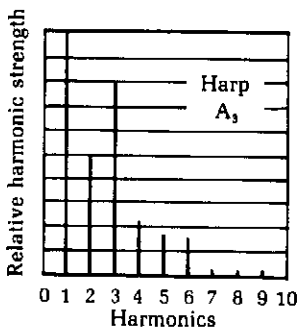

Figure 6.3 A harp.

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hardwood along the center of the soundboard. The upper ends are attached to pegs on the curved neck. There are 46 strings encompassing 6½ octaves from C_1 to G_7.

The hollow pillar carries seven rods connected to seven foot pedals. Each pedal acts on one particular note and all the other strings that are octaves of the note. In this way, all the strings may be changed by using only seven pedals. The rods operate the transposing disks arranged all along the neck as shown in Figure 6.4. Each pedal may be depressed to one of two notches. The first causes disk 1 to come in contact with the string, thus shortening its vibrating length and raising the pitch a semitone. Since the harp is normally tuned to the key of C flat major (that is, all the notes are flats), depressing all seven pedals to the first notch raises all the notes by a semitone to C major. If the F pedal is now depressed to the second notch, the second disk

from John Backus, The Acoustical Foundations of Music (1977)

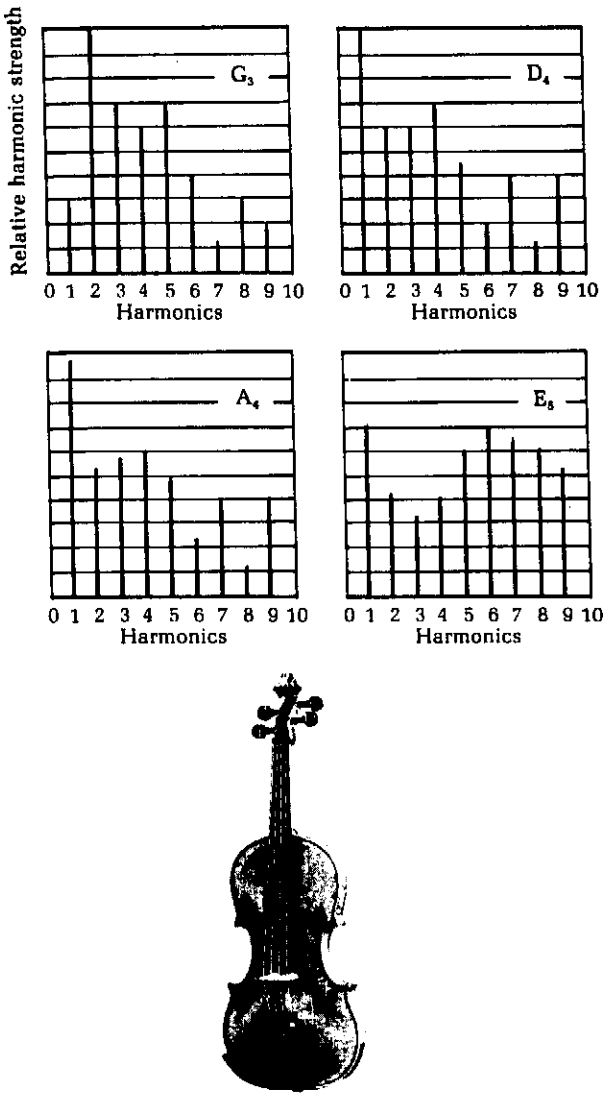

Figure 6.13 The violin (above) and the viola, cello, and double bass (opposite page).

