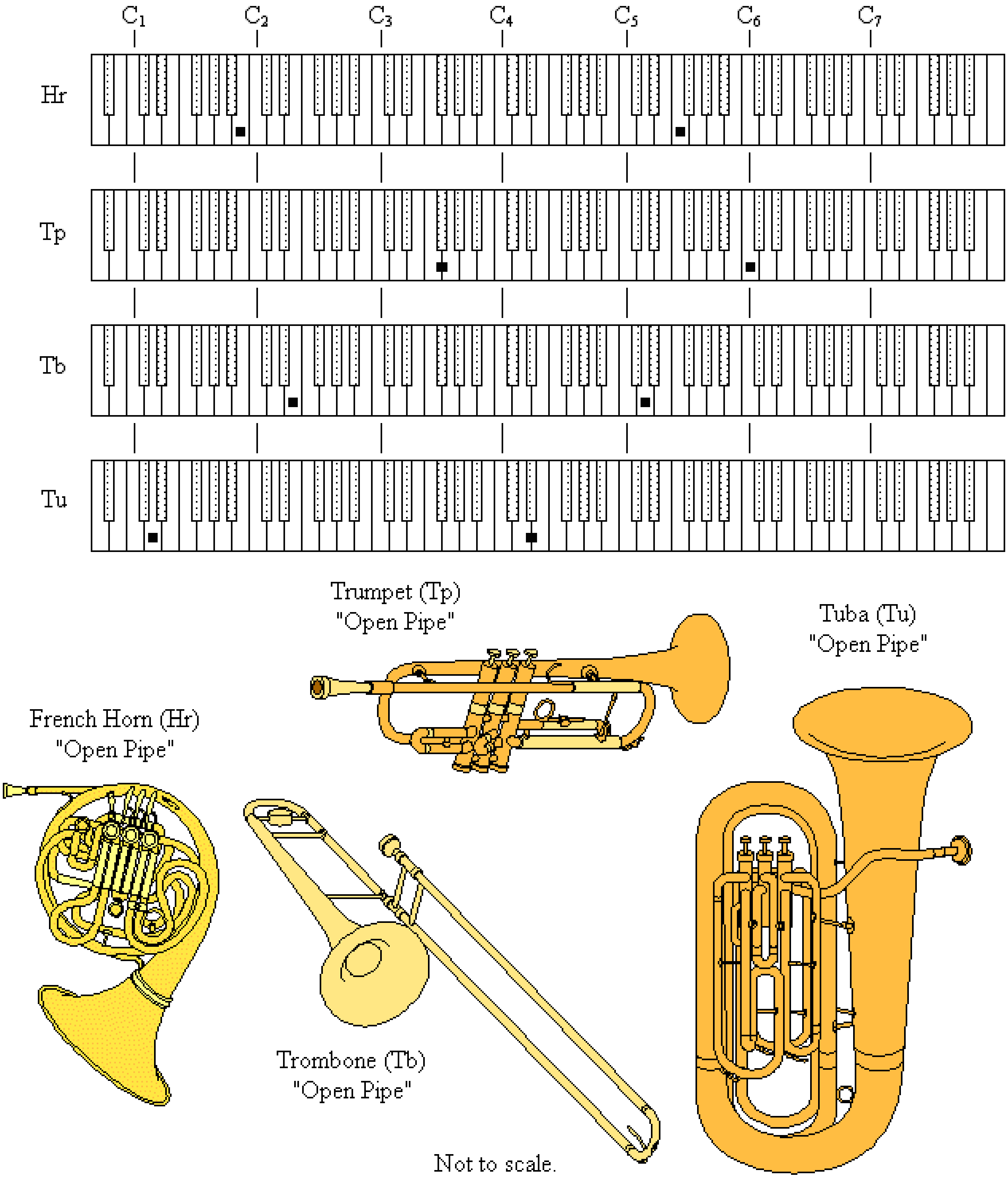
Fig. X-9. Synthesizing a Trumpet-Like Sound (Staccato Effect).



The Brass Choir

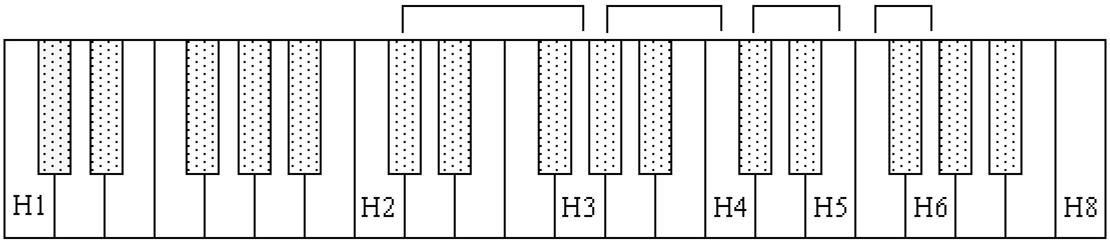
The “choir of brass” is shown below. in Fig. X-10. Think of this analogy with a choir of singers: trumpet (soprano), horn (alto), trombone (tenor), and tuba (bass). The convention is to place the horn at the top even though the trumpet reaches higher notes.

Fig. X-10. Brass Ranges.



An Exercise

Give the number of tone holes or playing positions needed to span each of the intervals in the table below. Note that the last note in each span is obtained by blowing harder on the configuration of the instrument needed to obtain the lower harmonic listed for each span.



Description	Number	Interval
Flute Tone Holes to Fill Gap Between H1 and H2		Octave
Clarinet Tone Holes to Fill Gap Between H1 and H3		Octave + Fifth
Brass Playing Positions to Span from H2 to H3		Fifth
Brass Playing Positions to Span from H3 to H4		Fourth
Brass Playing Positions to Span from H4 to H5		Third
Brass Playing Positions to Span from H5 to H6		Minor Third

--- End of Chapter X ---

