AN INVESTIGATION OF THE ACOUSTICAL PROPERTIES OF THE TRUMPET MOUTHPIECE

THESIS

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By

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PREFACE

Purpose of the Study

The purpose of this study was to present a comprehensive analysis of the acoustical properties of the trumpet mouthpiece. The first section will be concerned with the individual parts of the mouthpiece and their interrelationship. The second portion of the study will be the physical analysis of three commonly used trumpet mouthpieces. For this study, five examples of each size have been selected. The third section will present a tonal analysis of the selected mouthpieces.

These investigative procedures will attempt to recognize any relationships between the individual mouthpieces and the resulting tones.

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CHAPTER I

THE TRUMPET MOUTHPIECE

The Functions of the Mouthpiece

"The mouthpiece is probably the greatest single factor in tone quality and proper tone production, outside of the player himself."[1] To the devoted trumpet player, his mouthpiece is "the most intimate, personal, and cherished part of his instrument, and is the physical source of some of its most admired qualities."[2]

To determine the acoustical value of a mouthpiece, it is essential to establish the method of tone production for the trumpet. Like all brass instruments, the trumpet depends on the vibrations of the lips, which are "very slightly elastic membranous tongues, loaded with much inelastic tissue containing water, and they would consequently vibrate very slowly, if they could be brought to vibrate by themselves."[3]

The mouthpiece can be defined as "an enlargement of the bore to which the lips of the player are applied to form a

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[1]James Hamilton Winter, The Brass Instruments (Boston, 1964), p. 11.

[2]Philip Bate, The Trumpet and Trombone (New York, 1966), p. 16.

[3]Hermann von Helmholtz, On the Sensations of Tone (New York, 1954), p. 97.

kind of double reed."[4] When the lips are placed against the mouthpiece, only that amount of lip within the diameter of the mouthpiece cup is permitted to vibrate.

It is at this point in sound production that other physiological factors are required.

> The breath from [the player's] lungs produces a compression of air in his mouth-cavity. The tongue, acting as a valve, is sharply withdrawn so as to admit the breath between the slightly parted lips, and a puff of air passes through the mouthpiece into the interior of the instrument. At once the lips, through their elasticity, return to their original position, until a new access of pressure forces them open again, sending a second stream of air into the mouthpiece.[5]

One of the first acousticians to investigate what actually occurs within the trumpet mouthpiece was E. G. Richardson. He "recognized that a flat jet of air projected through a slit tends to break up into curls or vortices, but without any orderly sequence. If, however, the jet be directed against a more or less sharp edge the vortices are marshalled into regular cyclic order, and the jet+edge system becomes a form of tone generator."[6] Richardson suggested that the edge within a mouthpiece might have the same effect, and subsequently contribute to the tone quality.

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[4]Willi Apel, "Mouthpiece," Harvard Dictionary of Music (Cambridge, Massachusetts, 1944).

[5]Karl Geiringer, Musical Instruments--Their History in Western Culture (London, 1949), p. 41.

[6]Bate, op. cit., p. 18.

Once the basic sound is produced, every facet of the mouthpiece can be adapted to have a special effect on the sound. Mouthpieces of various sizes, shapes, and materials have been manufactured and employed. Although a special mouthpiece is no substitute for a particular skill, certain subtle alterations will affect the playing technique. Harry Glantz, former first trumpet player of the New York Philharmonic, lists five factors which are dependent upon a good mouthpiece: (1) a sharp attack; (2) ease of blowing; (3) a clear tone; (4) resonance and carrying quality; and (5) true intonation and facility in both extremes of the tonal range.[7]

Factors to be considered in the selection of a mouthpiece are physical make-up, teeth, type of instrument, lip construction, and type of playing to be done.

The trumpet mouthpiece has four essential parts: (1) the rim; (2) the cup; (3) the throat; and (4) the backbore. Figure 1 shows a cross section of a modern trumpet mouthpiece.

> It will be seen what hopeless confusion has existed in this field and how difficult it is for us today to get at the truth. But one thing is certain: the mouthpiece is the only part of the instrument which varies so individually according to the different natures and tastes of the players, that we must be careful not to want to set up any universal, standardized form.[8]

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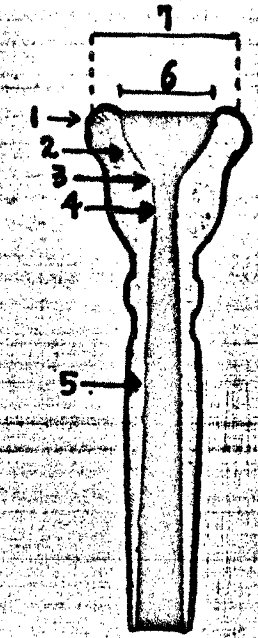
[7] Marion L. Jacobs, "Let's Talk About Cup-Mouthpieces," Etude, LXV (January, 1947), p. 19.

[8] Werner Menke, History of the Trumpet of Bach and Handel (London, 1934), p. 197.



1. Rim
2. Cup
3. Shoulder of the throat
4. Throat
5. Backbore
6. Width of cup
7. Outside diameter

Fig. 1--Cross section of a trumpet mouthpiece[9]

The Rim

The rim of the trumpet mouthpiece is of the utmost importance because it comes in contact with the player's lips. Three factors of the rim to be considered are the width, the

[9]Lester Remsen, "A Study of the Natural Trumpet and its Modern Counterpart," unpublished doctoral dissertation, University of Southern California, Los Angeles, California, 1960, p. 45.

curvature, and the bite as shown in Figure 2. Each of these parts can affect both the playing characteristics and the tone quality, but "the most important factor is the way the mouthpiece feels on the lips.[10]

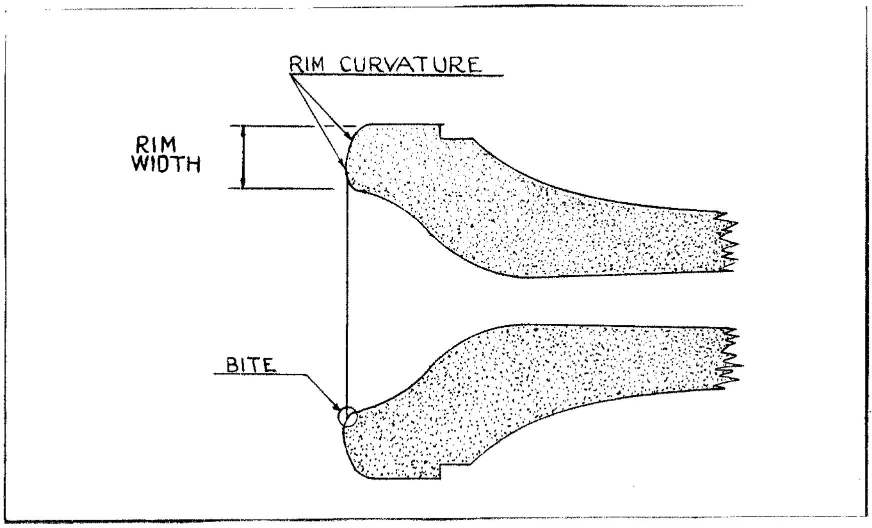


Fig. 2--Diagram of a rim[11]

The rim width determines how much of the lip surface will support the mouthpiece. The contour of the rim is usually convex, but can be modified to suit the individual player. A mouthpiece reputed to offer comfort to the lips is the "cushion rim" model which "is nothing more than a very wide rim which covers a greater area of the lips thus allowing the pressure to be spread out and not concentrated

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[10]John J. Haynie, "On Selecting the Proper Mouthpiece," Southwestern Brass Journal, I (Fall, 1957), p. 23.

[11]Jody Hall, The Proper Selection of Cup Mouthpieces (Elkhart, Indiana, 1963), p. 16.

in a very narrow area."[12] This type of rim "will reduce flexibility and may even disturb tone quality because of the abnormal position which it enforces upon the embouchure."[13] Although a narrow rim will afford more control and more consistency of attack, it will abuse the lip by cutting into it.

The curvature of the rim is usually slightly rounded to offer comfort to the lips. The surface of the rim which is placed against the lips must be kept clean and free of abrasions and scratches in order to protect the lips.

The inner edge or "bite" of the rim is the most vital area, for this is the contact point of the vibrating lips and the mouthpiece. The bite is the angle formed at the meeting of the rim and the cup. "Just as one must press the finger down tightly on a stringed instrument in order to produce a clear tone, so must one also have a definite contact point for the embouchure at the inner edge of the rim."[14] When the bite is sharp, the lips are provided with a definite stopping point in their vibrating, and the resulting tone and attack are more clear. However, the flexibility will be hindered because of the difficulty the lips will have in moving across the bite. If the bite is slightly rounded, the flexibility will be enhanced, but the attacks may not be precise.

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[12]Haynie, _op. cit._, p. 23. [13]Winter, _op. cit._, p. 12.

[14]Hall, _op. cit._, p. 17.

"The three rim factors are of first importance to the player's lip comfort, flexibility, and endurance. But they are also factors in tone quality because the way the lip is gripped by the mouthpiece rim can affect especially the clearness of tone."[15]

The Cup

The cup or "bowl" begins immediately below the rim and terminates with a "shoulder" at the throat. As with the rim, the cup has three separate areas which affect both the player and the acoustical results: the diameter, the depth, and the shape.

The diameter of the cup determines how much of the player's lips are used to produce a sound. A player's primary consideration in selecting a wider diameter will be "the relative strength or weakness of the embouchure; a large mouthpiece tends to produce a bigger tone, but not all embouchures are strong enough to use such a mouthpiece."[16] The quality of sound produced with a wide diameter will be "dark", possessing very few of the upper partials of the tone.[17] Another characteristic of the wide diameter is the ease of producing low tones and the difficulty of producing the higher register.

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[15] Dan Tetzlaff, "Mouthpieces--Trumpet Talk," _International Musician_, LII (December, 1953), p. 27.

[16] Winter, _op. cit._, p. 12

[17] Remsen, _op. cit._, p. 47.

A mouthpiece with a smaller diameter will produce a brighter, more compact sound. This sound may have a tendency to be shrill in quality and sharp in pitch. A player may experience difficulty in playing in the lower register, but will have less difficulty in playing in the high register.[18]

"It is an experimental fact that the depth of the cup affects the solidity with which a player can 'lock in' on a desired pitch, as well as affecting the tone color of the instrument."[19] The cup depth coupled with the diameter provides the total cup volume of a mouthpiece. A deep cup with a wide diameter will produce an enormous volume of sound, but will not have a bright, penetrating quality. A shallow cup with a small diameter will offer a brilliance with no body or breadth to the sound. It is important for a player to be aware of both factors because "the diameter and depth of the cup combine to create an area volume that is directly related to the volume or size of the tone produced."[20]

In examining the depth factor without considering the diameter, Remsen states that the shallow cup facilitates the high register, and brings out the higher partials in the tone, adding a thinner, brighter quality. A shallow cup can also sharpen the pitch, especially in the upper register.[21]

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[18]Haynie, _op_. _cit_., p. 24.

[19]Arthur Benade, _Horns_, _Strings_, _and_ _Harmony_ (Garden City, New York, 1960), p. 189.

[20]Tetzlaff, _op_. _cit_., p. 27. [21]Remsen, _op_. _cit_., p. 47.

One of the most underrated factors of the trumpet mouthpiece is the configuration of the cup. "Contour of cup is naturally affected by depth and width, but has its own peculiarities."[22] That property of contour is the "shoulder" or "edge."[23] This is the angle formed where the cup joins the throat, and the location of the point of impact of the air as discussed in dealing with the Richardson edge-tone theory. A "V" shaped cup with sides sloping to the throat would eliminate the shoulder and produce a mellow sound.[24] The addition of "a high shoulder with a sharp, abrupt edge dropping into the throat facilitates a brillian tone and attack."[25]

Figure 3 shows two examples of identical mouthpieces with different shoulders. Example A has a rounded edge whereas example B has a sharp edge.

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[22] *Ibid.*

[23] Norman J. Hunt, *Guide to Teaching Brass* (Dubuque, Iowa, 1968), p. 61.

[24] Remsen, *op. cit.*, p. 48.

[25] Tetzlaff, *op. cit.*, p. 27.

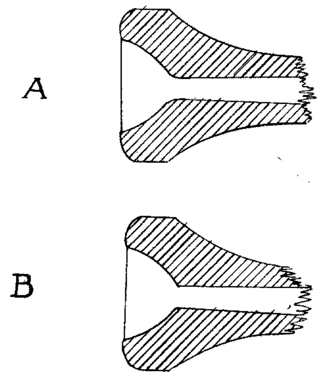

Fig. 3--Cross section of shoulders in cup contours[26]

Whether the bottom of the cup has a sharp edge as in the trumpet mouthpiece, or has none as in that of the horn, is important. The effect is usually described thus: a sharp-edged cup gives a 'hard', 'incisive', tone, while rounding the edge off, or removing it altogether, gives a 'softer', or 'smoother' tone.[27]

The Throat

"The smallest passageway through which the vibrating column travels at the bottom of the cup is referred to as the 'throat'."[28] The throat or "bore" is usually cylindrical and connects the cup and the backbore. The size of the throat governs the amount of air which will pass into the instrument, which in turn will affect the ease of playing, range, volume of tone, and projection of sound. "The larger the throat,

[26]Hall, op. cit., p. 15.

[27]Benade, op. cit., p. 189.

[28]Remsen, op. cit., p. 48.

the greater demands on the physical development of the embouchure."[29] A large throat will increase the volume of sound and cause the tone to be mellow. However, a large throat will also cause the attacks to be sluggish and might give the sound a "tubby" quality which lacks clarity. While a smaller throat might add brilliance to the sound, one which is too small would choke the sound making it thin, and would cause great discomfort to the player.[30]

One facet of the throat which has only recently been considered is the length. This factor is difficult to determine without destroying the mouthpiece.[31] It has been ascertained that a long throat will emphasize the high partials in the tone. The long throat will facilitate the production of the high register, but can often make that register sharp in pitch.[32]

The Backbore

"The boring. . . serves as the critical 'stowage-corner' for the air poured from the player's lungs."[33] In addition to being the shank of the mouthpiece, the backbore serves as the connector of the instrument and the total mouthpiece.

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[29]Hall, *op. cit.*, p. 10.

[30]Haynie, *op. cit.*, p. 24.

[31]Letter from R. Dale Olson, Acoustic Instruments, Fullerton, California, November 27, 1968.

[32]Remsen, *op. cit.*, p. 48.

[33]Menke, *op. cit.*, p. 189.

The essential factor of the backbore is the "flare" or angle of taper from the throat to the main tube of the instrument.

Many authorities feel that the backbore is often overlooked because it is not readily observed. Haynie feels that "the conical shape of the backbore enriches the tone while a very straight or cylindrical backbore aids the production of the upper tones."[34] Winter claims "a radical cone in the backbore tends to facilitate playing, but may cause the instrument to become rough in *forte* passages, while a more cylindrical backbore offers greater resistance, resulting in a more solid tone which will not 'speak' quite so readily."[35] Schilke states:

> If the backbore flares out rather rapidly, the tone will be full but slightly more difficult to control. If the backbore becomes straighter, with less flaring out, the tone becomes thinner but more easily controlled; at the same time the blowing resistance is increased.[36]

Figure 4 shows a group of cornet and trumpet mouthpiece cross sections. It is interesting to note that all five mouthpieces illustrated are available on the commercial market.

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[34]Haynie, *op. cit.*, p. 24.

[35]Winter, *op. cit.*, p. 12.

[36]Remsen, *op. cit.*, p. 49.

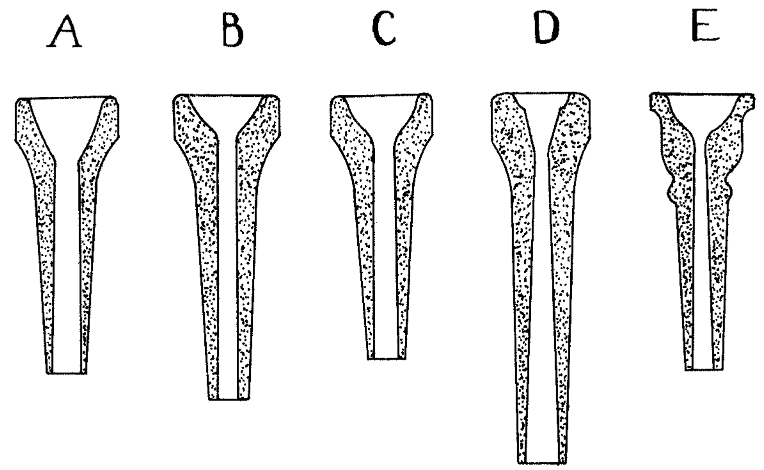

Fig. 4--Cross sections of various backbores[37]

The Complete Mouthpiece

> The mouthpiece serves as a very important link between the player and his instrument, not only because it is the point of physical contact and must feel comfortable on the lips, but for the fact that its proportions and dimensions have a marked influence on the vibrating column of air before it enters the trumpet.[38]

The volume of the cup, the size of the throat, the amount of flare in the backbore, and the type of rim will individually and collectively affect the production of tone. "That the above factors are aligned with each other is of the greatest importance. They must be compatible to (1) the tonal conception in the performer's ear; (2) his method of blowing; (3) and the instrument he chooses to play on."[39]

[37]Hall, op. cit., p. 10. [38]Remsen, op. cit., p. 43.