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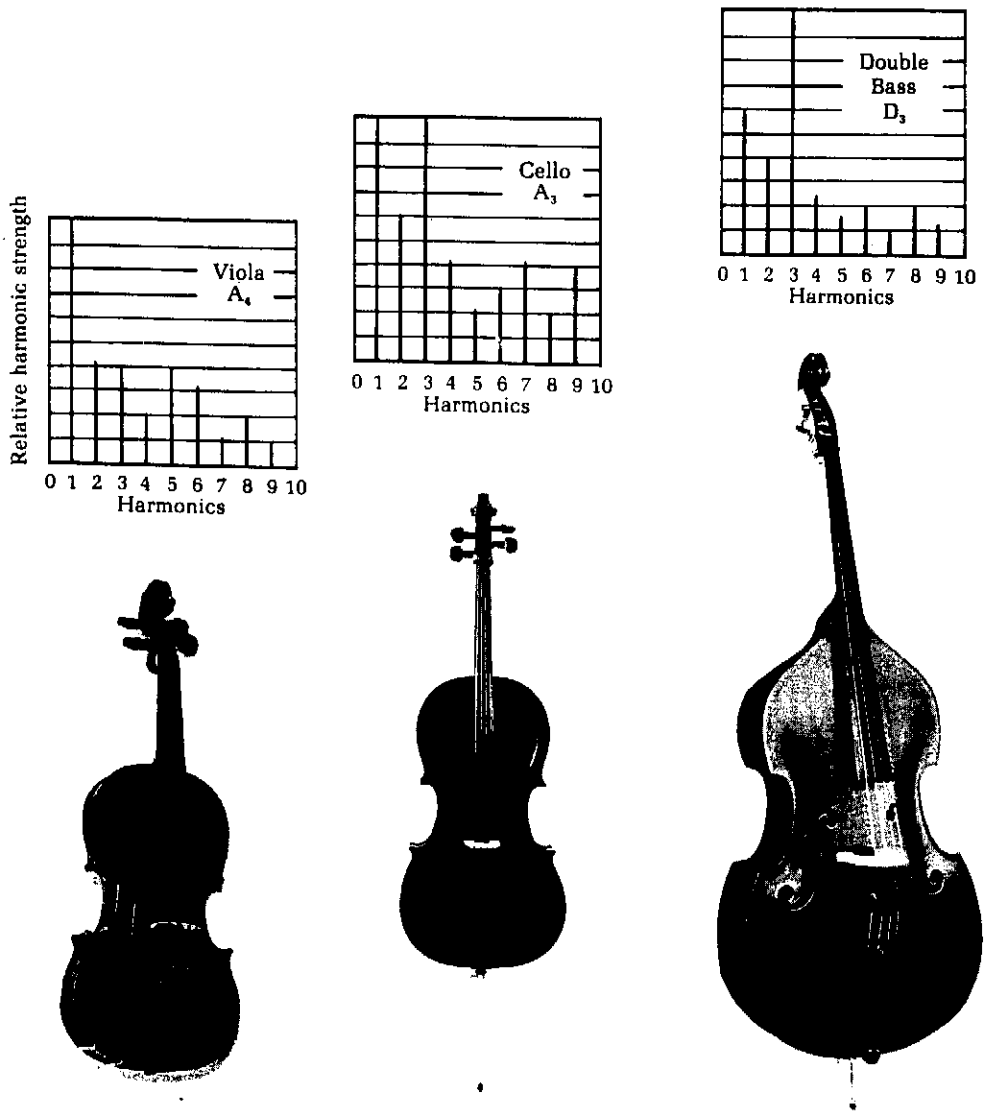
Relative harmonic strength
Viola
A_4
0 1 2 3 4 5 6 7 8 9 10
Harmonics
Cello
A_3
0 1 2 3 4 5 6 7 8 9 10
Harmonics
Double
Bass
D_3
0 1 2 3 4 5 6 7 8 9 10
Harmonics

of pipe to length) is about 1/30. When the flute is played softly, the waveform is close to a pure sine wave, whereas when it is played loudly, higher harmonics are excited. The metal flutes, especially the silver ones, appear to have more higher overtones than wooden ones do. Figure 7.5 shows the flute and the piccolo with their harmonic spectra at a particular frequency.

