J O S E P H   S C H I L L I N G E R

C O R R E S P O N D E N C E   C O U R S E

With: Dr. Jerome Gross   Subject: Music

Lesson CCLVIII.

THEORY OF ORCHESTRATION

PART ONE: INSTRUMENTS

Introduction

What has been known for the last couple of centuries as "symphony orchestra" is a heterogeneous aggregation of antiquated tools. Wooden boxes and bars, wooden pipes, dried sheep's guts, horse hair and the like are the materials out of which the sound-producing instruments are built.

Evolution of musical instruments, during its history of several millenia, followed the course of individual craftsmanship and of trial and error method.

The instruments themselves are not scientifically conceived and not scientifically combined with each other. Some of the orchestral groups participate with the others by virtue of tradition (like brass and string instruments which, in most cases, do not blend) and not by necessity. Nobody ever asks the basic question: why should there be such a combination as the stringed-bow, the wood-wind, the brass-wind and the percussive instruments; and why should the respective groups be used in the unjustified ratios, which are considered standard.

It takes a long time to force upon an average normal human ear such combinations as piano and violin or strings and

brass. And this imposition of unblendable combinations upon a selector called the human ear is termed "cultivation of musicianship". But eventually people begin to like it, as they begin to like smoking tobacco, which suffocates them at first. It is even possible to condition the human ear to hear the sound at a sustained intensity, while the sound at its source is fading. Such is the case of piano. Ordinarily we are not aware of the fact that piano tone fades very quickly. I once, intentionally, subjected myself (at the age of 30) to a forced isolation from the piano for three whole months. The only sounds I heard at that time were that of an organ and of choral singing (i.e., the durable sounds). I lived among the peasants. When I returned to the city, the piano sounded to my ear as it really sounds, i.e., as a percussive instrument with exaggerated attack and quick fading. It took me two whole weeks to "recover" from this unconditioned modus of hearing.

The implication is that many of the orchestral tone-qualities and blends are gradually assimilated by our ear. Many of them are highly artificial and do not possess the appeal of natural beauty, as many of the natural forms and natural colors do.

The musician's argument against better balanced, more uniform tone-qualities, which are possible on the electronic instruments, is that they have no individuality, while the old instruments have. But what they call "individuality" is often a group of minor defects and imperfections. A

trombone, due to its acoustical design, has several (or at least one) tones missing. The composer, on the other hand, can easily imagine those missing tones and imagine them in the trombone quality. Yet he cannot use them in his score, as they cannot be executed. Now, take a bassoon. Its low b♮ is of inferior quality than the surrounding tones. Why should it be necessary to have a defective quality on one particular pitch? No one knows.

On the other hand, a composer, due to his experience, can imagine certain tone-qualities beyond the ranges of the respective standard instruments. He cannot use these qualities because there are no instruments to perform them.

Under such conditions, the art of orchestration amounts to a constant (and in most cases unsuccessful) struggle of the composer's imagination and inventiveness against the actuality of instrumental limitations and imperfections. The way things stand today, the composer cannot compose in terms of tone-qualities, intensities, frequencies and attack-forms (if he does not want to live in a fool's paradise), but in terms of concrete instruments, each designed with no regard to any other instrument, each, therefore, having peculiarities of its own.

Musicians also have a sentimentally-childish attachment to craftsmanship of executing a "beautiful" tone from a violin or other instruments. Very few performers, indeed, can execute such a tone. But why is this self-imposed

difficulty and struggle necessary? Such an attitude has a flavor of sportsmanship and competition. Why not liberate the performer from the necessity of struggle for obtaining the proper tone-quality, while such tone-quality can be achieved, and has been achieved, by means of electronic sound production.

The answer in many cases is that many good performers, once relieved from this struggle, would feel lost, as to them production of tone-quality is one half of the entire interpretation.

In 1918 I published an article ("Electrification of Music") in which I expounded my own ideas (at that time completely new and original) on the inadequacy of old musical instruments and on the necessity of developing new ones, where sound could be generated and controlled electrically. I thought it would be desirable to have tone-qualities, attack-forms, frequencies (tuning) and intensities under control, and to be able to vary each component through continuous or discontinuous (tempered) scales, suddenly or gradually, and, where the degree of the graduality of transition could be determined as well.