[39]Tetzlaff, op. cit., p. 27.

"The parts of the mouthpiece are interacting, and bear a relationship to each other in that any one part cannot be changed without necessitating a change in the other parts."[40] If a player selects a mouthpiece with a very large cup volume and an extremely small throat, he will become uncomfortable because the throat will not accept the amount of air that the cup will require.

Vincent F. Malek conducted an extensive survey of the mouthpieces of fifty-two of the leading players in all fields of music. His conclusions showed that no mouthpiece in the sample had any of the following extreme dimensions: (1) a throat smaller than .140 inches (drill size 28) or larger than .159 inches (drill size 21); (2) a cup diameter of less than .61 inch or more than .67 inch; (3) a rim curvature of more than 15/64 inch radius; (4) a rim thickness of greater than .255 inch; and (5) a bite curvature of more than 6/64 inch radius.[41]

"The trumpet has somehow managed to attract more alleged mouthpiece inventors than any of the other brasses; there are a great many freak mouthpieces on the market at the present time, and a steady flow of new ones."[42] The pioneers of

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[40]Hall, op. cit., p. 8.

[41]Vincent F. Malek, "What is a Good Cornet or Trumpet Mouthpiece?" The Instrumentalist, VII (May, 1954), p. 23.

[42]Winter, op. cit., p. 36.

modern mouthpiece design were trumpet players who began duplicating their personal mouthpieces for their friends. Representatives of this group include Vincent Bach, Renold Schilke, and Irving Bush.

It is because of the search for "the perfect mouthpiece" that manufacturers are turning to the computers for assistance.[43] William Cardwell, Jr., is currently involved in a study of mouthpiece design by computers. His first efforts offer revolutionary design of the rim, cup, and backbore.[44] Most of Cardwell's testing has dealt with correcting the intonation problems of the trumpet <u>and</u> mouthpiece by changing only the latter. Studies of this type may completely revolutionize the trumpet mouthpiece as it is known today.

"A good mouthpiece on an inferior instrument is still to be preferred to a poor mouthpiece on a good instrument."[45]

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[43]Olson, *op. cit.*

[44]Letter from Willi Cardwell, Jr., Whittier, California, January 7, 1969.

[45]Marion L. Jacobs, "Uses and Abuses of Cup Mouthpieces," *Etude*, LXV (January, 1947), p. 19.

CHAPTER II

THE PHYSICAL ANALYSIS OF SELECTED MOUTHPIECES

For the purpose of this study, five examples each of three different sized trumpet mouthpieces were collected from the teachers and students at North Texas State University. These mouthpieces were the 1C, 7C, and 10 1/2C models manufactured by the Vincent Bach Corporation. The Bach system of identification uses "the low numbers [to] indicate a larger cup diameter. . . while the high numbers represent smaller size cup diameters."[1] The letter "C" indicates that the depth of the cup is that of the "medium-shallow 'C' trumpet cups."[2] The 7C and the 10 1/2C mouthpieces were selected because of their reputation of being widely used models of the average and small inside cup diameters.[3] The 1C was selected because it is the largest inside cup diameter manufactured by Bach. With the standardization of the "C" cup, the only intended variable was that of the cup width.

When all fifteen mouthpieces were assembled, it was necessary to thoroughly clean all of them before any measurements were made. Some mouthpieces had not been cleaned for

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[1]Vincent Bach, _Embouchure and Mouthpiece Manual_ (Mt. Vernon, New York, 1954), p. 42.

[2]_Ibid._, p. 43.

[3]_Ibid._, p. 53.

some time, and consequently some sediment had formed in the throat and backbore which would have affected the actual measurements of the mouthpiece. Figure 5 shows the fifteen mouthpieces.

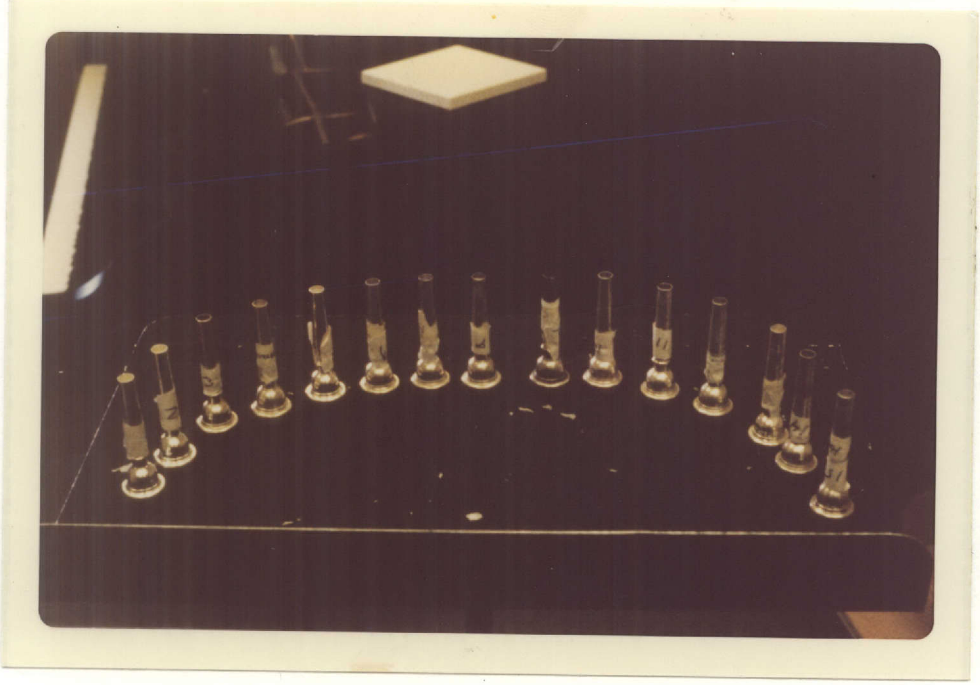

Fig. 5--Fifteen selected mouthpieces

A total of seven measurements was made on each of the fifteen mouthpieces. The purpose of these measurements was to establish the average dimensions for each of the three mouthpiece sizes. Variations in dimensions within the same mouthpiece classification can be attributed to wear through use, differences in the sharpness of the cutting tools when the mouthpiece was manufactured, and in some instances, mis-numbering.

The first measurement taken was that of the throat diameter. A series of Briggs and Weaver drill blanks, series 902, was used. The measurement was made by placing the largest possible drill blank through the throat. Figure 6 shows the placement of a drill blank into the throat.

Fig. 6--Measuring the throat

The second measurement taken was that of the inside cup diameter. A Brown and Sharpe micrometer/caliper tool #577 was used. One foot of the caliper was placed on a point just below the bite, where the cup meets the rim, while the other foot was extended until it touched the same point directly across the cup. The gauge on the tool was read with the aid of a magnifying glass. To insure accurate measurements, this process was repeated several times. Figure 7 shows how the inside cup diameter was measured.

Fig. 7--Measuring the inside cup diameter

The depth of the cup was the next measurement to be taken. In order to measure the cup only to the top of the throat or to the shoulder of the inner cup, a series of nails was prepared so that they could be placed into the throat so that the head of the nail would form an even seal across the inner cup. The measuring bar of the Brown and Sharpe micrometer/caliper #577 was extended to the nail in such a way so that the tool was anchored against the rim of the mouthpiece. The resulting angle between the tool and the top of the mouthpiece rim was 90°, insuring an accurate measurement. This figure, as all others, was checked repeatedly. Figure 8 illustrates the measuring of the cup depth.

Fig. 8--Measuring the cup depth

The width of the outer cup was determined by using the Brown and Sharp micrometer/caliper #577. The rim widths were determined by subtracting the cup width from the outer cup width and dividing by two. Figure 9 demonstrates the measuring of the outer cup width.

In measuring both the rim curvature and the bite curvature, the Starrett radius gauges #S167A were used. For both dimensions the smallest possible gauge which had no gap in the center when placed against the curve was selected.

Fig. 9--Measuring the outer cup width

Figure 10 shows the measuring of the rim curvature whereas Figure 11 shows the measuring of the bite.

Fig. 10--Measuring the rim curvature

Fig. 11--Measuring the curvature of the bite

Table I presents all of the physical measurements for each of the fifteen mouthpieces. From left to right, the columns are: the individual mouthpiece, with the five 1C mouthpieces listed first followed by the 7C and 10 1/2C; the throat; the cup width; the cup depth; the outer cup width; the rim width; the rim curvature; and the bite curvature. Table II presents the average measurements as compiled for each of the three mouthpiece sizes.

TABLE I

PHYSICAL ANALYSIS OF SELECTED MOUTHPIECES

MP	Throat	C Width	C Depth	O Width	Rim W	Rim C	Bite
1	27[1]	.667	.325	1.079	.206	12/64	2/64
2	27	.667	.329	1.083	.208	12/64	2/64
3	28	.670	.328	1.079	.204	10/64	3/64
4	28	.663	.315	1.075	.206	12/64	2/64
5	27	.670	.314	1.085	.207	10/64	3/64
6	28	.655	.330	1.061	.203	10/64	3/64
7	27	.648	.335	1.056	.204	10/64	3/64
8	26	.625	.316	1.083	.229	12/64	3/64
9	28	.628	.322	1.082	.227	11/64	3/64
10	28	.659	.329	1.061	.201	12/64	3/64
11	28	.645	.323	1.059	.207	12/64	3/64
12	27	.645	.328	1.056	.205	12/64	4/64
13	28	.650	.316	1.061	.205	12/64	3/64
14	28	.647	.324	1.055	.204	13/64	4/64
15	28	.620	.319	1.069	.224	13/64	4/64

[1]This number refers to the number of the drill blank, with 27 representing .144 inch, and 28 representing .140 inch.

TABLE II

PHYSICAL ANALYSIS AVERAGES FOR THREE MOUTHPIECE SIZES

MP	Throat	C Width	C Depth	O Width	Rim W	Rim C	Bite
1C	27.4	.667	.322	1.080	.206	11/64	2/64
7C	27.4	.643	.326	1.068	.212	11/64	3/64
10 1/2C	27.8	.641	.322	1.050	.209	12/64	3/64

CHAPTER III

THE TONAL ANALYSIS OF SELECTED MOUTHPIECES

The next procedure involves the analysis of individual tones produced with the selected fifteen mouthpieces. These mouthpieces were tested individually, and the results grouped according to the 1C, 7C, and 10 1/2C classifications for further study.

The tonal analysis was conducted so that the only variable factors were the mouthpieces. Since the study dealt only with the mouthpieces, the same B^b trumpet was used throughout the test--a Conn 60B. This instrument was selected because none of the players involved in the study played on this particular brand. All testing was conducted in the same room, with all the apparatus in the same position.

Five trumpet players from North Texas State University were selected for participation in this study. Each of the five players had received extensive training and exhibited a high level of musicianship and playing ability. They were each tested a total of three times in an attempt to get an accurate representation of each mouthpiece.

Although intonation was not a consideration of this study, a Stroboconn was used to maintain a constant pitch level throughout the testing. The player was then positioned so that he could view the sound level meter and maintain the same intensity for each tone. The microphone was attached to the sound wave analyzer which measured the presence and strength of each partial in the tone. These results were then recorded by the graphic level recorder on a chart roll. The description of the presence, frequency, and strength of each partial on the chart roll constitutes the spectrum of a tone.

A list of the equipment used in this phase of the testing is as follows:

Stroboconn
Electrovoice Microphone--model 655C
General Radio Sound Level Meter--type 1551C
General Radio Wave Analyzer--type 1900D
General Radio Graphic Level Recorder--type 1521B
General Radio Stylus 80db Potentiometer--type 1521 p[3]
General Radio Chart Roll--type 1521-9464

All the equipment was operated by a research assistant of the Chairman of Music Research Department at North Texas State University. The following sketch is a diagram of the equipment used in the testing.

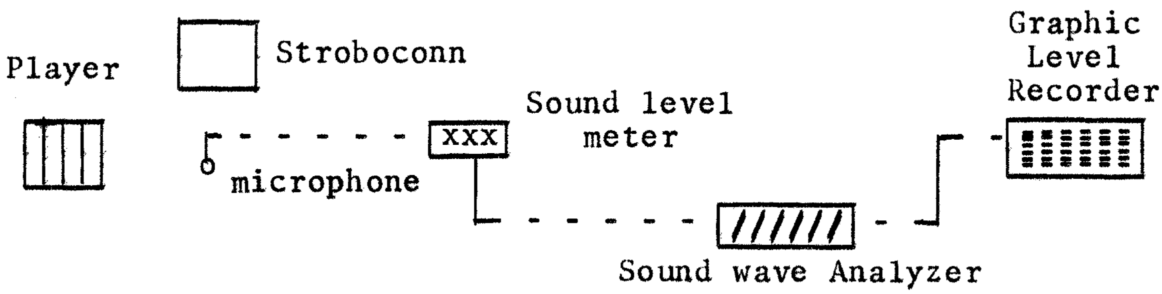

Fig. 12--Diagram of equipment

Figure 13 shows the sound level meter, sound wave analyzer, and the graphic level recorder.

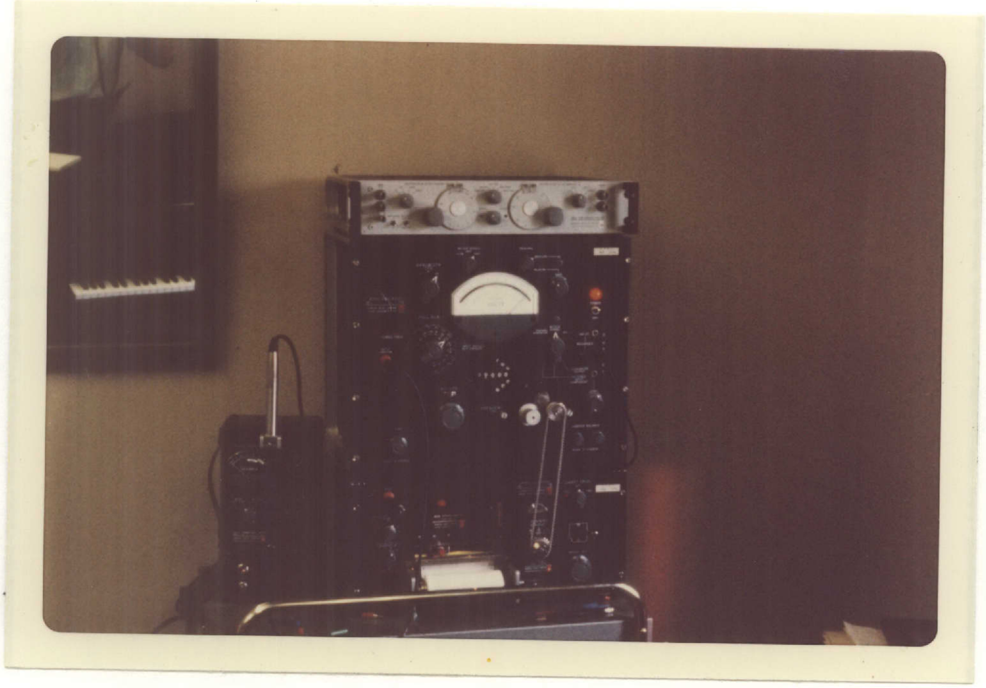

Fig. 13--Photograph of equipment

The harmonic series as produced on a trumpet is as follows:

Fig. 14--Harmonic series of trumpet

The playing portion of this study consisted of sustaining each of the six tones for the analyzer to accurately scan 3000 Hz,[1] about a total of 20 seconds. The six tones were:

Fig. 15--Playing portion of test

All six tones were played on one mouthpiece before moving onto the succeeding mouthpiece. All of the 1C mouthpieces were tested first, with the 7C tested second. The player was permitted to play for one minute on the first of each different mouthpiece size. When each tone was sustained for approximately 3000 Hz, the sound wave analyzer and graphic recorder were able to record seven partials for the tone founded upon the fundamental frequency of the fourth harmonic (c5), ten each for the second harmonic (c4) and the third harmonic(g4), six partials for the fifth harmonic (e5), five partials for the sixth harmonic (g5), and three partials for the eighth harmonic (c6).[2] The total number of partials recorded was forty-one.

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[1]The term Hertz (Hz) is a new designation which refers to cycles per second. One Hz is equal to one CPS.

[2]Although the equipment used in this study produced a very accurate analysis of the spectrum of a musical tone, it operated very slowly. Therefore, it was necessary for the player to sustain each tone for 3000 Hz in order to measure the desired partials. In recent years, a real-time analyzer has been developed which will analyze a tone many times faster than the current equipment, and still maintain a high degree of accuracy.