The tone quality of the instruments in the flute family is characterized by strong fundamental and second harmonics—the third, fourth, and fifth harmon-

Piccolo

Flute

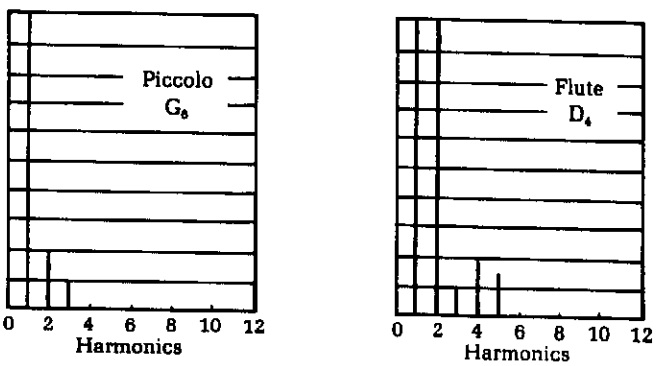

Figure 7.5 The flute and piccolo.

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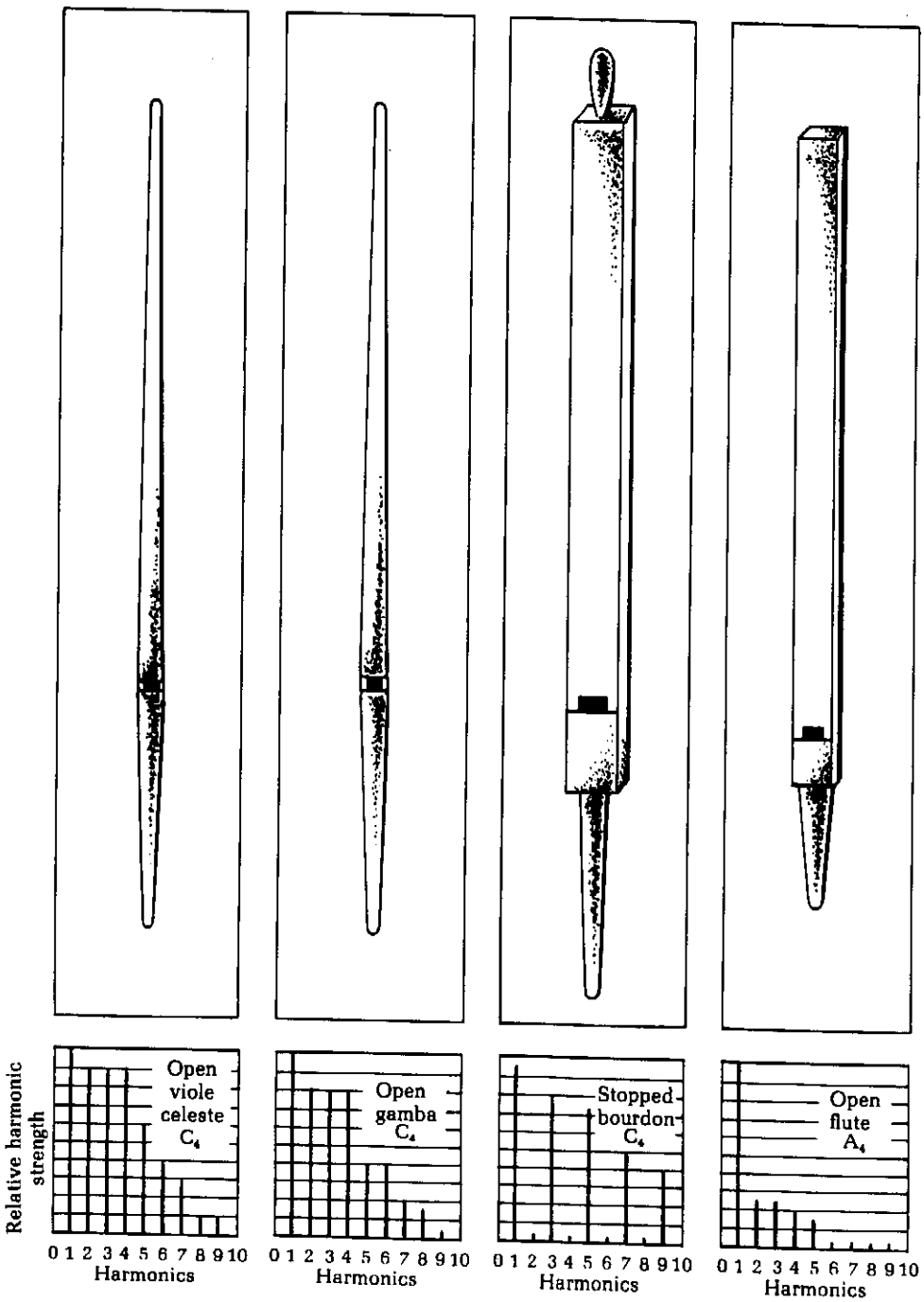