And though there is no universal use of electronic music yet, it is progressing very rapidly. Most of my dream has already come true. In 1920 Leon Theremin demonstrated his first primitive model of an electronic instrument before a convention of engineers in Moscow, Russia. On this model

pitch was controlled by movement of the right hand in free space (in actuality, in electro-magnetic field) and volume, by a specifically designed pedal; the form of attack was controlled by a knob; the timbre was constant.

Through a number of years of my collaboration with this inventor, the early history of the electronic music culminated in two Carnegie Hall performances in New York, where a whole ensemble of 14 improved space-controlled theremins, manufactured by Radio Corporation of America (on a mass production scale at the plant in Camden, New Jersey) participated in 1930.

That first decade of electronic music, in which I am proud to have taken the part of a musical pioneer, started the art of music on an entirely new road, which is in pace with the engineering accomplishments of our industrial era of applied science. There is no turning back from this road, regardless of the absolute value of today's models of electronic instruments. The fact is that a new principle of sound production and control has been established, and this principle will bring further improvements and perfection.

It is important to realize that the existing musical instruments and their combinations are not stabilized but ever-changing accessories of musical expression; that the absolute knowledge of the functioning of the keys of a clarinet is of no basic value, as the design of such an instrument varies and the whole family of such instruments may vanish.

Thus, though in my Description of Standard Instruments all the necessary information is given, the composer must not overrate the importance of it, as the entire combination of a symphony orchestra, with all its component instruments, very soon may become completely outmoded and eventually obsolete. It will be a museum combination for the performance of old music. New instruments and combinations will take its place.

The moral of this Introduction is that it is more important for the composer to know the physical aspects of tone-qualities, frequencies, intensities and attack-forms per se, rather than their resultant forms, as they appear on certain types of the old instruments. It is a warning not to place too much importance and confidence upon certain types of instruments, only because they are so much in use today.

In my Acoustical Basis of Orchestration the student will find the type of knowledge which is basic and general and, therefore, can be applied to any special case. This system is devised with a point of view which will give a lasting service and will not become antiquated with the first turn the history of this subject takes.

In order to broaden the student's outlook upon the existing instruments, I am supplementing this Introduction with a chronological table borrowed from my other work: "Varieties of Musical Experience".

Two items of this table deserve particular attention: (1) the chronological precipitation of progress and (2) the age of the new "electronic" era.

SCHEME OF EVOLUTION OF MUSICAL INSTRUMENTS

From Prehistoric Time

I. Man utilizes his own organs: voice, palms, feet, lips, tongue, etc.

From 10 - 20 Thousand Years Ago Until Our Time

II. Man utilizes finished or almost finished objects of the surrounding world: bamboo pipes, shells, bones of birds, animal horns and antlers, etc.

From 5 - 10 Thousand Years Ago Until Our Time

III. Man processes raw material, giving it a definite form: from a piece of terra cotta and hunter's bow up to the Steinway piano and modern organ.

From 18th Century A.D.

IV. Man constructs automatically performing instruments:
from 18th Century, mechanical musical instruments;
from 19th Century, recording and reproducing musical instruments.

From the End of 19th Century

V. Man invents a transmission of sound waves on long distances: radio.

From the Beginning of 20th Century

VI. Man devises the sound production by means of:

1. Electro magnetic induction
2. Interference in electro magnetic field

DESCRIPTION OF STANDARD INSTRUMENTS

Stringed-Bow Instruments (The Violin Family)

The contemporary stringed-bow instruments have as their immediate ancestor the viol family. When the treble-viol, in the hands of Italian craftsmen, achieved its ultimate degree of perfection it became the dominant member of the viol family: the treble-violin emancipated itself into plain "violin". In this sense, the evolution of the violin family followed the downward (in the way of frequency) trend, i.e., the perfecting of the violin was followed up by the perfecting of violas, 'celli and string double-basses (or contrabasses). This course of evolution was somewhat contrary to the development of the viol-family, where bass-viol (later, violone) was the dominant instrument of the group, the patriarch of the family. Thus "violoncello" originated as the diminutive form of the "violone".

The more remote ancestor of this family is the Arabian "rebab", a primitive type of stringed-bow (often having only two strings, however tuned in 3÷2 ratio, i.e., in a perfect fifth) instrument and having a resonating chamber. This ancient instrument leads us back to the "monochord", a one-string bow instrument with a resonating chamber, and, finally, to the actual source of the violin, which is bow and arrow.