When all the testing was completed, the graphs were evaluated to determine the strength of each partial for each tone on each mouthpiece. This was achieved by measuring the decibel[3] ratings for each partial. Appendix A contains all the ratings for each partial of the six tones as produced on each of the fifteen mouthpieces by the five subjects for each of their three tests.

It was then necessary to determine the value of each mouthpiece as played by all five subjects. This was accomplished by adding the players' test scores for each partial for a given mouthpiece. This total was then divided by the number of scores, with the quotient carried to the third decimal place. This information is presented as Appendix B.

In order to deal with all five mouthpieces of identical size, the average ratings for each size had to be determined. This was accomplished by adding the scores for each partial for all five mouthpieces of the same size, and dividing by five to the third decimal place. The succeeding table (see page 29) presents the average ratings for each partial of the six tones for the tested Bach 1C, 7C, and 10 1/2C mouthpieces.

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[3]A decibel is a logarithmic unit used for measurements of sound levels. In this case no reference is made to absolute levels, the figures referring only to relative levels.

TABLE III

RELATIVE DECIBEL STRENGTH OF PARTIALS PRODUCED ON SELECTED MOUTHPIECES

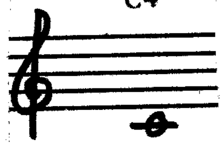
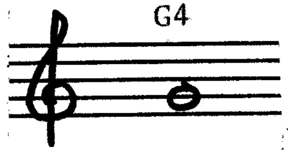
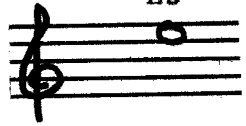
MP	F	2	3	4	5	6	7	8	9	10
1C	60.972	62.672	61.879	57.605	53.926	44.245	35.099			
7C	57.893	62.212	63.186	56.492	50.599	41.891	31.030			
10 1/2C	58.453	61.512	61.933	56.853	51.706	41.136	33.322			
						C5				
1C	39.786	51.796	54.186	54.519	53.779	53.493	50.228	47.024	46.971	42.314
7C	39.653	49.839	53.039	51.906	52.213	53.653	48.933	45.214	44.506	40.590
10 1/2C	38.879	47.813	52.826	52.266	53.226	52.460	48.376	45.826	44.639	39.909
						C4				
1C	56.373	59.066	60.508	58.095	54.666	51.396	44.516	38.412	30.778	26.629
7C	54.639	57.106	57.946	56.906	51.439	49.908	40.843	34.842	26.751	20.684
10 1/2C	55.199	56.346	58.506	56.319	51.866	50.506	43.252	35.080	28.965	22.610
						G4				

TABLE III--Continued

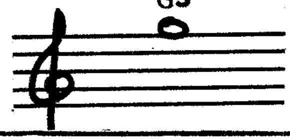
MP	F	2	3	4	5	6	7	8	9	10
1C	64.879	64.213	60.083	55.371	42.140	32.665				
7C	64.666	63.653	58.603	53.333	40.659	30.533				
10 1/2C	65.359	64.479	58.399	52.811	39.700	29.760				

E5



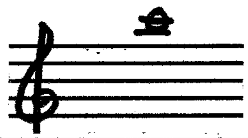
MP	F	2	3	4	5	6	7	8	9	10
1C	67.572	65.306	60.763	47.889	38.531					
7C	66.277	66.306	60.414	46.279	34.774					
10 1/2C	67.249	64.319	60.293	46.300	34.949					

G5



MP	F	2	3	4	5	6	7	8	9	10
1C	72.178	63.102	54.704							
7C	71.359	63.412	53.357							
10 1/2C	69.723	63.132	52.639							

C6



CHAPTER IV

PRESENTATION OF DATA

The following pages contain samples of the chart roll used in the testing. Each table represents one tone with the location and average strength of each partial as produced by the three different size mouthpieces. Since pitch was not one of the criteria, the partials are shown in their relative location. These are marked along the bottom of the chart, while the decibel ratings are along the left margin. The average rating for each of the three mouthpiece sizes is shown at each partial, and each decibel rating is designated by a colored mark. This mark corresponds with the actual numerical rating which appears above the mark. The red mark represents the 1C, whereas the green is the 7C, and the blue is the 10 1/2C.

Accompanying each chart will be a brief discussion which will recognize any trends which are present. These trends will often be any repeated patterns or a particular point where all three mouthpieces will be close to one another.

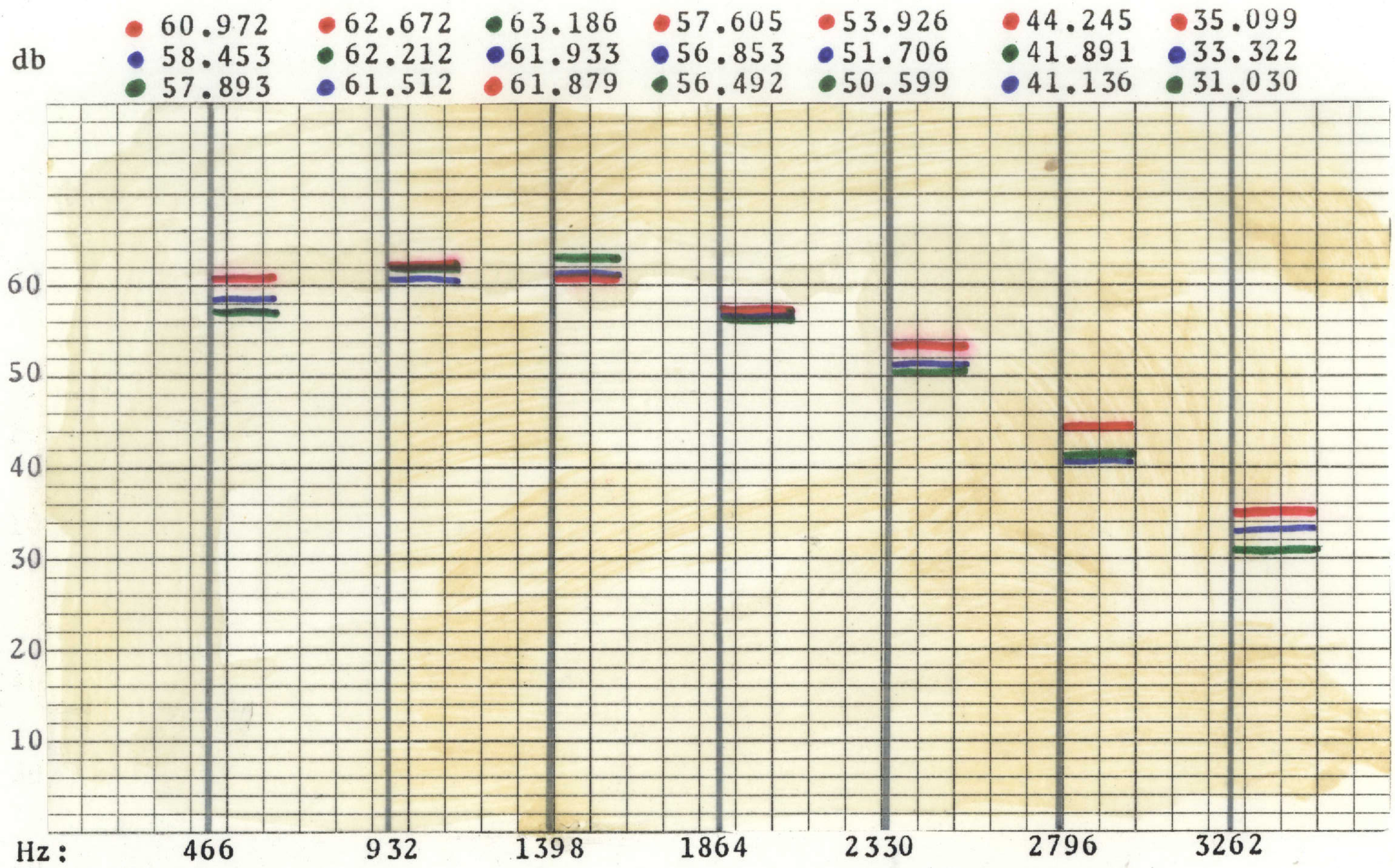
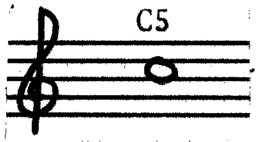


Fig. 16--Spectrum of C5 produced by selected mouthpieces



In all partials except the third, the 1C registers as the strongest of the three mouthpieces. At the fundamental, the three mouthpieces are 3db apart. The mouthpieces are within 1.2db at the fourth partial, only to drift farther apart in the succeeding partials. At the seventh partial, the three mouthpieces are 4db apart.

The 1C mouthpiece reaches its strongest point at the second partial with a 62.672db rating, and gradually tapers to 35.099db at the seventh partial which is its lowest point.

The 7C mouthpiece records the third partial as its strongest at 63.186db. Its lowest point is the seventh partial at 31.030. This mouthpiece is the strongest of the three at the third partial.

The 10 1/2C mouthpiece reaches its peak at the third partial with a level of 61.933db. Its lowest point is the seventh partial at 33.322.

The 1C mouthpiece produces the strongest activity in all the ten partials with the exception of the sixth partial, where the 7C registers .16db stronger. All three mouthpieces are within 1db at the fundamental and within1.2db at the sixth partial. The widest interval occurs at the second partial with a spread of almost 4db.

The strongest partial of the 1C is the fourth with a reading of 54.519db. The weakest partial is the fundamental at 39.786.

In the sixth partial, the 7C reaches 53.653db for its strongest rating in this tone. Its lowest rating is 39.653db at the fundamental.

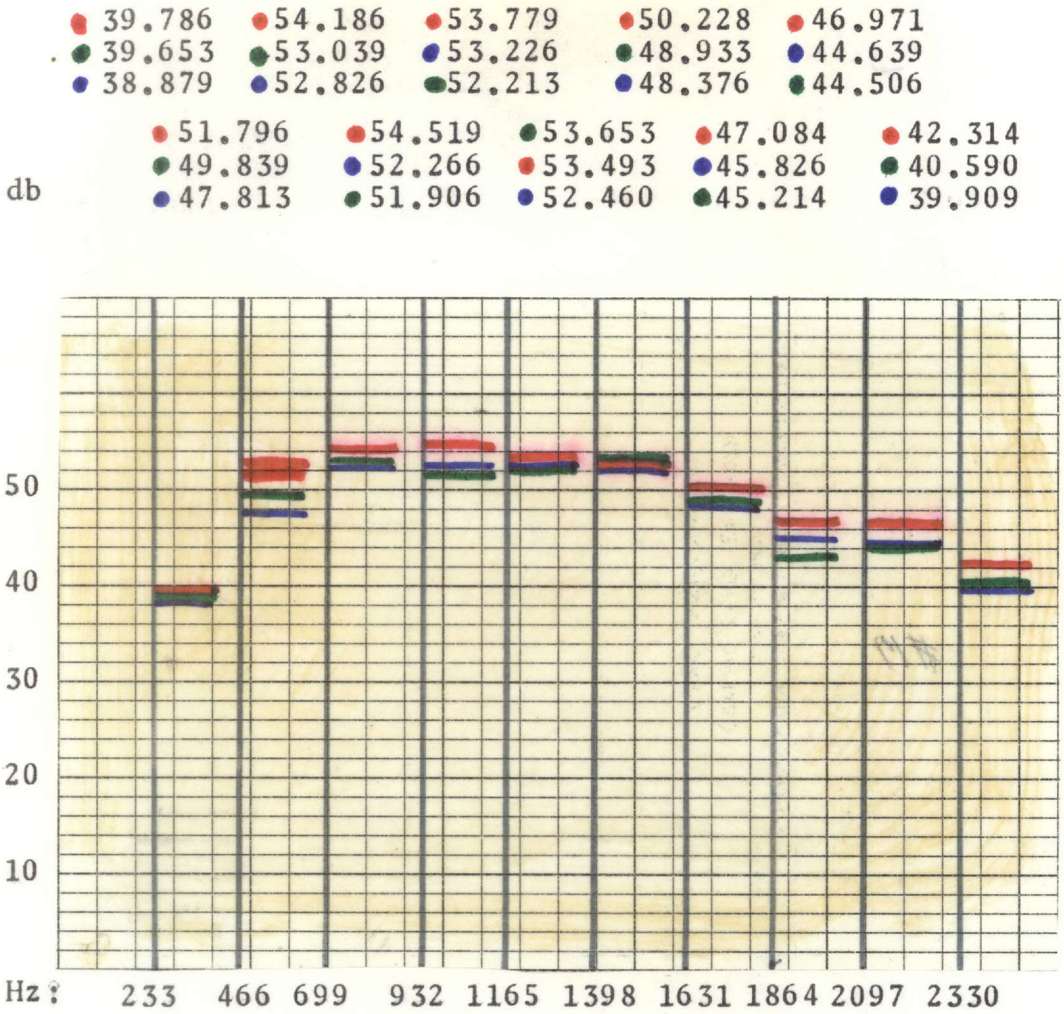


Fig. 17--Spectrum of C4 produced by selected mouthpieces.

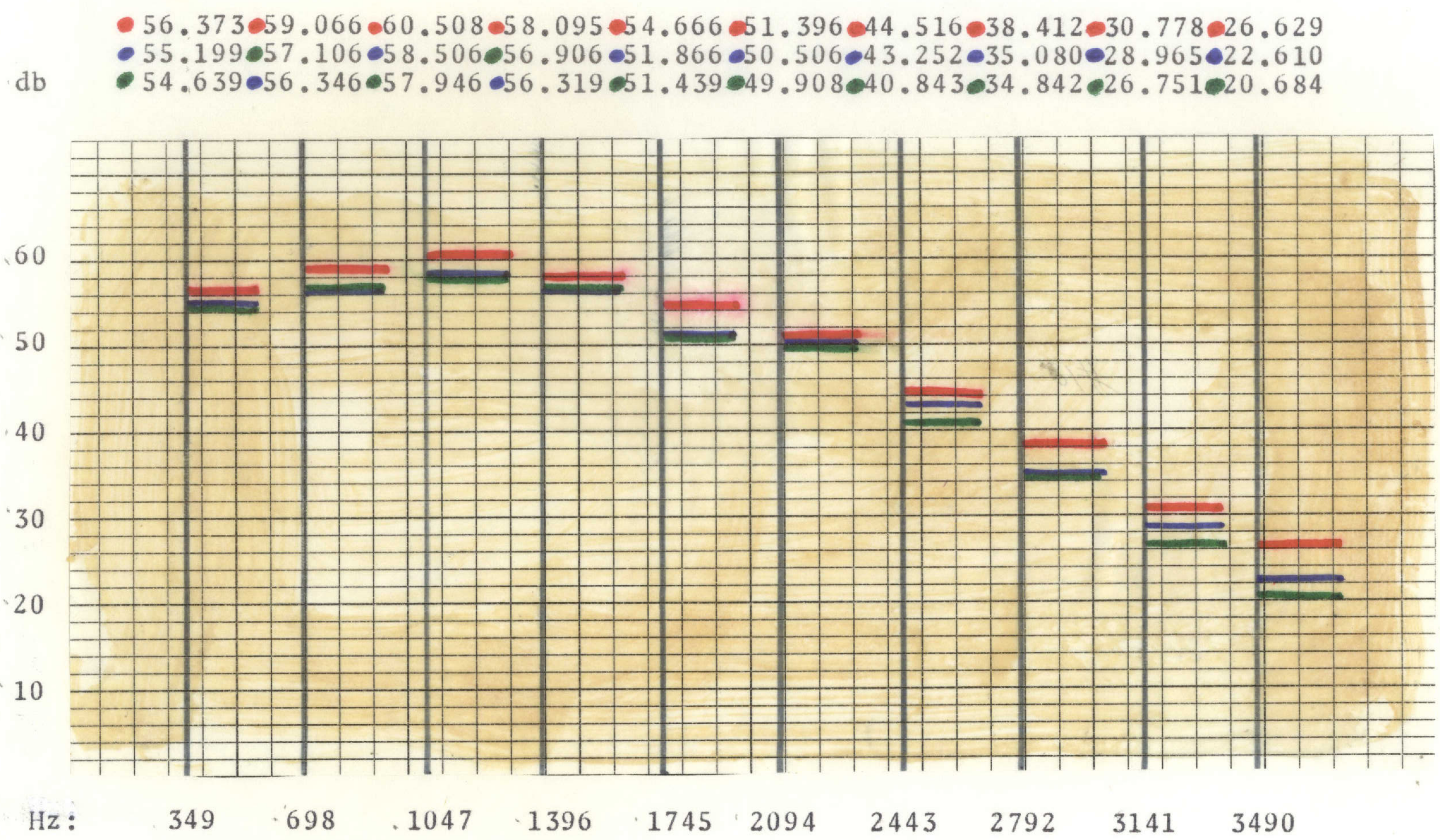
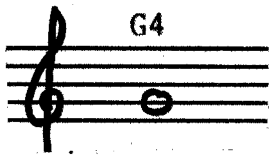


Fig. 18--Spectrum of G4 produced by selected mouthpieces

The 10 1/2C mouthpiece reaches its strongest point at the fifth partial at 53.226db. Its lowest reading occurs at the fundamental with 38.879db.