Figure 7.4 Flue organ pipes.

Harmonic spectra from data given by C. P. Boner, JASA, *10 (1), 1938.*

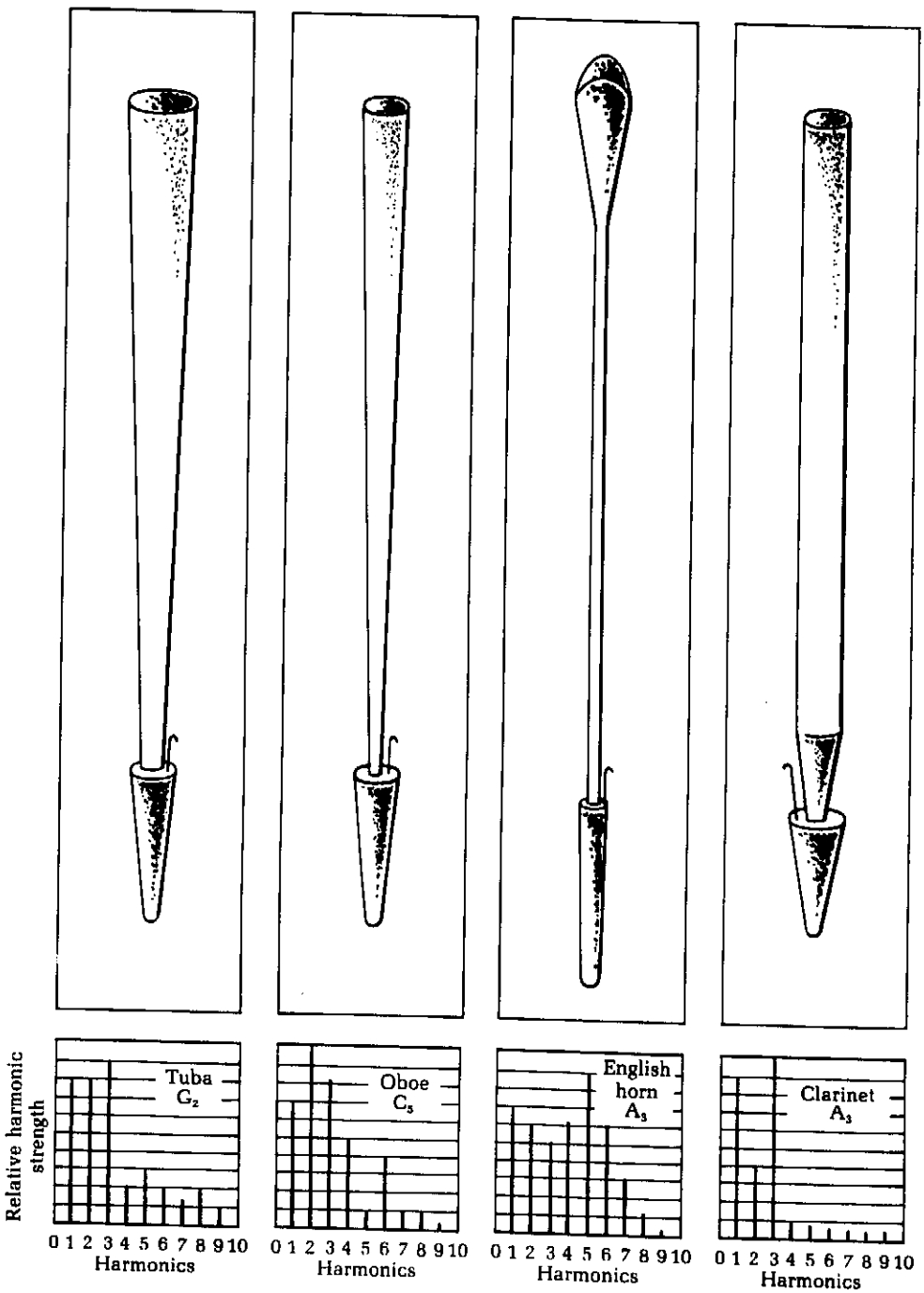

Figure 7.8 Reed organ pipes.