This remarkable evolution of a defense weapon into a musical instrument of high degree of perfection consumed not

only millenia of astronomical clock-time, but also an incalculable amount of human energy so lavishly spent by the generations of craftsmen and musical performers.

But with so much said and written about the violin-making and violin-playing, certain facts remain obscure. As humanity, most of its time (between and during the eras of mutual mass-extermination), is engaged in creative mythology, the history of violin discloses a constant struggle between the glorification of violin-makers and violin-players. The fundamental question is: which factor is more essential in achieving perfection, the instrument or the player? Nobody would deny the importance of both. However, I am entitled to state, on the basis of experiments performed with Nathan Milstein and another highly accomplished, but not extraordinary, representative of the same Leopold Auer school (which contributed Heifetz, Zimbalist, Elman, Piastro, Seidel and many other virtuosi), that the player is a more important factor than the instrument. I draw this comparison particularly in reference to quality of the tone-production. In my experiment both performers were tested on the same two instruments: one was a violin made by Antonio Stradivari and the other, a mediocre sample of a mediocre craftsmanship. Milstein's tone-quality was superior on both violins and with less individual difference between the two instruments, than that of the other violinist. This may be a good lesson to some parents and teachers: only a mediocrity needs a very

expensive instrument.

As the best musical organizations of today have at their disposal some of the best stringed-bow performers (usually the potential soloists rejected by the market's policy to use only the few very best), the composer of our civilization may indulge in scoring which requires, on the part of the performer, a highly developed and versatile technique.

A. Violin

1. Tuning

The entire range of the violin is written in treble clef.

The four strings are named g, d, a, e. From the physical standpoint all four strings have a different timbre. The timbre of the g-string is particularly different from the three upper strings. In the hands of an accomplished performer this timbral variance is greatly minimized. However, good playing does not affect the variance of the g-string with the three upper strings. This difference is due to the fact that g-string is a sheep's gut wrapped around with a metal wire, while d-string and a-string are sheep's guts which remain unwrapped. E-string only about three decades ago underwent a transformation: sheep's gut was replaced by a metal wire.

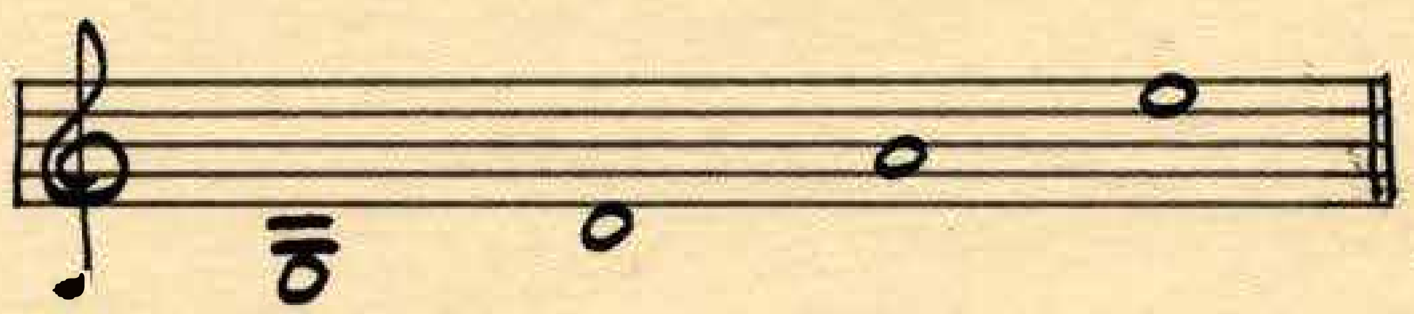
Violin is tuned in perfect fifths, i.e., in $3 \div 2$ ratio. The tuning begins with the a-string. Thus the ratios of the remaining strings are:

$$e = \frac{3}{2}\,;\quad d = \frac{2}{3}\,;\quad g = \left(\frac{2}{3}\right)^2 = \frac{4}{9}$$

As the above ratios noticeably deviate from the corresponding pitches of the twelve-unit equal temperament, some of the more discriminating composers (Hindemith, for instance, makes it a rigid rule) avoid the use of open strings altogether, except in chords.

Figure I.

Tuning of the Violin



Lesson CCLIX.