In this particular tone, ten partials are measured, and all ten show that the 1C mouthpiece produces the strongest activity. All three mouthpieces produce their highest levels at the third partial and begin a decline to their lowest levels at the tenth partial. The three mouthpieces come within 1.5db of each other at the sixth partial.

The 1C mouthpiece reaches its strongest point at the third partial with 60.508db, while its lowest reading at the tenth partial is 26.629db. It is interesting to note that beginning with the seventh partial, the 1C begins to show an increasingly superior strength over the other two mouthpieces.

The 7C mouthpiece records 57.946db at its highest point, and 20.684db at its lowest point. From the fifth partial to the tenth, the 7C registers as the weakest of the three mouthpieces.

The 10 1/2C mouthpiece is strongest at the third partial with a reading of 58.506db. The weakest reading is 22.610db at the tenth partial. In three of the last four partials, the 10 1/2C registers at a point 2db above the 7C, yet 1.4db below the stronger 1C. This appears to be a trend for the 10 1/2C in the upper partials of this tone.

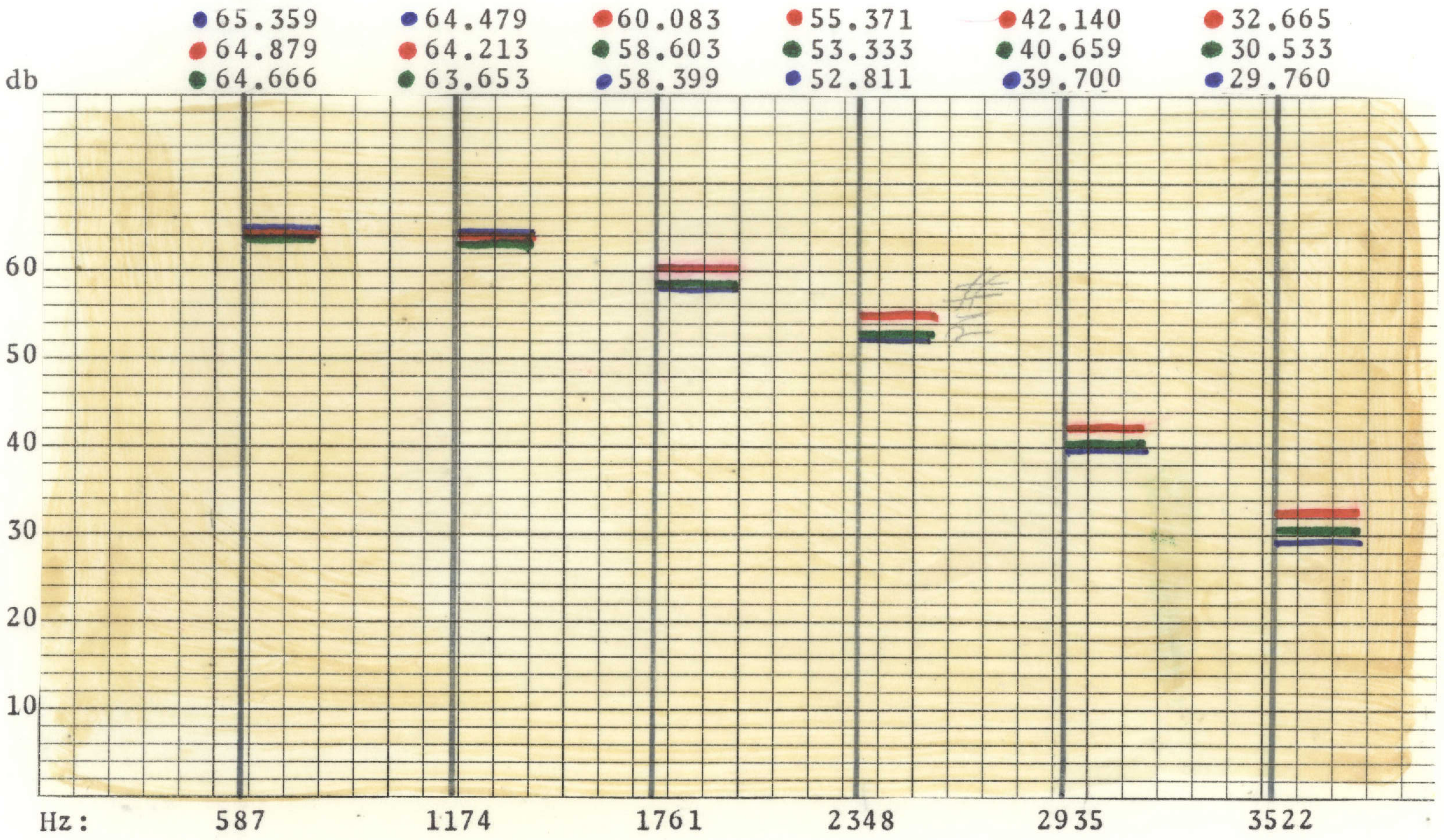
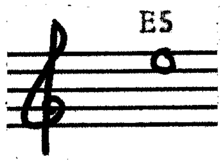


Fig. 19--Spectrum of E5 produced by selected mouthpieces



For the first two partials, the 10 1/2C records the strongest rating. At the third partial, the larger 1C begins a trend which continues for the remainder of the partials in question. All three mouthpieces are within 1db of each other at the fundamental, and spread to almost 3db at the sixth partial.

The 1C reaches its strongest point at the fundamental with a rating of 64.879db. Its weakest point is the sixth partial at 32.665db. The trend between the second and third partials develops when the reading on the 1C drops only 4db, while the 7C and 10 1/2C mouthpieces fall 5db and 6db respectively.

With a reading of 64.666db at the fundamental, the 7C records its strongest partial. Its weakest point comes at the sixth partial with 30.533db.

The 10 1/2C mouthpiece has its strongest rating at the fundamental with 65.359db, while its lowest rating is at the sixth partial with 29.760db.

In the sixth harmonic, five partials are measured, and the 1C is the strongest in all but the second partial. Both the 1C and the 10 1/2C mouthpieces record their strongest

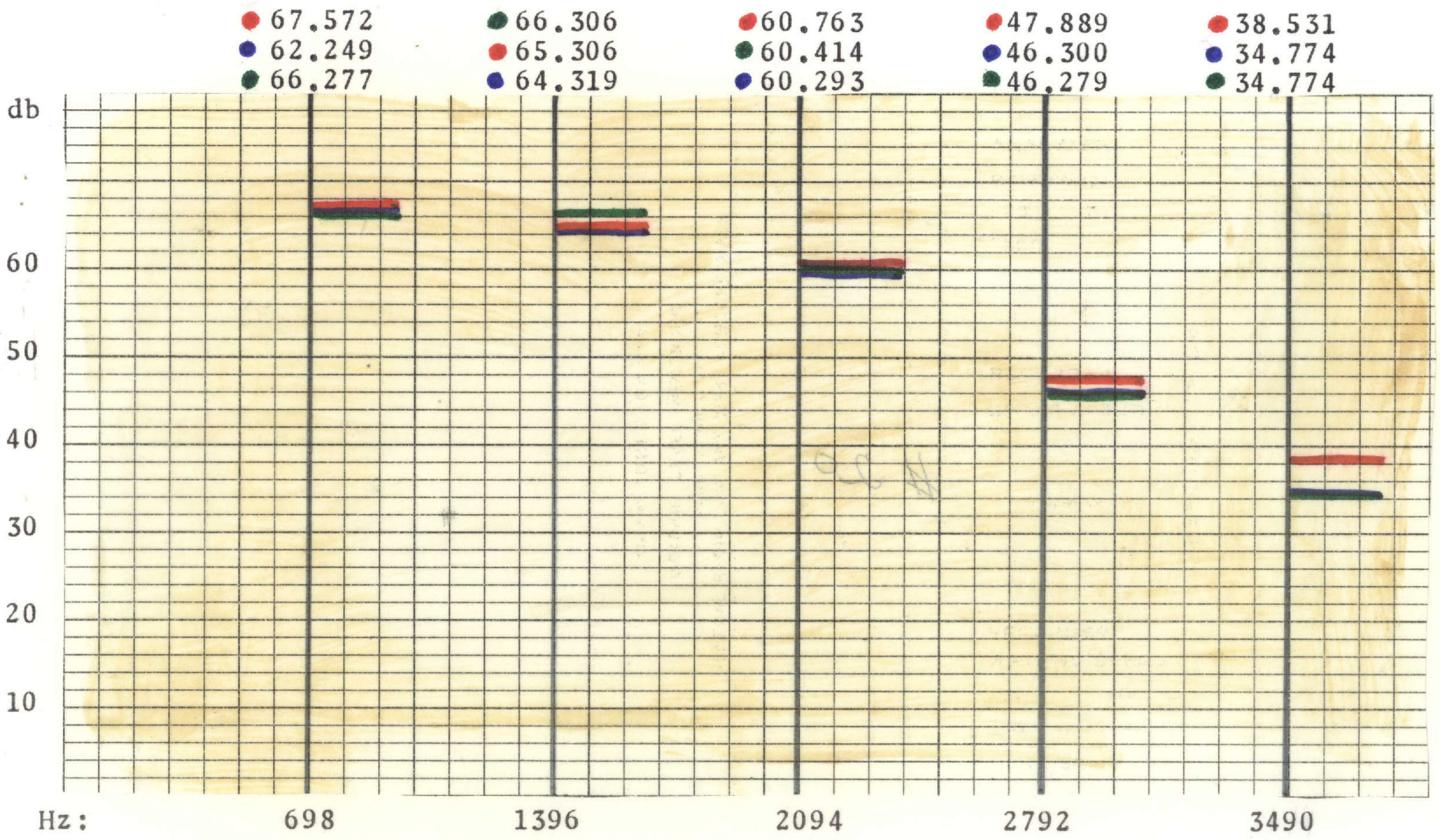


Fig. 20--Spectrum of G5 produced by selected mouthpieces

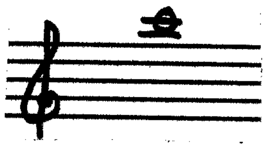
readings at the fundamental and begin a steady decline to their lowest readings at the fifth partial. The 7C reaches its peak at the second partial and is the strongest of the three mouthpieces for that partial, and then makes the same decline as the other mouthpieces. The three mouthpieces are within .5db of each other at the third partial only to arrive at the fifth partial with a spread of almost 4db.

The 1C mouthpiece has a rating of 67.572db at the fundamental and 38.531db at the fifth partial.

The 7C mouthpiece has its strongest reading of 66.306db at the second partial and its weakest reading of 34.774db at the fifth partial.

The rating of the 10 1/2C mouthpiece at the fundamental is 67.249db, while the rating at the fifth partial registers 34.774db.

C6



In examining the C6, three partials are registered. The 1C is the strongest of the three mouthpieces for the fundamental and the third partial, and the weakest of the three for the second partial. At the second partial, all three mouthpieces are within .3db, whereas the range for the fundamental is 2.4db, and 2.1db for the third partial.

The 1C reaches its strongest point at the fundamental with a 72.178db. rating. At the third partial, the level is 54.704db. Between the fundamental and the second partial, the 1C declines over 9db whereas the 7C drops under 8db and the 10 1/2C falls only 6.6db. However, between the second and third partials, the 1C falls 8.4db, while the 7C declines 10.1db and the 10 1/2C plunges 10.5db.

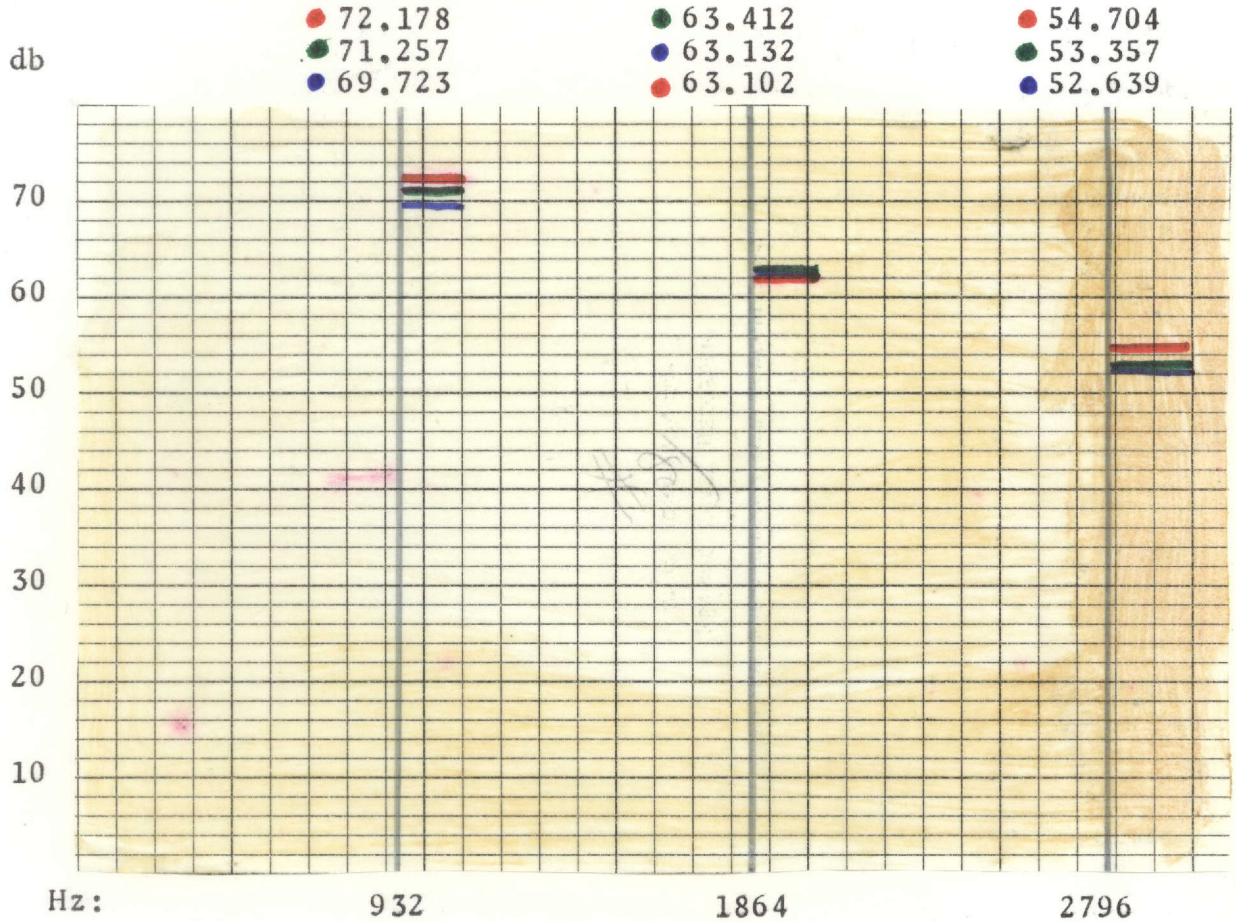


Fig. 21--Spectrum of C6 produced by selected mouthpieces.

CHAPTER V

ANALYSIS OF DATA AND CONCLUSION

It has been stated that this study was concerned only with the tone qualities produced with the selected Bach 1C, 7C, and 10 1/2C mouthpieces. While the pitch of a tone is determined by its fundamental, its upper partials control the tone quality. It is the presence and strength of these partials which first give the trumpet its characteristic sound, and secondly, allow for discrete variations in that tone quality.

In explaining the actual effect of the upper partials on the tone quality, Helmholtz states that "the influence of the upper partial tones is by no means unfelt. They give a compound tone a brighter and higher effect."[1] Backus claims that "tones with many high-frequency harmonics tend to sound brighter."[2] In discussing an experiment with strings of varying tensions, Benade states that one tone differed from another "chiefly in having larger amounts of the higher frequency components; it produces a tone color that is a little

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[1]Hermann von Helmholtz, _On the Sensations of Tone_ (New York, 1954), pp. 61-62.

[2]John Backus, _The Acoustical Foundations of Music_ (New York, 1969), p. 101.

'brighter' and 'more penetrating,' as the musicians say."[3] Finally, Culver declares that "a shallow cup-shaped mouthpiece facilitates the formation of the higher partials, and hence a 'bright' tone."[4]

In this study, a total of forty-one partials was recorded and measured. In all but six of these, the 1C mouthpiece produced the highest degree of intensity. This can be cited as a definite behavioral characteristic of tones produced with this mouthpiece. Table IV presents a comparative relationship of the three mouthpiece sizes, with the most intense being designated as first, and the least intense, third.

TABLE IV

COMPARATIVE RELATIONSHIP OF SELECTED MOUTHPIECES FOR FORTY-ONE PARTIALS

Mouthpiece	First	Second	Third
1C	35 Partials	4 Partials	2 Partials
7C	4 Partials	16 Partials	21 Partials
10 1/2C	2 Partials	21 Partials	18 Partials

The 7C and the 10 1/2C mouthpieces ranked very close to each other. Although the 7C illustrated the most intensity

[3]Arthur H. Benade, Horns, Strings, and Harmony (Garden City, New York, 1960), p. 119.