Harmonic spectra from data given by C. P. Boner, JASA, *10(1), 1938.*

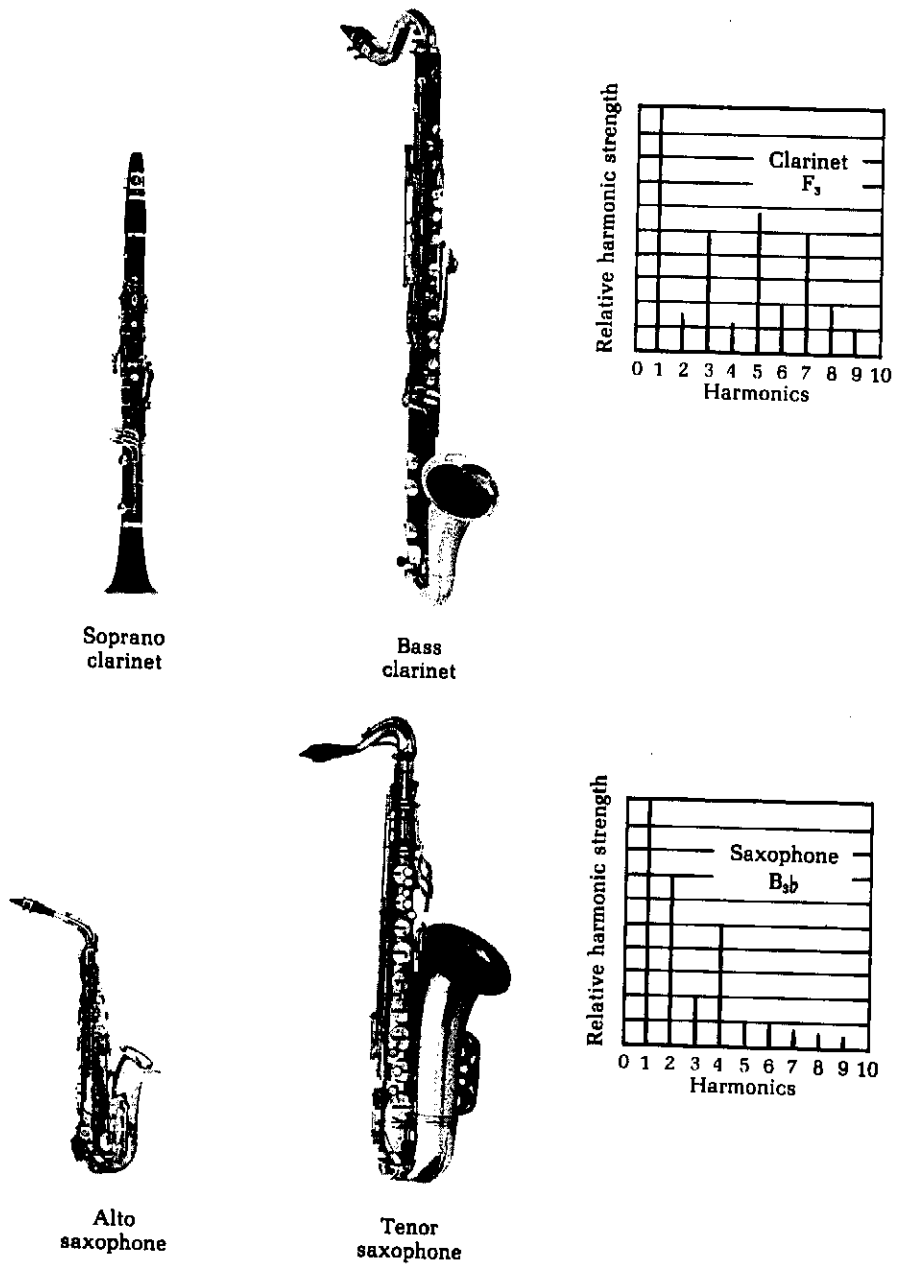

Figure 7.9 The soprano and bass clarinets and alto and tenor saxophones.

Photographs courtesy of C. G. Conn Ltd. (the soprano clarinet and alto and tenor saxophones) and The Selmer Co. (bass clarinet); harmonic spectra from MUSICAL ACOUSTICS by Charles A. Culver. Copyright © 1969 by Charles A. Culver. Used with permission of McGraw-Hill Book Company.

Figure 7.11 An oboe, cor anglais (English horn), and bassoon.

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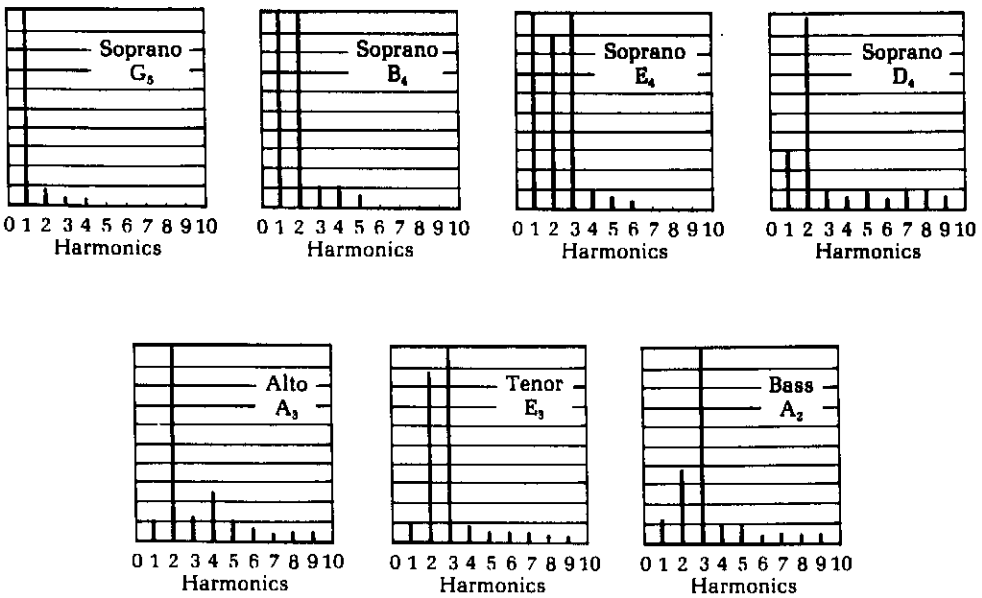

Figure 7.20 The harmonic spectrum of the human voice at various frequencies.

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PERFECT PITCH

Perfect pitch is the name given to the ability that a few people (about 1 in 1000) have of being able to name the pitch of a tone or a combination of tones, or to be able to sing a given note without comparison to any reference tone. Some people are able to name the pitch of a sound to less than a semitone. It seems to be a hereditary trait as opposed to one that is learned. Whatever its cause, it is certainly cherished by those few musicians who have it.