2. Playing

The Left Hand Technique

Intonation is obtained on the violin by means of shortening its strings, which is accomplished by pressing the string against the fingerboard. For this purpose fingers of the left hand are employed. Strings vibrate between the two fixed points (nut and bridge) and transfer their vibrations to the bridge. The vibrations of the bridge stimulate sympathetic response from the body of the violin, which is a resonating chamber.

Four fingers of the left hand (thumb is excluded) participate in producing intonations. The various distances which the left hand occupies on the fingerboard (while supporting the violin) in relation to the nut are called positions. Each position on each string emphasizes four pitch-units of the common diatonic scales. The positions begin with an open string. Such a position is known as zero position.

Figure II.

The Zero Position

Arabic numerals indicate the fingers employed. Major tetrachords are used here merely for convenience: other accidentals can be employed as well.

The first position begins with a whole tone from the open string.

Figure III.

The First Position

If the first pitch-unit is only a semi-tone away from the open string, then such a position is called half-position or semi-position.

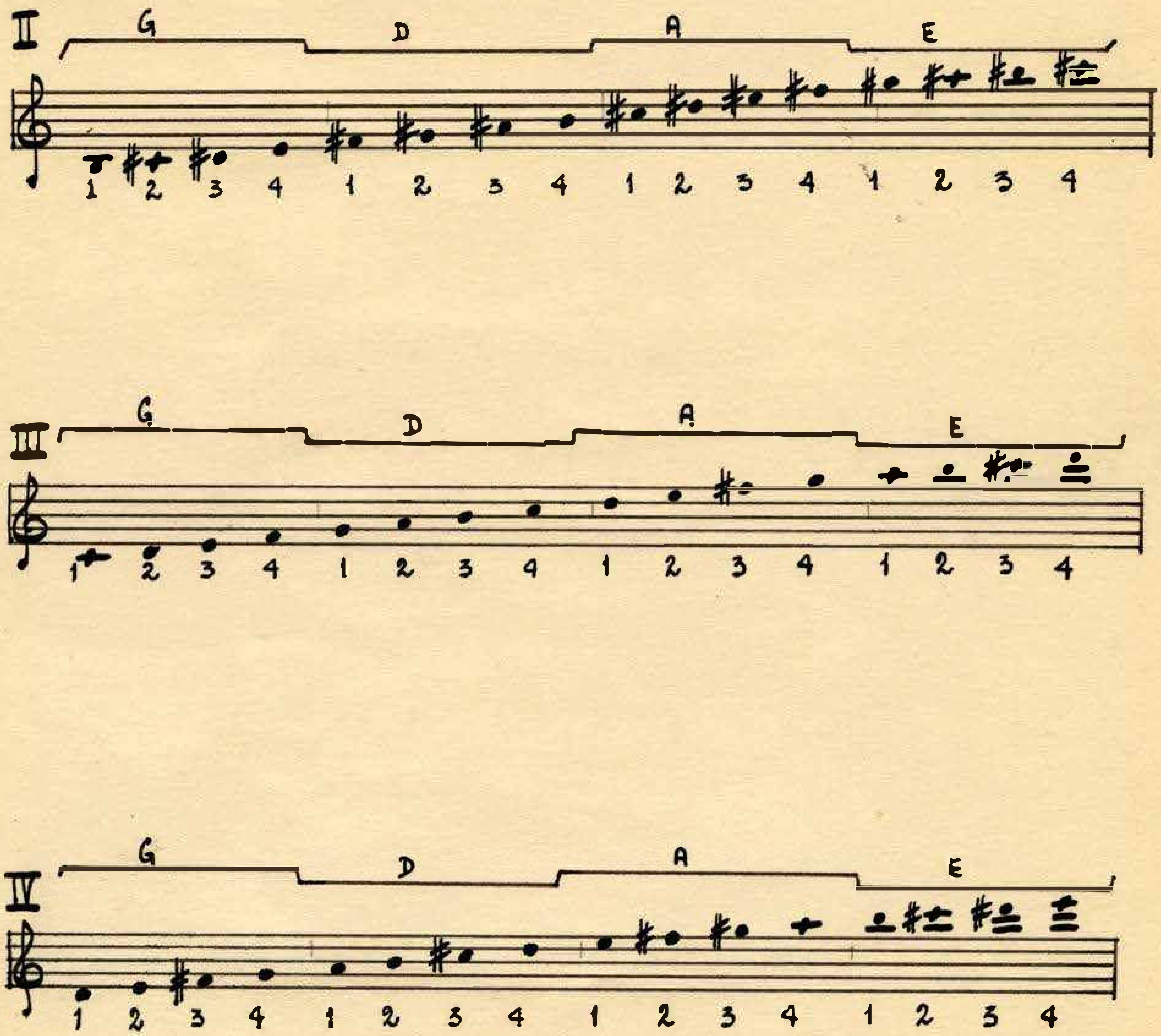
Figure IV.