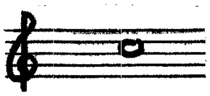
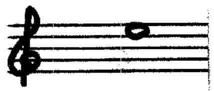
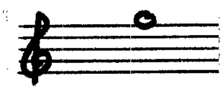
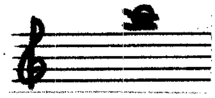
[4]Charles A. Culver, Musical Acoustics (New York, 1956), p. 215.

on two more partials than did the 10 1/2C, it was the weakest mouthpiece on three more partials than the 10 1/2C. On the basis of these relationships, no decisive pattern was evident.

There were only six out of forty-one partials in which the 1C did not rank first in intensity. Of these, four were strongest in the 7C, and the remaining two in the 10 1/2C. The six exceptions are presented in Table V.

TABLE V

EXCEPTIONS TO THE ESTABLISHED BEHAVIORAL PATTERN

Note	Partial	Hz	First	Second	Third
 C5	3rd	1398	7C	10 1/2C	1C
 C4	6th	1398	7C	1C	10 1/2C
 E5	Fund.	587	10 1/2C	1C	7C
 E5	2nd	1174	10 1/2C	1C	7C
 G5	2nd	1396	7C	1C	10 1/2C
 C6	2nd	1864	7C	10 1/2C	1C

It is interesting to note that three of these six exceptions occur in the 1396-1398 Hz range. The only other partial to fall within this range is the fourth partial of G4 (1396 Hz), and it recorded the 1C as the strongest.

The tonal analysis has produced a trend which shows the 1C mouthpiece providing more intensity in the partials than the 7C and the 10 1/2C mouthpieces. This analysis also shows that the results produced by the 7C and 10 1/2C mouthpieces are very similar. In this study a total of forty-one partials of six different fundamental pitches was recorded and measured.

It is now necessary to re-examine the physical properties of the 1C, 7C, and 10 1/2C mouthpieces as presented in Chapter II.

TABLE VI

PHYSICAL ANALYSIS OF SELECTED MOUTHPIECES

MP	Throat	Cup Width	Cup Depth	Outer Width	Rim Width	Rim Cup	Bite
1C	27.4	.667	.322	1.080	.206	11/64	2/64
7C	27.4	.643	.326	1.068	.212	11/64	3/64
10 1/2C	27.8	.641	.322	1.050	.209	12/64	3/64

The physical measurements of the Bach 1C, 7C, and 10 1/2C mouthpieces are very similar with the exception of the cup width. The 1C mouthpiece (widest inside cup diameter) produces the strongest partials in thirty-five out of forty-one instances, while the partials produced by the 7C and 10 1/2C mouthpieces are very similar in strength. In comparing these factors to their physical properties, a relationship is found to exist in direct proportion. The wider inside cup diameter enables the

1C to produce significantly stronger partials. The similarity of the inside cup diameters of the 7C and 10 1/2C mouthpieces (difference of .002 inch) can be cited as the reason for the lack of distinction in the partials produced with these mouthpieces.

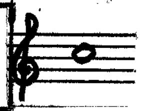
APPENDIX A

EVALUATION OF INDIVIDUAL PLAYER TESTS

FOR EACH OF THE MOUTHPIECES

TABLE VII

MOUTHPIECE NO. 1

Player	Partial F	2	3	4	5	6	7	8	9	10	Note
	27	31	26	24	21	16	11				
1	29	27	33	24	23	14	8				
	27	29	29	26	25	19	20				
	31	34	35	29	27	27	25				
2	38	••	37	40	35	33	29				
	25	37	31	31	30	27	24				
	33	32	35	24	26	20	11				
3	34	28	29	25	22	13	10				
	29	24	29	20	20	13	6				
	25	34	31	31	28	••	••				
4	35	36	35	27	32	28	21				
	20	27	27	23	23	21	18				
	35	36	37	37	35	34	29				
5	30	32	28	29	31	24	16				
	26	28	31	27	26	25	20				
	16	19	23	21	22	25	20	17	19	14	
1	14	23	14	22	22	23	21	19	15	16	
	20	19	16	18	19	18	14	12	11	6	
	23	21	24	27	34	30	33	26	27	23	
2	28	32	36	38	36	40	40	35	34	33	
	14	29	28	31	27	27	28	25	24	21	
	19	30	27	27	27	28	29	24	20	11	
3	18	31	27	27	28	26	26	••	25	17	
	16	25	26	19	25	26	22	18	16	12	
	32	28	32	29	25	29	••	••	••	••	
4	21	30	29	31	31	28	24	23	23	23	
	18	21	27	23	28	23	26	22	24	21	
	30	32	36	35	38	38	35	34	34	32	
5	17	27	28	23	24	25	25	21	23	21	
	16	21	28	23	27	26	22	21	24	20	
	27	27	26	29	22	22	18	12	9	9	
1	30	19	33	30	28	24	18	13	8	7	
	31	30	30	32	29	25	12	15	11	10	
	31	20	28	30	30	26	25	20	18	••	
2	30	37	35	••	35	37	35	33	30	27	
	25	32	33	24	26	27	24	21	20	14	
	29	32	29	31	25	20	14	14	••	••	
3	29	32	29	31	25	20	14	14	••	••	
	19	26	29	26	17	20	14	10	••	••	
	23	22	29	26	29	29	27	28	••	••	
4	29	31	33	33	32	27	27	25	21	20	
	24	27	30	26	24	25	20	19	10	8	
	41	38	36	42	34	36	34	32	31	26	
5	23	29	32	28	29	22	26	24	20	17	
	30	36	28	30	20	29	23	23	17	15	

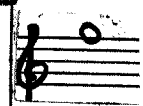
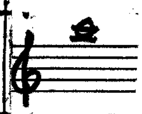
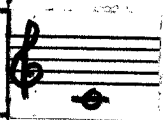
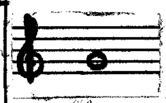
Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
	29	28	25	19	8	5					
1	34	32	30	28	18	13					
	31	35	28	23	15	10					
	30	36	31	34	26	••					
2	34	31	34	32	31	12					
	32	39	36	33	26	21					
	32	34	33	31	21	16					
3	37	36	35	28	20	16					
	29	33	28	26	18	11					
	34	32	34	••	••	••					
4	32	34	36	32	26	25					
	31	32	27	25	19	12					
	40	38	36	35	32	32					
5	33	34	31	26	20	18					
	35	32	29	33	21	24					
	34	33	26	17	13						
1	26	24	31	16	15						
	28	29	21	11	6						
	33	36	30	29	••						
2	37	35	38	30	26						
	36	38	32	29	22						
	35	36	30	20	17						
3	33	36	32	21	21						
	32	35	26	22	13						
	35	35	••	••	••						
4	39	35	35	29	24						
	30	29	31	25	19						
	37	35	35	••	34						
5	35	32	26	23	25						
	36	38	33	29	23						
	39	29	21								
1	38	30	24								
	33	34	29								
	38	35	32								
2	39	35	35								
	40	38	32								
	33	33	26								
3	35	29	28								
	33	29	23								
	35	35	31								
4	38	34	37								
	33	30	29								
	37	35	35								
5	37	33	30								
	40	30	28								

TABLE VIII

MOUTHPIECE NO. 2

Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
	26	25	23	25	19	15	10				
1	32	33	34	30	26	16	12				
	30	25	33	25	24	16	••				
	30	40	35	31	31	31	••				
2	30	37	34	37	35	27	26				
	30	31	28	27	26	17	13				
	37	29	36	31	25	26	23				
3	37	35	29	33	28	19	20				
	30	27	41	19	25	20	12				
	27	34	31	••	••	••	••				
4	29	31	29	23	22	22	18				
	27	24	29	26	25	21	19				
	40	36	37	35	39	33	23				
5	32	31	25	26	28	23	15				
	27	28	32	35	31	26	23				

	16	20	25	25	23	19	20	19	18	16	
1	20	27	23	27	27	24	19	20	19	20	
	20	26	26	23	25	26	23	20	19	16	
	23	24	23	29	35	33	32	28	26	26	
2	27	28	40	34	32	36	30	29	32	28	
	14	25	25	35	28	21	25	23	24	19	
	17	32	28	21	25	33	31	27	27	21	
3	21	32	27	28	27	33	20	22	25	24	
	16	26	23	24	25	25	24	29	21	21	
	23	22	23	29	30	28	25	25	••	••	
4	16	25	24	26	23	24	23	20	22	19	
	18	21	26	22	26	24	23	21	23	23	
	27	33	35	35	36	35	35	33	35	35	
5	17	28	27	25	26	19	22	18	19	20	
	19	24	29	25	27	26	20	27	27	25	

	26	27	26	25	24	22	18	12	6	4	
1	30	28	32	26	28	22	17	10	9	••	
	32	25	28	26	22	18	15	11	12	9	
	32	25	34	33	32	27	28	22	19	••	
2	31	35	36	35	35	33	31	29	24	22	
	21	31	21	24	23	22	20	19	11	10	
	30	30	28	35	32	30	23	22	18	15	
3	29	28	35	35	32	27	23	21	18	13	
	25	26	28	24	26	24	20	8	••	••	
	32	28	32	32	30	22	••	••	••	••	
4	23	28	29	26	28	24	23	21	12	••	
	24	27	30	25	25	24	22	20	10	7	
	38	36	41	36	35	40	35	33	30	27	
5	21	29	31	30	37	23	26	17	14	8	
	28	31	28	30	22	34	26	24	19	16	

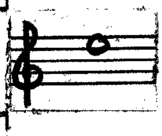
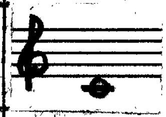
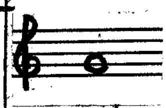
Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
	30	27	24	18	13	11					
1	33	30	28	22	••	••					
	32	33	29	22	13	8					
	40	35	31	30	24	••					
2	37	35	38	35	28	23					
	32	30	26	28	23	14					
	37	33	31	32	20	••					
3	28	32	28	22	16	8					
	27	22	39	24	24	20					
	34	33	••	••	••	••					
4	25	26	25	30	21	18					
	31	29	28	25	21	12					
	38	35	35	37	34	31					
5	29	40	33	27	24	••					
	35	28	27	28	24	20					
	32	27	25	18	12						
1	33	30	24	18	••						
	31	31	25	17	••						
	37	35	34	27	24						
2	40	36	41	33	26						
	33	30	32	26	19						
	35	30	29	23	••						
3	29	32	28	18	15						
	30	26	25	22	15						
	42	35	34	••	••						
4	34	35	29	25	21						
	33	30	27	22	13						
	36	35	36	33	30						
5	34	29	26	27	11						
	31	37	31	27	22						
	41	26	20								
1	38	25	20								
	39	33	25								
	38	35	29								
2	38	35	35								
	38	31	25								
	37	25	12								
3	41	31	27								
	34	29	24								
	36	35	••								
4	33	29	28								
	33	39	27								
	••	••	40								
5	34	32	30								
	36	34	31								

TABLE IX

MOUTHPIECE NO. 3

Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
	31	34	26	24	18	14	9				
1	33	29	34	27	21	11	10				
	25	27	27	25	21	••	••				
	30	37	35	33	30	26	22				
2	25	37	••	35	34	30	25				
	30	28	27	25	26	23	16				
	36	27	35	32	30	28	12				
3	36	34	31	36	31	26	14				
	29	32	25	27	22	17	13				
	24	34	34	••	••	••	••				
4	29	31	20	20	24	18	14				
	26	21	24	25	23	19	16				
	35	39	37	35	41	35	27				
5	32	33	28	27	28	18	20				
	28	28	30	29	28	25	23				
	22	24	30	27	26	25	25	21	18	13	
1	20	27	27	27	26	22	24	23	21	20	
	20	25	25	20	22	23	20	18	20	19	
	23	24	30	26	28	28	30	24	27	22	
2	24	27	36	34	32	33	30	29	31	29	
	15	24	26	27	24	19	24	23	23	21	
	15	31	25	25	29	33	29	24	19	20	
3	18	34	26	29	31	28	32	27	20	23	
	15	24	22	24	26	24	20	21	20	14	
	23	20	29	29	29	29	26	••	••	••	
4	16	25	25	25	21	24	21	20	17	16	
	19	22	25	19	25	22	21	20	23	20	
	27	34	36	35	38	35	34	34	34	32	
5	17	26	26	23	25	25	24	21	21	22	
	19	24	28	33	26	31	30	30	32	31	
	37	31	26	26	25	22	20	13	7	7	
1	28	29	30	27	27	21	14	6	11	6	
	31	27	28	30	24	20	8	9	7	9	
	29	33	29	29	28	28	26	21	18	13	
2	29	41	36	37	35	34	32	29	24	17	
	20	28	23	23	26	24	21	20	16	12	
	26	30	31	24	24	21	16	8	6	••	
3	28	21	39	30	28	26	17	20	13	8	
	26	24	28	22	20	21	18	9	10	••	
	32	29	29	31	25	••	••	••	••	••	
4	24	28	29	25	26	21	23	20	10	10	
	24	26	29	21	26	23	23	18	7	10	
	35	38	39	37	35	35	35	32	31	26	
5	23	29	28	26	27	25	23	22	18	14	
	30	32	29	32	27	28	26	23	20	13	

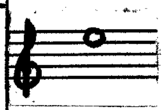
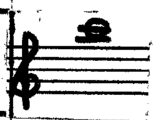
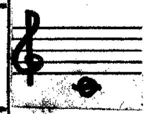
Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
	35	32	25	27	19	15					
1	32	32	28	22	12	10					
	32	30	29	25	15	11					
	30	36	30	27	18	23					
2	37	35	38	35	34	30					
	30	29	29	32	20	15					
	34	32	28	28	17	••					
3	39	33	35	28	20	13					
	32	39	29	24	16	••					
	33	33	34	••	••	••					
4	24	28	24	26	21	20					
	29	31	24	26	19	16					
	37	35	35	37	32	30					
5	32	33	28	27	22	14					
	35	29	27	30	24	19					
	38	33	26	18	15						
1	34	26	25	13	••						
	32	27	26	15	••						
	35	35	34	29	••						
2	39	35	37	29	24						
	32	33	30	24	19						
	34	33	28	24	••						
3	34	37	33	26	16						
	29	26	25	19	14						
	37	35	35	••	••						
4	34	33	29	24	22						
	30	26	27	21	20						
	35	35	40	35	34						
5	35	29	28	26	20						
	30	32	31	25	20						
	41	30	26								
1	40	27	24								
	31	30	16								
	36	35	32								
2	41	30	33								
	36	33	21								
	37	32	20								
3	36	32	22								
	33	29	18								
	35	35	••								
4	35	27	25								
	26	28	36								
	36	35	36								
5	32	31	33								
	39	28	27								

TABLE X

MOUTHPIECE NO. 4

Player	F	2	3	4	5	6	7	8	9	10	Note
	Partial										
	35	33	32	26	22	18	11				
1	31	33	29	25	18	16	7				
	31	34	25	27	••	••	••				
	31	34	35	33	31	29	22				
2	32	35	37	35	34	27	27				
	29	27	23	24	25	21	17				
	32	41	34	29	28	21	16				
3	34	35	29	36	28	27	19				
	30	32	24	28	21	21	14				
	24	34	34	••	••	••	••				
4	29	26	27	21	25	24	17				
	21	28	30	27	25	20	17				
	36	35	35	39	35	33	32				
5	41	33	25	28	26	21	11				
	25	26	32	31	29	27	21				
	24	27	29	29	28	20	22	21	22	17	
1	24	24	25	29	27	27	25	24	21	20	
	20	24	24	27	23	18	20	20	20	14	
	23	29	25	28	29	28	32	29	28	24	
2	15	25	24	27	24	23	17	21	21	23	
	26	24	41	31	34	34	33	30	36	31	
	16	29	25	29	30	32	29	25	26	23	
3	19	29	27	30	28	29	23	24	22	21	
	15	26	25	24	25	23	22	15	19	20	
	24	22	25	23	28	30	22	••	••	••	
4	16	24	28	25	26	21	19	22	18	17	
	19	19	24	24	26	23	25	22	21	20	
	30	35	36	35	37	35	35	35	34	32	
5	16	27	26	27	25	19	18	21	21	19	
	19	22	29	21	29	29	26	25	26	25	
	34	27	33	29	27	21	22	15	11	11	
1	27	27	28	28	24	21	13	••	••	••	
	31	30	26	28	24	19	••	16	11	13	
	31	33	31	29	32	29	25	20	16	••	
2	28	35	37	35	34	33	30	25	20	20	
	23	25	26	22	23	23	20	22	15	13	
	30	32	33	30	25	24	16	15	10	9	
3	33	29	35	34	31	31	29	22	20	13	
	23	27	32	25	16	25	20	11	10	••	
	31	27	31	31	25	••	••	••	••	••	
4	22	29	29	26	26	22	23	18	10	11	
	22	27	28	28	23	21	22	17	12	9	
	35	38	35	36	35	36	33	30	30	18	
5	23	29	29	24	29	24	24	25	22	24	
	27	28	30	30	26	28	25	24	19	14	