Summary of Terms

All wind instruments consist of a *sound generator* and a *resonant air column.* Wind instruments are grouped according to the type of sound generator: (1) Air-reed, (2) single mechanical reed, (3) double mechanical reed, (4) lip reed, (5) human voice.

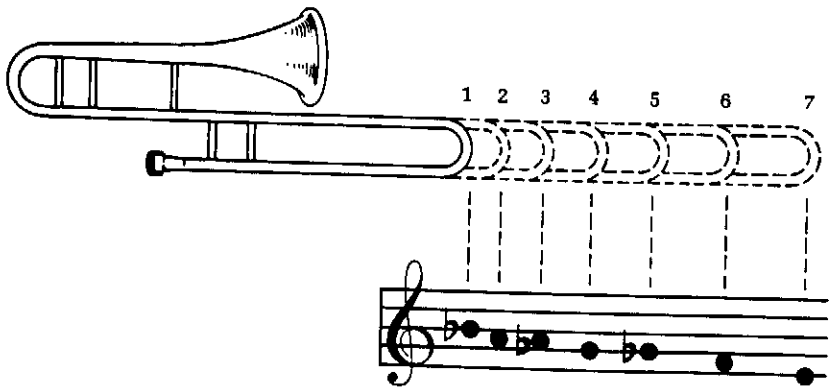
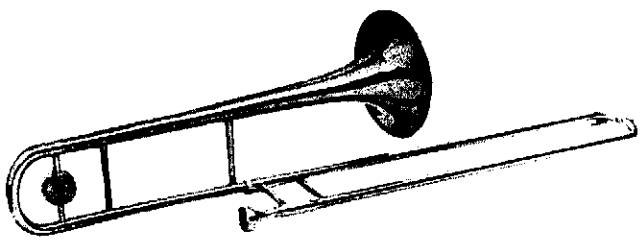


Figure 7.13 The trombone slide positions.

Table 7.4 The Frequency Ranges of the Trombone

Instrument	Frequency range	Remarks
Alto trombone	A_2 to $G_{5}\flat$	Octave higher than bass trombone
Tenor $B\flat$ trombone	E_2 to $B_{4}\flat$	
Bass trombone	A_1 to $G_{4}\flat$	Fifth lower than tenor trombone



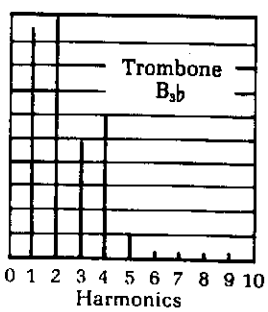


Figure 7.14 A trombone.

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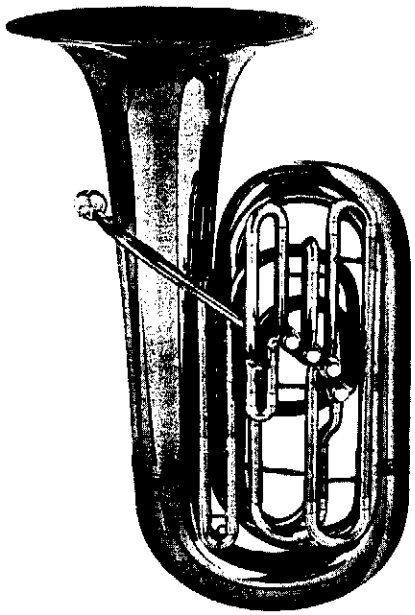
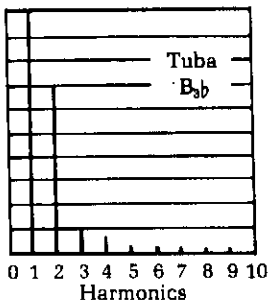
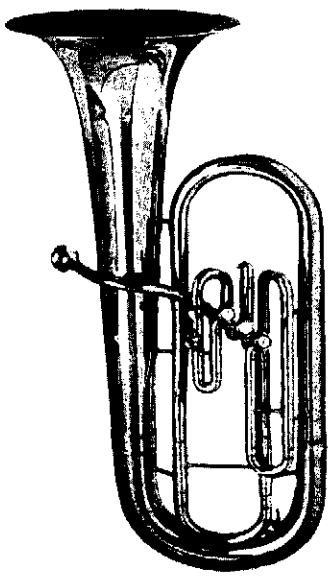
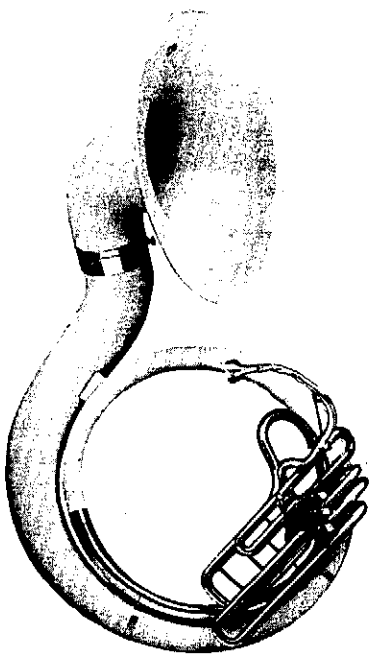