The Half-Position

From here on, violinists do not discriminate any semi-positions, but consider only the Second, the Third, the Fourth and so on, positions, regardless of the fact whether they are tone-and-a-half or two tones, two-and-a-half or three tones from the open string.

Figure V.

Positions above the First



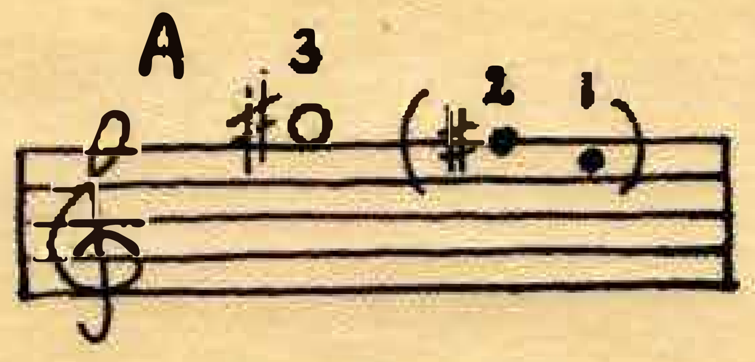
The three lower strings (G, D, A) are seldom used beyond the eighth position; the e-string is used even in orchestra-playing up to the fifteenth position (the beginning of Rimsky-Korsakov's opera "Kitezh").

All violin-playing is accomplished in most cases, including double-stops and chords, by means of standard fingering. Chromatic alterations are performed by moving the same finger a semitone up or a semitone down.

Insofar as the quality of intonation is concerned, it is always easier to move the fingers in the same position, making transitions from one string to another, than to change positions rapidly, particularly when such positions are not adjacent. It is to be remembered that though the use of the four fingers is analogous on all four strings and in all positions, the actual spatial intervals on the fingerboard contract logarithmically while moving upward in pitch. This means that a semitone in the first position is spatially wider than a semitone in the second position; the latter is wider than the semitone in the third position, and so on.

Musical intervals from the open strings can be defined in terms of positions and positions can be defined in terms of musical intervals.

Position, where a given note is produced by the first finger, equals the number of the corresponding musical interval, minus one. For instance:



The given note g# to be played on a-string with the third finger requires the hand to be in such a position where e can be played on a-string with the first finger. As the musical interval from a to e (up) is a fifth, the position can be defined as 5 - 1 = 4 (i.e., it is the fourth position). This is so because the first position is produced by the interval of a second (i.e., 2) from the open string.

This proposition can be reversed. For example: what note is played by the second finger in the sixth position on the e-string?

The first finger in the sixth position produces an interval of a seventh (i.e., 6 + 1 = 7); therefore the second finger, in the same position produces an octave. Thus the note to be found is e, one octave above the open string.

Figure VI.

(please see next page)

(Fig. VI)

Example of Fingering (Single Notes)

Playing of S2p

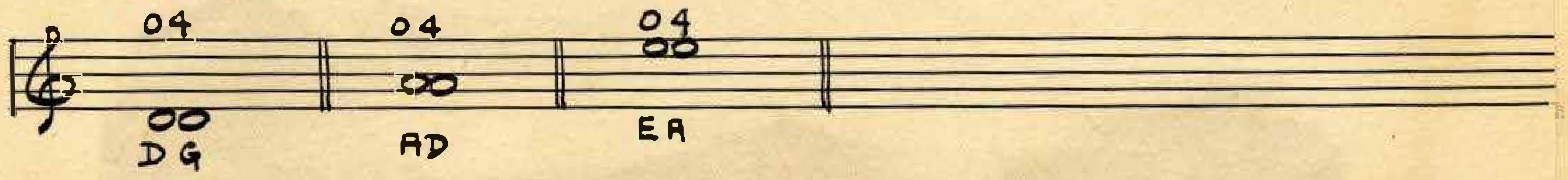
The so-called "double-stops", i.e., couplings, harmonic intervals and two-part harmonies belong to this category.