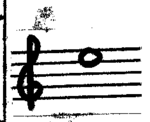
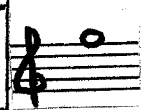
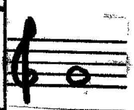
Player	Partial F	2	3	4	5	6	7	8	9	10	Note
	31	28	30	24	12	11					
1	32	34	30	26	16	9					
	35	34	27	26	16	13					
	35	33	35	32	25	••					
2	41	35	39	34	31	22					
	28	31	27	29	23	19					
	26	31	25	24	8	••					
3	37	37	35	30	25	21					
	31	31	34	28	20	11					
	33	31	32	••	••	••					
4	22	23	29	25	24	20					
	30	31	26	25	21	16					
	36	35	35	35	31	32					
5	25	34	29	25	16	7					
	36	33	30	29	25	16					
	33	34	26	16	15						
1	29	32	27	22	22						
	33	32	24	20	11						
	35	35	32	29	••						
2	39	35	36	33	27						
	31	30	31	24	18						
	37	35	32	18	14						
3	37	34	33	24	15						
	31	33	29	25	12						
	35	33	••	••	••						
4	33	32	27	25	20						
	30	24	28	23	19						
	35	35	35	35	34						
5	33	25	28	24	16						
	32	35	33	28	23						
	36	33	21								
1	39	33	29								
	35	30	21								
	34	34	32								
2	40	35	35								
	37	25	27								
	34	33	21								
3	37	35	22								
	35	32	23								
	39	33	••								
4	33	28	28								
	28	32	25								
	39	35	35								
5	36	31	19								
	40	33	31								

TABLE XI

MOUTHPIECE NO. 5

Player	Partial F	2	3	4	5	6	7	8	9	10	Note
	30	32	31	29	23	17	12				
1	32	31	34	27	20	12	7				
	29	23	32	28	22	10	11				
	30	40	35	32	30	27	28				
2	34	40	35	35	35	28	28				
	31	33	29	28	29	17	19				
	33	33	32	31	22	18	17				
3	32	32	29	33	24	22	14				
	29	31	41	27	26	14	14				
	23	32	30	••	••	••	••				
4	29	28	26	24	24	23	16				
	20	23	29	26	27	23	17				
	32	33	28	28	29	21	15				
5	29	32	35	30	29	25	22				
	25	29	32	30	31	27	24				

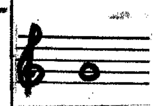
	24	25	26	26	24	27	22	20	19	23	
1	23	25	25	28	23	26	26	23	18	20	
	19	28	29	24	26	26	24	24	21	19	
	21	24	27	31	28	30	31	26	27	22	
2	26	28	37	35	32	34	33	29	32	32	
	13	25	25	26	25	25	20	24	23	23	
	20	32	28	28	27	30	26	27	29	23	
3	20	29	28	26	26	26	23	22	23	20	
	18	25	20	20	23	22	20	19	23	19	
	23	21	25	29	28	27	23	••	••	••	
4	16	25	25	26	23	23	21	22	21	20	
	20	20	25	17	25	24	20	21	19	18	
	19	24	28	27	26	29	25	24	24	22	
5	16	27	27	25	26	18	21	23	21	21	
	19	21	28	25	28	29	28	25	27	23	

	32	30	25	27	23	21	17	11	8	6	
1	31	30	33	31	29	20	19	16	11	6	
	32	28	25	27	25	22	13	10	••	••	
	32	29	31	33	31	31	24	22	17	••	
2	31	35	35	41	35	40	33	26	22	17	
	23	29	28	24	26	22	21	21	12	9	
	27	29	31	32	27	27	13	19	15	11	
3	36	31	32	33	32	29	26	10	15	••	
	21	27	29	23	22	23	19	18	9	8	
	32	27	28	30	22	••	••	••	••	••	
4	24	28	30	29	27	24	23	18	9	10	
	20	37	26	25	25	23	12	14	6	10	
	27	32	29	34	31	28	27	22	21	16	
5	25	30	22	40	27	25	22	22	16	13	
	28	28	30	31	26	27	25	23	17	16	

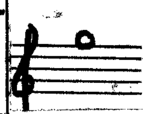
Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
	35	31	28	20	18	12					
1	32	31	27	22	11	8					
	34	31	24	20	14	8					
	36	26	29	30	28	••					
2	35	36	35	37	29	27					
	32	30	29	30	24	19					
	34	35	31	26	15	••					
3	35	30	30	27	20	15					
	28	31	27	23	19	15					
	31	30	28	••	••	••					
4	24	26	25	28	26	10					
	29	31	24	20	14	11					
	34	34	32	29	24	20					
5	29	34	29	27	21	10					
	35	30	24	28	22	16					
	41	35	27	17	16						
1	28	32	28	22	10						
	33	35	32	23	12						
	35	36	34	29	••						
2	41	35	35	33	24						
	32	31	30	23	21						
	35	34	34	16	••						
3	34	40	30	25	21						
	31	33	28	23	13						
	37	28	••	••	••						
4	33	35	32	27	22						
	30	29	29	23	15						
	34	35	33	28	24						
5	35	33	31	31	20						
	32	35	33	22	21						
	40	31	26								
1	40	32	28								
	35	34	28								
	39	35	33								
2	41	35	35								
	34	30	25								
	38	35	23								
3	37	33	27								
	25	30	26								
	33	18	••								
4	35	31	28								
	34	25	24								
	35	34	30								
5	34	30	29								
	34	30	31								

TABLE XII

MOUTHPIECE NO. 6

Player	Partial F	2	3	4	5	6	7	8	9	10	Note
	29	32	34	24	17	15	10				
1	31	22	34	27	23	11	7				
	28	26	35	27	19	14	8				
	33	30	36	33	29	27	20				
2	27	41	35	32	33	22	14				
	30	29	28	26	26	21	13				
	34	35	33	31	15	20	12				
3	35	37	35	29	31	26	20				
	29	30	26	26	19	21	14				
	24	31	32	••	••	••	••				
4	29	28	24	18	22	21	13				
	24	27	29	••	24	20	11				
	29	33	35	30	29	28	23				
5	29	26	27	27	28	22	15				
	20	31	37	27	26	22	13				
	25	27	29	23	22	28	26	19	18	16	
1	23	27	25	27	24	28	23	20	18	15	
	14	26	21	22	29	27	21	14	16	16	
	22	23	24	31	27	30	31	28	24	23	
2	23	22	33	29	28	32	29	29	31	27	
	17	26	21	24	24	26	22	23	20	21	
	21	29	30	29	23	25	21	24	25	20	
3	21	29	26	30	31	32	24	24	25	23	
	16	25	25	25	26	25	21	13	19	19	
	22	20	29	27	30	28	26	••	••	••	
4	16	24	26	26	26	24	13	22	22	21	
	19	20	25	20	25	24	26	23	21	17	
	17	24	28	28	23	30	25	24	25	23	
5	17	25	26	25	24	23	19	22	22	22	
	20	19	29	26	25	28	26	24	23	21	
	34	28	29	31	28	25	15	11	11	8	
1	29	27	31	29	28	25	14	13	••	••	
	33	29	27	25	26	22	16	10	9	7	
	31	28	29	30	27	28	22	20	14	13	
2	20	32	32	35	31	29	25	22	16	14	
	20	28	26	24	25	22	20	20	13	9	
	29	31	28	28	26	26	16	11	8	6	
3	29	30	35	33	30	25	20	21	9	7	
	21	26	27	21	23	18	13	14	4	5	
	33	29	25	30	24	••	••	••	••	••	
4	22	28	28	26	19	23	22	18	12	7	
	21	27	28	24	23	23	18	19	13	5	
	28	29	28	34	30	29	26	23	20	16	
5	25	28	27	23	27	24	21	20	13	14	
	28	30	28	34	24	25	22	19	15	12	

Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
	31	16	22	29	24	20					
1	33	33	25	22	••	••					
	24	36	30	27	16	••					
	36	34	32	30	27	••					
2	41	34	32	35	22	19					
	31	31	24	23	18	17					
	27	39	31	27	19	••					
3	41	33	34	29	23	20					
	31	37	30	24	20	13					
	29	29	31	••	••	••					
4	27	28	21	30	21	18					
	29	32	27	27	20	13					
	34	34	32	29	22	18					
5	30	33	31	25	23	••					
	34	31	23	27	21	15					

Player	F	2	3	4	5	6	7	8	9	10	Note
	35	34	27	22	13						
1	24	34	26	19	10						
	27	36	27	22	13						
	41	35	34	28	23						
2	36	35	35	31	23						
	27	34	32	23	19						
	35	35	32	20	6						
3	38	40	30	18	19						
	31	34	31	24	••						
	33	35	••	••	••						
4	34	35	33	26	21						
	31	29	26	23	21						
	34	34	31	24	20						
5	33	29	27	23	17						
	32	34	31	24	19						

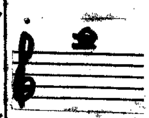
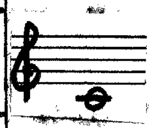
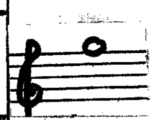
Player	F	2	3	4	5	6	7	8	9	10	Note
	38	25	24								
1	40	32	22								
	37	31	27								
	35	34	32								
2	35	32	29								
	36	31	26								
	35	35	25								
3	39	26	28								
	32	36	26								
	35	27	••								
4	32	31	27								
	29	31	27								
	39	33	29								
5	34	34	29								
	35	28	27								

TABLE XIII

MOUTHPIECE NO. 7

Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
	30	33	32	29	24	20	••				
1	31	33	36	29	22	16	12				
	29	32	32	27	26	13	8				
	27	37	41	32	30	29	20				
2	28	41	34	32	31	24	24				
	31	28	29	28	25	23	19				
	34	33	30	31	23	17	14				
3	34	35	34	32	27	25	16				
	27	29	24	27	24	22	14				
	23	31	31	••	••	••	••				
4	28	31	28	22	23	24	17				
	24	23	24	22	25	19	14				
	29	33	33	28	29	25	22				
5	31	29	32	26	24	20	8				
	21	31	33	29	30	26	18				
	24	25	26	25	27	27	24	24	24	17	
1	23	24	22	27	25	27	22	24	20	20	
	21	27	28	25	25	28	26	23	21	21	
	23	25	27	26	33	31	34	28	26	22	
2	20	26	41	28	28	30	27	26	26	22	
	13	27	22	27	24	23	24	24	26	22	
	22	29	27	27	28	29	21	23	26	20	
3	20	28	24	29	27	29	25	23	25	22	
	18	25	23	26	27	20	25	23	18	13	
	22	26	28	28	28	29	25	••	••	••	
4	16	25	28	27	23	25	23	20	21	21	
	18	26	23	19	27	25	21	19	23	23	
	19	26	30	28	27	29	22	24	23	21	
5	18	27	26	23	22	27	25	21	23	18	
	19	21	29	21	28	26	24	22	25	22	
	33	22	32	33	24	24	20	13	10	10	
1	30	24	29	27	25	20	14	13	9	6	
	32	29	28	21	24	21	4	••	••	••	
	41	31	32	34	31	27	27	22	23	••	
2	23	34	32	37	25	29	25	21	16	12	
	21	28	26	29	24	27	24	20	12	7	
	29	32	30	29	24	25	19	13	12	6	
3	31	24	28	37	29	27	23	18	11	••	
	22	25	29	26	21	23	18	11	6	••	
	32	31	30	28	25	••	••	••	••	••	
4	21	28	29	26	25	21	21	17	9	12	
	19	25	28	25	23	19	20	16	11	6	
	28	32	27	31	29	26	24	21	15	18	
5	24	28	31	27	25	22	26	19	19	16	
	27	30	28	31	24	25	19	20	13	10	

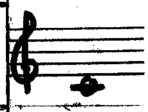
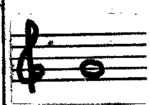
Player	Partial F	2	3	4	5	6	7	8	9	10	Note
	28	41	29	21	17	13					
1	39	27	29	23	10	••					
	28	33	28	23	18	10					
	33	39	35	33	30	••					
2	30	31	28	29	23	17					
	28	42	32	35	25	22					
	35	32	31	29	21	••					
3	37	33	35	28	26	13					
	29	28	28	23	8	••					
	31	30	27	••	••	••					
4	25	28	23	27	20	17					
	30	30	25	24	16	17					
	33	30	31	28	18	16					
5	33	33	24	37	23	14					
	41	30	27	28	21	16					

	36	40	30	21	18						
1	28	31	25	18	13						
	35	27	29	16	15						
	36	35	30	29	25						
2	40	35	31	24	22						
	30	27	27	25	18						
	38	34	35	16	••						
3	34	41	33	22	20						
	30	32	32	24	15						
	34	32	••	••	••						
4	33	33	29	24	21						
	32	23	32	25	20						
	34	35	31	23	20						
5	33	34	28	25	19						
	32	33	30	23	18						

	38	35	34								
1	41	28	23								
	40	28	19								
	36	41	29								
2	40	34	29								
	33	33	25								
	35	33	25								
3	40	33	26								
	37	28	27								
	35	16	••								
4	31	31	28								
	31	30	24								
	35	35	29								
5	28	33	31								
	38	32	28								

TABLE XIV

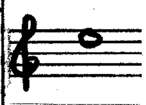
MOUTHPIECE NO. 8

Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
	41	32	34	28	21	17	13				
1	32	34	33	33	27	15	17				
	31	33	35	26	29	19	13				
	33	37	33	36	31	32	22				
2	29	36	34	34	31	22	22				
	30	27	24	27	27	24	14				
	32	34	33	31	20	24	13				
3	35	36	31	32	31	26	19				
	27	29	28	28	18	18	9				
	20	34	29	••	••	••	••				
4	27	29	28	26	25	24	16				
	17	26	29	26	19	19	16				
	29	34	36	30	29	26	24				
5	33	29	31	28	31	23	21				
	28	32	33	27	27	21	15				
	24	28	25	27	26	27	25	19	18	17	
1	23	25	21	27	29	26	23	25	22	19	
	23	26	27	27	29	29	28	27	20	21	
	24	25	30	33	29	28	28	27	26	19	
2	19	26	32	30	28	29	31	28	26	25	
	9	27	23	26	18	21	21	20	21	20	
	21	28	30	23	26	27	26	24	20	17	
3	22	29	26	32	26	28	23	22	23	17	
	18	23	23	24	23	20	23	16	12	16	
	23	19	26	28	25	30	22	••	••	••	
4	18	25	27	23	26	22	24	23	24	22	
	19	19	26	18	26	27	24	20	22	18	
	20	26	31	29	30	29	26	26	25	24	
5	17	28	29	27	26	24	20	24	24	26	
	20	25	27	28	23	24	19	12	19	20	
	32	28	30	31	28	25	19	9	9	11	
1	30	24	32	27	25	17	14	16	11	7	
	33	24	28	28	22	21	15	10	9	8	
	29	36	30	32	33	30	27	23	19	13	
2	24	41	30	36	32	26	24	22	16	9	
	24	25	30	20	25	26	18	19	16	13	
	38	33	30	30	25	24	17	8	13	9	
3	31	29	27	32	28	37	24	16	20	12	
	22	25	28	25	23	19	16	••	••	••	
	31	26	29	32	21	••	••	••	••	••	
4	21	28	29	31	24	25	21	16	13	7	
	21	26	28	25	25	23	20	16	••	••	
	28	33	26	32	28	27	24	24	19	16	
5	24	29	27	29	21	25	22	21	16	16	
	27	29	32	29	25	25	22	17	15	11	

Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
	39	28	32	25	20	8					
1	37	31	29	24	13	14					
	35	35	30	22	18	12					
	33	35	28	31	29	••					
2	40	34	37	33	25	23					
	32	29	29	28	21	13					
	23	35	32	29	18	17					
3	36	32	34	29	19	11					
	30	31	28	25	18	12					
	32	41	••	••	••	••					
4	24	22	28	23	21	15					
	31	30	26	25	13	15					
	34	33	29	25	22	15					
5	33	34	32	27	23	14					
	35	29	28	25	17	11					
	34	37	31	24	17						
1	29	33	25	19	10						
	32	34	28	19	20						
	41	35	34	29	19						
2	35	40	35	31	23						
	31	33	28	23	17						
	34	34	31	21	15						
3	35	36	32	16	15						
	29	33	30	22	15						
	34	34	••	••	••						
4	34	31	32	23	20						
	28	33	29	25	18						
	34	34	32	23	19						
5	36	28	26	27	21						
	33	34	31	21	18						
	39	32	26								
1	39	32	24								
	37	33	26								
	37	36	30								
2	37	34	30								
	36	33	27								
	35	33	21								
3	28	35	20								
	27	29	25								
	37	31	32								
4	32	31	33								
	29	31	25								
	40	35	31								
5	34	32	29								
	40	34	28								