Euphonium



Sousaphone

Figure 7.18 A tuba, baritone euphonium, and sousaphone.

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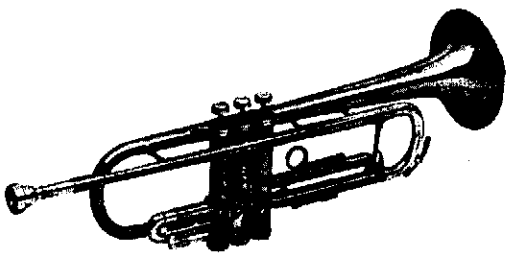

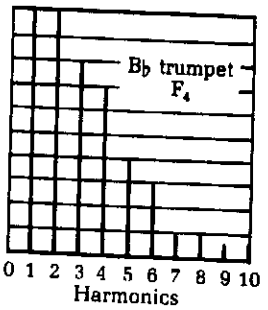

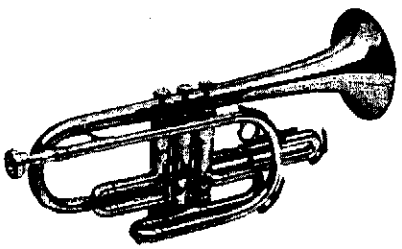

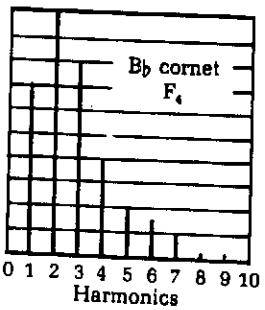

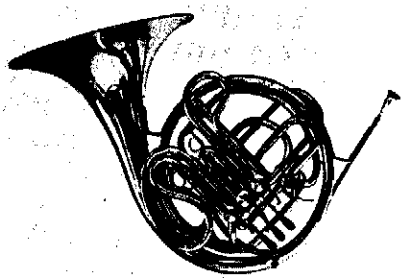

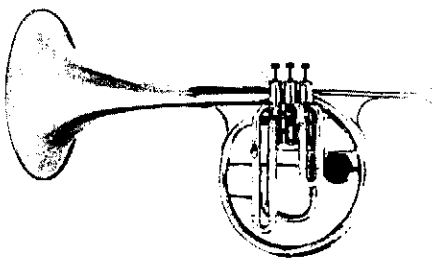

Mellophonium

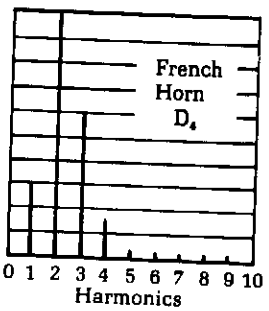

Figure 7.17 A trumpet, cornet, French horn, and mellophonium.

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