TABLE XV

MOUTHPIECE NO. 9

Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
1	24	25	33	29	24	11	8				
	33	36	29	26	22	17	12				
	29	34	33	32	29	22	17				
2	33	34	28	22	25	20	••				
	28	34	39	30	25	21	17				
	29	30	28	29	23	20	20				
3	32	27	34	26	23	14	10				
	34	35	35	35	28	22	23				
	28	25	26	23	21	20	9				
4	21	33	32	31	••	••	••				
	27	29	24	26	24	23	17				
	21	25	28	24	20	19	12				
5	29	33	35	32	29	24	21				
	40	25	32	29	29	25	19				
	27	32	33	27	27	22	16				
1	24	24	20	21	26	28	27	19	21	20	
	24	29	28	29	28	31	21	20	20	18	
	21	28	28	29	27	27	27	24	20	19	
2	23	24	30	29	28	27	28	26	25	19	
	22	26	34	33	26	32	29	29	28	31	
	9	26	23	26	25	26	24	22	24	23	
3	27	21	25	29	30	22	26	24	15	16	
	21	27	26	26	29	28	20	23	23	18	
	18	24	23	20	24	24	21	13	16	17	
4	23	20	23	29	30	29	25	26	26	20	
	16	24	25	24	26	24	24	21	21	19	
	19	18	25	17	28	25	24	20	22	17	
5	19	25	29	29	29	32	28	28	27	25	
	18	27	28	23	24	28	23	25	23	21	
	20	26	28	29	23	28	25	20	22	20	
1	36	25	34	28	27	28	21	14	12	11	
	31	24	34	30	29	26	20	15	12	10	
	31	30	29	23	23	22	16	14	9	7	
2	29	34	32	29	21	32	25	21	11	••	
	24	34	29	32	23	31	24	20	15	13	
	22	27	28	25	29	25	21	21	16	13	
3	27	26	32	28	25	24	24	20	14	7	
	31	32	27	32	30	27	23	19	18	11	
	20	25	28	21	19	19	17	10	••	••	
4	31	25	28	33	25	27	23	17	13	••	
	22	27	29	21	26	24	21	20	14	8	
	21	26	27	25	23	22	20	16	23	••	
5	28	32	26	34	29	27	26	24	19	16	
	25	35	26	27	26	28	23	20	18	13	
	27	30	27	31	19	27	24	22	15	14	

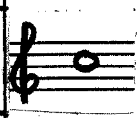
Player	F	2	3	4	5	6	7	8	9	10	Note
	37	27	29	24	18	16					
1	••	32	32	23	13	8					
	33	30	29	24	17	••					
	31	35	32	28	27	23					
2	31	31	29	36	25	18					
	30	31	29	30	22	20					
	27	30	35	31	26	16					
3	37	32	34	25	21	14					
	30	30	27	24	22	15					
	32	33	32	••	••	••					
4	27	28	33	21	21	17					
	31	32	25	24	19	13					
	34	33	27	27	20	17					
5	33	33	32	25	20	••					
	35	27	28	27	20	••					

Player	F	2	3	4	5	6	7	8	9	10	Note
	39	35	32	24	19						
1	28	33	27	20	14						
	34	35	30	20	14						
	41	35	34	23	••						
2	41	35	34	24	22						
	22	36	31	23	17						
	35	30	31	25	7						
3	41	37	32	23	18						
	33	34	31	21	13						
	38	32	31	••	••						
4	33	28	29	24	20						
	31	29	27	25	16						
	34	33	32	25	23						
5	37	31	28	27	21						
	33	32	32	26	20						

Player	F	2	3	4	5	6	7	8	9	10	Note
	34	31	28								
1	39	33	22								
	37	32	19								
	37	35	30								
2	40	34	33								
	37	28	23								
	36	34	28								
3	37	35	27								
	35	33	25								
	35	28	27								
4	32	27	27								
	31	30	23								
	39	34	30								
5	32	39	20								
	35	31	30								

TABLE XVI

MOUTHPIECE NO. 10

Player	Partial F	2	3	4	5	6	7	8	9	10	Note
1	29	36	30	26	26	14	10				
	31	30	37	29	25	12	11				
	30	27	30	25	25	16	10				
2	34	33	37	30	30	25	24				
	34	35	29	38	27	18	19				
	28	29	29	27	25	21	17				
3	31	29	25	16	15	••	••				
	33	36	37	31	28	26	19				
	25	29	23	30	20	18	7				
4	28	30	24	26	••	••	••				
	28	21	28	31	29	23	14				
	22	28	27	24	17	19	17				
5	27	33	36	31	30	25	33				
	29	32	38	30	28	24	16				
	26	29	30	28	27	22	18				
1	24	26	27	24	28	26	29	22	22	20	
	23	25	29	28	29	31	22	19	20	20	
	18	24	25	18	20	19	12	16	18	15	
2	23	21	28	27	27	28	28	25	25	19	
	20	26	31	29	22	28	27	25	25	18	
	12	25	18	25	24	26	24	22	19	17	
3	19	29	29	29	27	29	23	25	26	24	
	21	29	27	30	27	25	32	29	22	21	
	18	22	22	23	25	24	23	20	22	20	
4	21	25	27	24	29	31	27	23	26	22	
	17	24	23	19	26	21	25	21	22	22	
	19	19	24	22	25	27	25	23	22	21	
5	19	24	27	29	27	30	28	27	26	23	
	17	27	25	24	19	26	24	22	16	29	
	19	22	28	23	25	24	25	23	20	20	
1	30	29	32	32	28	21	18	••	10	7	
	31	26	33	26	26	24	18	7	8	8	
	32	23	21	25	13	16	8	••	••	••	
2	31	33	32	29	29	30	22	20	16	15	
	24	36	30	32	25	28	24	16	14	8	
	27	20	30	26	22	26	22	16	14	8	
3	29	31	27	29	27	26	15	12	13	8	
	32	29	33	29	37	30	22	20	15	8	
	24	26	26	27	23	23	18	13	5	6	
4	25	28	25	30	29	28	24	23	••	••	
	25	26	31	26	26	25	23	19	15	11	
	22	27	29	25	26	23	22	21	13	7	
5	29	29	30	32	32	29	25	24	20	17	
	25	28	27	26	26	25	21	20	16	15	
	27	30	28	29	22	26	20	20	12	9	

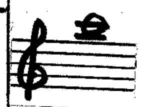
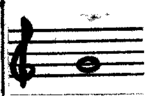
Player	Partial F	2	3	4	5	6	7	8	9	10	Note
1	40	33	28	25	20	13					
	33	32	35	23	11	7					
	31	33	23	22	14	10					
2	32	34	35	28	27	16					
	34	34	37	30	24	19					
	29	29	25	24	20	6					
3	33	28	29	23	20	13					
	41	36	38	25	27	21					
	28	32	28	25	15	13					
4	29	35	28	31	••	••					
	29	25	28	25	24	21					
	31	32	23	23	19	12					
5	34	32	30	25	20	14					
	32	34	31	25	22	17					
	37	28	18	26	19	11					
1	38	35	26	20	16						
	27	29	25	21	16						
	35	29	27	14	13						
2	16	24	34	28	20						
	40	36	34	25	21						
	28	32	28	22	16						
3	34	28	29	23	7						
	33	41	27	17	15						
	29	30	33	23	8						
4	35	35	31	25	••						
	31	36	29	27	22						
	30	26	31	25	21						
5	34	34	29	28	••						
	31	29	31	25	19						
	34	34	32	25	••						
1	41	32	27								
	39	29	24								
	38	30	20								
2	42	34	29								
	39	34	28								
	34	31	24								
3	35	35	28								
	37	33	21								
	33	31	23								
4	34	32	30								
	34	25	28								
	32	27	23								
5	41	34	30								
	32	34	29								
	35	26	29								

TABLE XVII

MOUTHPIECE NO. 11

Player	F	2	3	4	5	6	7	8	9	10	Note
	41	29	27	25	24	21	16				
1	32	26	28	28	24	15	11				
	30	22	27	27	23	10	9				
	34	35	37	33	29	21	21				
2	35	36	35	33	32	27	22				
	28	29	33	29	26	19	17				
	38	33	33	34	32	24	25				
3	33	35	34	32	26	18	20				
	27	29	30	27	24	20	11				
	25	23	34	32	30	••	••				
4	29	30	29	31	28	24	13				
	16	26	27	23	22	21	17				
	29	33	34	31	27	23	22				
5	36	28	31	30	32	25	19				
	25	27	31	28	27	24	18				
	21	28	23	23	25	24	22	18	20	18	
1	23	27	24	27	27	28	23	20	13	15	
	19	26	27	28	25	23	22	17	22	21	
	23	19	27	23	29	27	28	23	21	••	
2	19	26	36	29	31	29	30	29	28	27	
	8	25	17	24	26	26	24	22	18	21	
	35	18	29	26	27	25	23	24	24	22	
3	18	28	28	30	26	30	29	27	22	22	
	19	24	24	24	25	23	26	19	20	19	
	24	21	31	24	22	29	27	27	28	••	
4	17	25	22	26	28	23	22	22	20	24	
	19	19	26	19	27	25	22	20	21	19	
	19	23	28	28	26	30	26	27	24	23	
5	16	27	27	25	29	24	24	24	20	22	
	18	20	28	27	28	30	25	23	24	24	
	26	26	31	29	24	26	16	8	6	9	
1	32	29	34	25	27	28	23	18	14	9	
	32	29	26	26	19	22	15	••	••	••	
	29	34	32	32	33	26	19	19	14	••	
2	19	41	29	32	28	34	27	19	18	13	
	27	22	26	24	25	22	19	16	12	6	
	30	29	27	28	26	23	25	17	17	12	
3	33	30	27	28	32	24	19	15	15	11	
	22	27	28	27	23	23	15	16	7	••	
	30	24	27	29	29	28	27	••	••	••	
4	23	27	29	24	32	20	26	17	16	16	
	20	26	28	24	27	24	23	18	7	11	
	27	30	27	33	29	27	26	24	20	15	
5	27	26	41	27	27	26	10	24	21	17	
	27	29	30	32	25	29	24	22	17	14	

Player	F	2	3	4	5	6	7	8	9	10	Note
	35	31	26	25	12	12					
1	35	39	31	25	8	9					
	34	36	25	23	20	8					
	24	42	33	27	26	21					
2	31	33	32	30	24	18					
	26	30	28	27	21	14					
	30	30	28	24	21	14					
3	34	33	29	27	20	19					
	29	32	28	21	18	8					
	37	28	29	30	••	••					
4	27	32	29	35	25	21					
	31	29	28	26	20	19					
	35	33	31	28	23	20					
5	29	36	30	25	19	17					
	34	28	26	24	20	15					

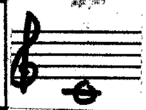
Player	F	2	3	4	5	6	7	8	9	10	Note
	37	33	25	17	18						
1	29	31	27	16	12						
	31	32	28	12	11						
	37	38	29	27	25						
2	37	35	30	22	10						
	29	33	30	25	17						
	38	34	29	24	22						
3	34	35	29	20	15						
	26	31	29	24	17						
	33	35	34	••	••						
4	33	33	31	27	26						
	31	23	28	24	19						
	34	34	32	25	23						
5	40	29	32	26	18						
	33	40	30	23	9						

Player	F	2	3	4	5	6	7	8	9	10	Note
	38	34	24								
1	41	28	23								
	38	33	23								
	36	36	31								
2	37	35	25								
	28	31	24								
	35	34	27								
3	37	37	28								
	34	31	29								
	32	32	33								
4	33	34	28								
	28	30	26								
	38	33	29								
5	34	32	29								
	35	27	29								

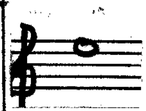
TABLE XVIII

MOUTHPIECE NO. 12

Player	F	2	3	4	5	6	7	8	9	10	Note
	37	29	27	29	20	16	6				
1	30	33	34	24	25	12	16				
	30	34	41	28	25	19	13				
	33	36	35	28	24	28	24				
2	29	36	34	34	30	23	22				
	27	27	30	27	32	22	18				
	27	34	33	33	27	27	22				
3	34	36	26	33	30	21	20				
	26	29	31	33	19	22	13				
	28	25	36	24	31	••	••				
4	29	30	29	26	28	23	20				
	17	28	29	24	26	21	16				
	29	34	34	32	30	25	22				
5	31	35	25	27	29	24	13				
	22	30	33	28	25	24	17				

	22	27	23	25	26	34	25	24	20	16	
1	24	24	26	28	27	28	21	20	20	14	
	19	24	24	23	23	19	16	16	10	11	
	25	28	31	30	29	28	25	26	31	25	
2	20	24	33	33	30	32	32	27	27	25	
	6	24	21	19	27	24	24	21	20	21	
	28	20	29	31	33	••	••	••	28	26	
3	22	29	24	32	25	28	20	21	23	21	
	18	23	25	24	25	26	24	22	21	17	
	23	23	25	27	26	27	29	29	29	25	
4	16	25	24	25	26	25	21	23	22	22	
	18	18	25	17	24	24	26	24	22	17	
	19	25	28	27	28	29	26	24	24	24	
5	16	26	27	25	24	23	23	21	22	19	
	19	19	28	27	25	28	23	24	26	22	

	27	31	22	34	19	21	19	17	9	7	
1	30	27	25	21	25	25	21	13	11	9	
	31	26	26	27	23	20	11	7	••	••	
	41	33	27	29	32	27	25	18	17	••	
2	24	38	31	35	23	29	28	18	20	13	
	27	25	28	28	18	22	22	21	16	11	
	26	26	32	19	28	20	18	19	17	13	
3	34	24	31	32	34	28	20	17	11	••	
	23	27	27	28	25	21	9	12	6	6	
	34	30	26	29	25	34	25	18	15	••	
4	24	24	29	26	23	24	25	17	20	15	
	18	27	29	26	27	23	19	15	7	10	
	28	32	28	32	21	29	24	20	17	13	
5	25	28	24	30	22	24	22	20	14	11	
	27	30	29	31	22	28	22	21	17	14	

Player	F	2	3	4	5	6	7	8	9	10	Note
	41	36	28	27	22	16					
1	34	38	29	23	10	9					
	27	34	23	22	12	••					
	36	34	27	28	••	••					
2	37	34	29	30	25	19					
	30	28	26	27	17	12					
	36	38	37	31	24	••					
3	41	37	33	22	19	15					
	38	37	37	16	15	7					
	28	36	32	31	••	••					
4	27	33	27	29	30	19					
	31	32	28	21	14	16					
	33	33	29	28	18	19					
5	32	35	31	28	23	17					
	36	31	29	30	24	20					

	35	35	28	24	17	
1	30	28	31	22	11	
	31	32	24	12	10	
	36	39	31	27	13	
2	41	34	33	26	19	
	32	32	26	27	19	
	39	34	33	21	••	
3	34	38	32	23	23	
	30	29	31	22	12	
	34	33	31	23	••	
4	33	29	28	25	24	
	29	27	31	22	20	
	33	37	31	25	21	
5	38	31	24	25	18	
	34	35	31	27	23	

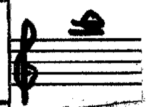
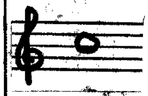
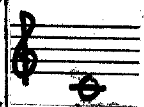
	37	31	24	
1	41	29	24	
	33	28	21	
	••	33	31	
2	35	37	27	
	29	29	23	
	36	28	19	
3	41	33	28	
	28	31	24	
	32	33	29	
4	31	33	28	
	28	29	24	
	34	34	29	
5	33	31	25	
	35	34	30	

TABLE XIX

MOUTHPIECE NO. 13

Player	F	2	3	4	5	6	7	8	9	10	Note
	34	33	36	31	23	22	18				
1	29	35	27	27	23	16	18				
	24	33	29	28	24	15	8				
	36	31	••	34	30	28	23				
2	28	38	34	32	33	26	22				
	25	26	32	25	26	15	14				
	33	29	28	27	23	18	11				
3	33	••	32	27	25	21	16				
	26	31	29	28	22	23	12				
	28	33	••	31	••	••	••				
4	29	31	23	27	26	17	14				
	15	25	32	27	25	19	16				
	29	33	34	31	28	24	20				
5	40	31	23	28	29	24	18				
	31	32	41	30	27	27	21				
	22	27	27	29	27	31	28	23	22	19	
1	23	23	24	27	27	29	25	24	21	20	
	18	21	26	27	28	26	22	25	21	18	
	23	22	22	24	29	32	31	27	26	18	
2	21	22	38	33	28	30	29	28	25	22	
	14	20	19	21	25	26	22	18	20	18	
	21	28	30	29	26	30	23	28	26	17	
3	21	29	28	30	28	26	24	22	23	19	
	19	23	24	24	24	24	25	20	19	16	
	23	23	25	26	29	28	22	28	28	23	
4	17	25	26	28	26	24	23	23	25	24	
	20	16	26	24	26	24	26	22	22	17	
	19	24	29	29	27	29	25	25	24	22	
5	17	26	26	23	27	21	23	20	18	18	
	18	17	28	25	26	30	27	26	28	24	
	28	25	29	31	26	27	19	16	12	11	
1	31	15	31	26	25	14	19	13	12	8	
	31	31	33	27	18	17	16	12	12	8	
	29	36	30	33	28	29	24	21	17	13	
2	25	35	32	32	28	27	27	21	16	15	
	26	23	23	27	23	23	22	17	14	8	
	40	33	30	28	25	25	23	19	14	12	
3	36	31	31	28	25	27	20	13	10	7	
	22	25	28	25	23	20	18	15	••	10	
	30	24	29	32	29	31	••	••	••	••	
4	22	28	36	21	25	18	26	18	17	13	
	22	26	29	25	21	23	21	19	13	••	
	27	29	28	33	29	27	25	24	21	19	
5	25	32	25	23	28	26	23	23	18	16	
	28	31	30	33	25	28	24	23	21	12	

Player	F	2	3	4	5	6	7	8	9	10	Note
	40	34	25	39	20	10					
1	37	30	31	24	14	11					
	33	32	26	21	17	••					
	27	29	36	31	27	••					
2	41	35	26	32	21	20					
	27	28	24	22	20	9					
	35	32	33	30	21	12					
3	40	32	28	28	21	18					
	30	27	27	26	16	8					
	32	34	31	••	••	••					
4	27	28	28	27	21	19					
	31	30	27	24	16	17					
	35	34	30	24	22	••					
5	33	34	27	27	22	16					
	34	33	31	29	23	••					

	36	33	29	18	15	
1	30	33	28	18	12	
	35	21	29	14	12	
	40	32	36	31	••	
2	35	37	32	25	24	
	29	33	27	21	15	
	38	33	32	27	14	
3	36	37	34	22	16	
	29	33	24	21	16	
	25	30	30	26	••	
4	33	30	30	26	23	
	32	25	29	24	16	
	34	39	32	27	24	
5	35	31	27	26	20	
	33	41	29	24	21	

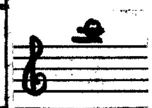
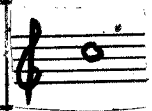
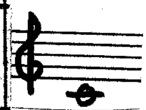
	41	31	22	
1	40	29	27	
	36	28	20	
	36	35	31	
2	41	34	28	
	37	29	21	
	36	33	28	
3	40	30	18	
	25	29	24	
	34	29	26	
4	31	33	30	
	32	27	24	
	35	35	29	
5	41	33	28	
	39	29	30	

TABLE XX

MOUTHPIECE NO. 14

Player	Partial									Note
	F	2	3	4	5	6	7	8	9	10	
	35	23	33	28	24	17	8				
1	30	32	35	26	22	15	11				
	30	34	26	24	17	7	••				
	30	34	33	30	31	28	24				
2	30	39	25	33	28	26	18				
	28	25	29	23	25	22	18				
	35	32	32	28	22	15	11				
3	31	34	30	29	31	21	18				
	27	29	28	27	22	20	13				
	27	34	31	24	27	••	••				
4	28	28	22	26	23	17	12				
	21	24	28	22	20	23	20				
	28	34	34	29	27	24	23				
5	31	29	31	29	28	17	18				
	24	33	36	30	29	25	18				
	22	26	23	21	25	21	19	20	19	16	
1	22	21	27	29	24	24	22	22	20	17	
	14	25	28	27	27	22	19	16	20	18	
	23	23	29	24	28	27	34	25	26	22	
2	22	24	34	30	27	32	31	27	26	25	
	15	25	10	24	26	19	21	22	17	14	
	15	27	27	29	25	27	19	21	17	18	
3	20	26	26	25	28	26	20	25	22	19	
	16	24	24	25	24	20	21	21	19	19	
	23	20	24	30	30	29	25	27	28	26	
4	15	25	27	26	35	••	20	21	19	20	
	20	20	25	17	27	26	24	22	22	19	
	19	24	29	29	27	29	27	25	27	24	
5	17	26	27	26	29	25	25	22	23	20	
	18	18	28	27	28	30	28	25	24	23	
	27	25	34	21	22	20	••	••	••	••	
1	32	30	28	27	26	27	23	15	12	10	
	29	27	31	20	22	32	22	17	12	7	
	32	20	37	33	28	28	25	20	21	14	
2	23	33	29	32	26	27	24	16	17	10	
	26	15	28	27	19	22	23	17	14	11	
	32	29	29	34	28	30	25	11	12	10	
3	32	29	27	33	21	21	22	20	14	10	
	23	25	29	28	24	26	18	16	10	5	
	30	28	31	32	29	29	22	13	12	••	
4	23	28	29	22	32	20	23	15	15	12	
	22	26	28	26	23	24	21	20	16	9	
	27	29	29	32	30	28	25	21	18	16	
5	25	27	29	29	25	25	26	••	••	13	
	27	30	29	32	21	30	24	25	19	18	

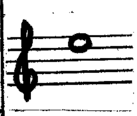
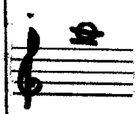
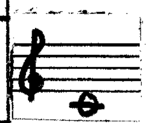
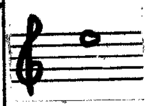
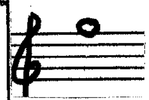
Player	F	2	3	4	5	6	7	8	9	10	Note
	Partial										
	36	34	28	24	19	8					
1	33	34	31	27	11	4					
	33	28	26	18	13	12					
	25	29	37	33	29	••					
2	40	34	29	32	21	20					
	30	29	26	24	17	14					
	30	32	36	27	22	14					
3	35	32	34	24	18	17					
	29	32	31	20	17	15					
	41	33	29	23	17	••					
4	28	31	29	27	23	20					
	30	29	28	25	17	18					
	38	32	30	26	20	12					
5	32	34	28	27	22	16					
	34	34	30	28	22	19					
	37	32	29	17	15						
1	33	31	35	19	17						
	34	32	30	20	13						
	36	41	34	30	12						
2	41	35	32	27	19						
	17	28	29	21	19						
	30	38	33	26	••						
3	39	34	33	23	20						
	33	35	31	20	8						
	41	30	28	20	••						
4	34	32	29	25	21						
	32	22	32	24	21						
	34	32	32	25	16						
5	35	24	28	25	17						
	32	36	31	25	23						
	37	35	29								
1	41	27	25								
	36	29	21								
	35	34	26								
2	38	36	27								
	30	32	32								
	38	36	27								
3	31	41	27								
	30	29	25								
	27	29	24								
4	33	31	27								
	29	24	24								
	41	34	29								
5	29	32	28								
	36	31	31								

TABLE XXI

MOUTHPIECE NO. 15

Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
	33	29	38	27	23	17	10				
1	32	35	25	26	18	15	10				
	24	29	22	20	9	8	6				
	31	36	34	30	31	19	24				
2	35	36	29	28	25	23	••				
	27	26	31	23	25	20	13				
	34	28	27	29	26	19	21				
3	36	28	28	31	23	21	14				
	26	27	29	26	23	12	13				
	24	••	32	32	27	25	19				
4	28	28	29	23	27	20	15				
	19	24	26	22	26	18	17				
	30	34	34	29	26	22	21				
5	40	31	29	29	32	24	20				
	21	32	38	28	25	25	21				
	21	27	18	25	22	14	21	14	14	11	
1	24	25	28	27	26	24	18	19	17	14	
	15	24	21	26	27	22	16	19	16	13	
	24	27	32	29	30	34	29	27	26	20	
2	21	24	35	32	28	29	29	28	27	26	
	14	23	18	22	26	25	23	22	20	17	
	19	39	26	27	26	28	26	25	26	20	
3	20	28	26	27	28	25	24	24	26	18	
	18	22	22	24	26	25	20	18	20	17	
	22	22	30	25	25	26	25	26	25	20	
4	16	25	36	24	19	24	22	23	22	20	
	18	17	23	23	24	21	25	21	22	18	
	21	25	28	30	27	28	25	22	22	21	
5	18	28	25	27	24	23	21	22	21	20	
	17	22	27	28	26	29	25	22	23	22	
	29	34	29	31	24	18	12	8	10	3	
1	33	30	31	29	25	23	20	16	12	7	
	32	28	30	21	25	22	13	7	7	9	
	28	33	35	25	40	27	26	22	20	15	
2	26	38	28	32	31	31	27	21	16	12	
	26	20	29	27	24	23	18	14	12	10	
	34	33	25	28	26	29	25	22	17	13	
3	31	23	23	29	27	39	27	20	17	10	
	23	27	35	22	24	21	19	17	17	9	
	29	27	29	31	28	27	24	20	16	••	
4	23	28	31	29	27	24	23	20	13	8	
	22	26	27	26	24	24	21	20	14	9	
	26	28	30	31	28	27	24	19	13	11	
5	26	27	24	23	28	25	18	23	19	18	
	27	29	41	29	27	26	25	21	16	13	

Player	Partial										Note
	F	2	3	4	5	6	7	8	9	10	
	38	32	28	21	13	11					
1	37	33	31	28	15	11					
	32	34	31	26	20	7					
	25	23	35	36	31	29					
2	41	35	31	34	27	16					
	29	30	27	27	16	15					
	34	38	27	21	20	14					
3	37	32	34	22	22	15					
	29	33	30	24	17	16					
	22	32	29	25	21	••					
4	28	29	33	26	28	19					
	31	29	24	27	20	14					
	36	30	28	24	18	15					
5	32	35	31	25	20	15					
	36	36	31	28	23	15					
	31	34	30	15	17						
1	29	36	32	21	12						
	38	33	35	20	13						
	36	33	35	24	••						
2	33	36	35	29	23						
	28	26	30	21	13						
	40	33	27	28	18						
3	35	40	33	21	17						
	29	35	28	24	16						
	35	30	33	27	23						
4	32	29	29	22	21						
	31	27	29	29	20						
	35	32	30	25	18						
5	37	28	22	25	20						
	34	36	31	23	19						
	41	33	24								
1	41	24	26								
	37	29	15								
	35	38	31								
2	41	35	35								
	33	31	25								
	33	36	28								
3	36	32	21								
	27	27	21								
	33	35	27								
4	32	33	26								
	28	28	24								
	35	33	31								
5	39	32	28								
	37	38	30								

APPENDIX B

EVALUATION OF INDIVIDUAL MOUTHPIECES FOR EACH OF SIX TONES

TABLE XXII

EVALUATION OF INDIVIDUAL MOUTHPIECES FOR TUNING C

Partial	Mouthpiece 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
F	60.533	61.866	59.866	61.466	58.333	57.466	56.933	59.200	58.000	57.866	61.066	57.200	57.333	58.000	58.666
2	61.428	62.133	62.133	64.733	62.933	61.066	63.866	64.266	60.933	60.933	58.800	63.466	63.000	61.866	60.428
3	63.066	63.466	59.000	60.133	63.733	64.200	63.733	62.800	62.533	62.666	62.666	63.600	61.537	61.733	60.133
4	55.600	57.571	57.142	58.428	58.285	54.923	56.285	58.857	56.133	56.266	59.066	58.666	57.733	54.400	54.400
5	54.533	54.857	53.857	53.384	53.000	48.714	51.857	52.285	49.857	50.285	54.133	53.466	52.000	50.133	48.800
6	44.857	44.571	44.615	46.615	40.571	41.428	43.285	44.285	40.000	40.461	41.714	43.857	42.142	39.571	38.400
7	35.428	35.666	34.000	35.538	34.857	27.571	31.692	33.428	30.923	31.538	34.428	34.571	33.000	32.615	32.000

TABLE XXIII

EVALUATION OF INDIVIDUAL MOUTHPIECES FOR LOW C

Partial	Mouthpiece 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
F	40.266	39.200	39.066	40.800	39.600	39.066	39.466	40.000	40.533	38.666	39.733	39.333	39.466	37.466	38.400
2	51.733	52.400	52.133	52.133	50.583	48.800	51.600	50.533	49.200	49.066	47.466	47.866	46.133	47.200	50.400
3	53.466	53.866	54.800	55.066	53.733	52.933	53.866	53.733	52.666	52.000	52.933	52.400	53.066	51.733	54.000
4	52.533	54.400	53.733	59.533	52.400	52.266	51.600	53.400	52.400	49.866	51.066	52.400	53.200	51.866	52.800
5	51.333	55.200	54.400	55.866	52.000	51.533	53.200	52.000	53.666	50.666	53.466	53.066	53.733	54.666	51.222
6	54.933	54.133	53.466	52.133	52.800	54.666	54.000	52.133	54.800	52.666	52.800	53.571	54.666	51.000	50.266
7	52.142	50.933	52.000	49.133	46.933	47.733	49.066	48.400	49.600	49.866	49.733	48.285	50.000	47.333	46.533
8	45.692	46.933	47.857	47.714	46.928	44.142	46.285	44.714	45.333	45.600	45.600	46.000	47.866	45.466	44.200
9	45.571	48.142	46.571	47.857	46.714	44.142	46.714	43.142	44.400	44.133	43.333	46.000	46.400	43.866	43.600
10	38.571	44.714	41.000	43.714	43.571	40.571	40.571	40.142	40.200	41.466	42.615	40.666	39.333	40.000	36.933

TABLE XXIV

EVALUATION OF INDIVIDUAL MOUTHPIECES FOR MIDDLE G

Partial	Mouthpieces 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
F	57.200	56.266	56.266	56.000	56.133	53.733	55.066	55.333	54.000	55.066	53.866	55.866	56.266	54.666	55.333
2	58.000	57.866	60.400	59.066	60.000	57.333	56.333	58.133	57.600	56.133	57.200	57.066	56.533	53.466	57.466
3	60.933	61.200	60.400	62.142	57.866	57.066	58.533	58.133	58.133	57.866	58.933	55.200	59.200	59.600	59.600
4	59.142	58.933	56.000	58.000	58.400	56.933	58.800	58.533	55.866	54.400	56.000	56.933	56.533	57.066	55.066
5	54.400	57.466	53.733	53.333	54.400	52.133	50.400	51.333	51.200	52.133	54.133	50.266	50.400	50.133	54.400
6	52.000	52.266	49.857	51.000	51.857	49.142	48.000	50.000	51.733	50.666	50.933	50.000	48.266	51.866	51.466
7	44.266	46.714	43.142	46.461	42.000	38.571	41.285	40.428	43.666	40.266	41.866	41.466	43.857	46.142	42.933
8	40.400	38.428	35.714	40.000	37.521	34.428	34.461	33.384	36.400	35.538	34.615	33.733	36.285	34.769	36.000
9	35.454	31.078	28.285	31.692	27.384	24.153	25.538	29.333	28.428	26.307	28.307	28.142	30.307	29.538	28.533
10	30.600	26.200	24.166	30.000	22.181	18.923	20.600	22.000	22.363	19.538	24.181	22.181	23.384	22.307	21.000

TABLE XXV

EVALUATION OF INDIVIDUAL MOUTHPIECES FOR E5

Partial	Mouthpiece														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
F	65.733	65.066	65.466	63.733	64.400	63.733	64.000	65.866	65.000	65.733	62.800	66.266	66.933	65.866	64.933
2	67.466	62.400	64.933	64.133	62.133	64.000	64.933	63.866	61.866	63.600	65.600	66.133	62.933	63.600	64.133
3	63.066	60.285	59.066	61.733	56.266	56.666	57.600	60.285	60.333	58.133	57.733	56.666	57.333	60.266	60.000
4	57.857	54.285	56.285	56.000	52.428	54.857	55.428	53.000	52.714	50.666	52.933	52.400	54.857	51.333	52.533
5	43.000	43.846	41.285	41.857	40.714	42.461	39.428	39.571	41.571	40.266	39.571	38.923	40.142	38.400	41.466
6	33.076	33.000	36.000	32.759	28.500	34.222	31.000	27.692	32.181	27.571	30.714	30.727	28.000	29.076	30.285

TABLE XXVI

EVALUATION OF INDIVIDUAL MOUTHPIECES FOR HIGH G

Partial	Mouthpiece														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
F	67.466	67.800	67.666	67.066	67.866	65.466	67.333	66.466	69.266	62.857	66.933	67.866	66.666	67.714	67.066
2	67.466	63.733	63.333	46.533	67.466	68.333	65.600	67.866	66.000	63.733	63.466	65.733	65.066	64.266	65.066
3	61.142	59.714	60.533	60.142	62.285	60.295	60.285	60.571	61.466	59.466	59.066	59.333	59.733	62.133	61.200
4	46.307	48.000	46.857	49.318	48.857	46.714	45.000	46.142	47.142	46.400	44.571	46.800	46.666	46.266	47.200
5	39.692	37.818	40.800	37.846	36.500	34.461	37.333	35.285	34.461	32.333	34.571	35.384	35.076	34.000	35.714

TABLE XXVII

EVALUATION OF INDIVIDUAL MOUTHPIECES FOR HIGH C

Partial	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
F	73.066	73.428	71.200	72.266	70.933	70.800	71.733	70.266	71.200	72.800	69.866	67.571	72.533	68.266	70.400
2	65.200	62.714	61.600	64.266	61.733	62.133	62.666	65.466	64.533	62.266	64.933	63.066	61.866	61.266	64.533
3	58.666	53.285	52.714	52.714	56.142	54.000	53.857	54.266	52.266	52.400	54.400	51.466	51.466	53.600	52.266

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