S2p are played by means of standard fingering. Left hand is considered in an open position if the finger of the lower of the two pitches corresponds to a smaller number than that of the higher of the two pitches. The reversal of this proposition corresponds to a closed position. Open positions are easier to play and therefore are more grateful. Closed positions can be used in double stops without particular difficulties, but preferably not too fast.

Figure VII.

Fingering of S2p

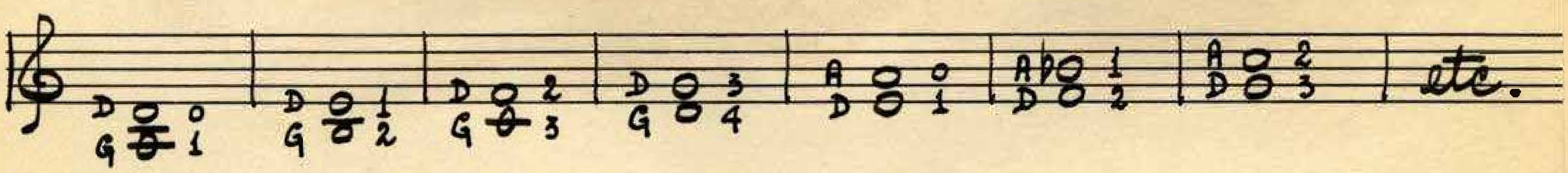
Unisons (possible only with one open string):



Seconds:

Thirds:

Fourths:



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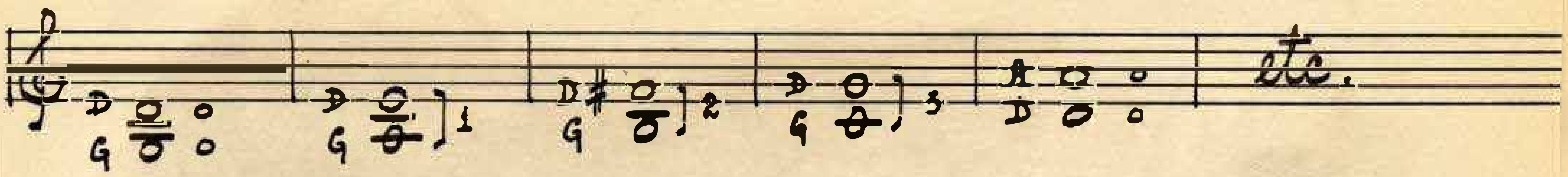
(Fig. VII, cont.)

Fifths (are played with one finger pressing two adjacent strings):



Sixths:

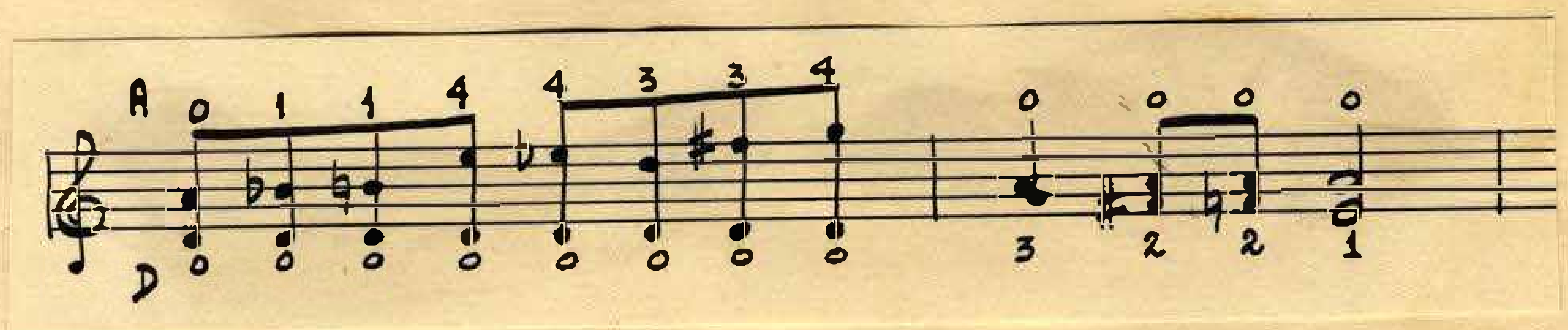
Sevenths:

Octaves (quite difficult on account of the stretch between the first and the fourth finger; easy, with one string open):

Octaves are mostly used in solo playing. As a perfect acoustical octave (i.e., 2 ÷ 1 ratio) sounds quite empty, soloists usually resort to playing an imperfect octave (somewhat more narrow in stretch than the acoustical octave), which sounds fuller. In scoring for an orchestra, octaves of violins are usually written divisi (i.e., both pitches are played by the different parts).

As octaves without participation of an open string require a stretch between the first and the fourth finger, it becomes obvious, that intervals wider than octave can be performed only if the use of at least one open string is possible.

A special double-stop effect should not escape the attention of the orchestrator: passages on one string combined with another string remaining open. For example:



Such passages can be played at a considerable speed.

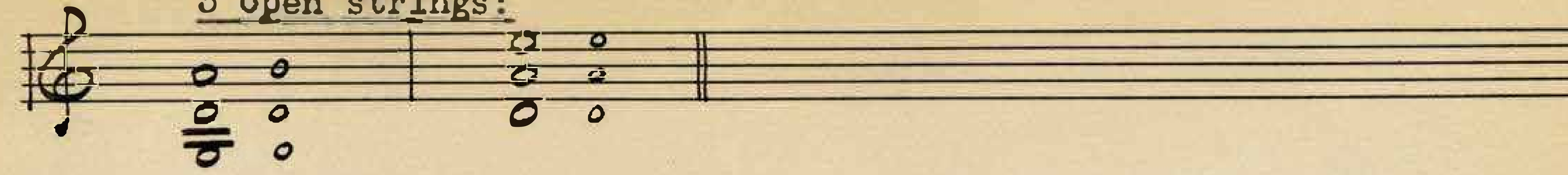
Playing of S3p

Playing of triple-stops includes melody with two couplings and three-part harmony.

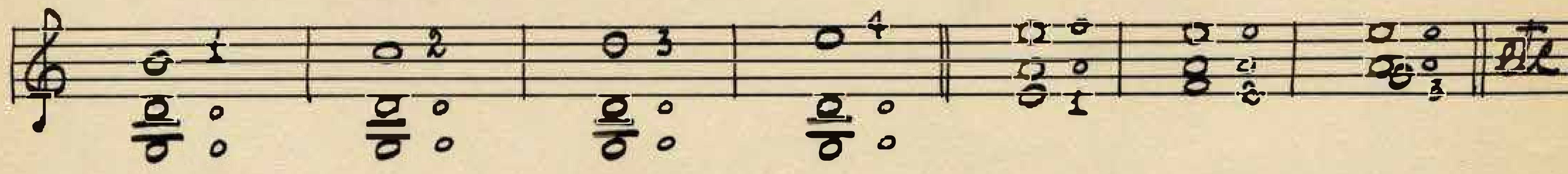
When employing 3 fingers at a time (i.e., without participation of open strings), only open position of the left hand can be used. In all other cases, previous considerations hold true.

Figure VIII.
Fingering of S3p

3 open strings:



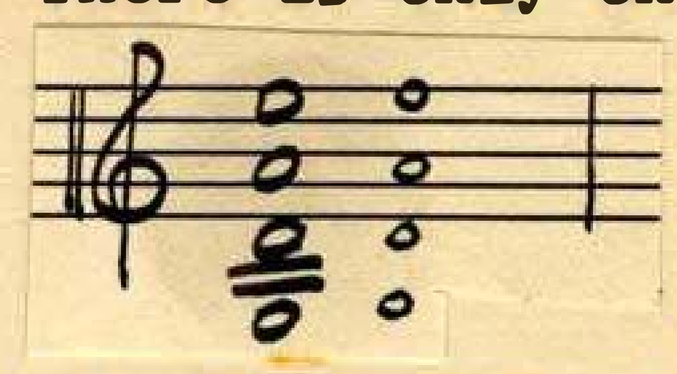
2 open strings:



1 open string:

No open strings:

Playing of S4p

Playing of quadruple-stops includes melody with three couplings and four-part harmony. There is only one quadruple-stop with four open strings: 

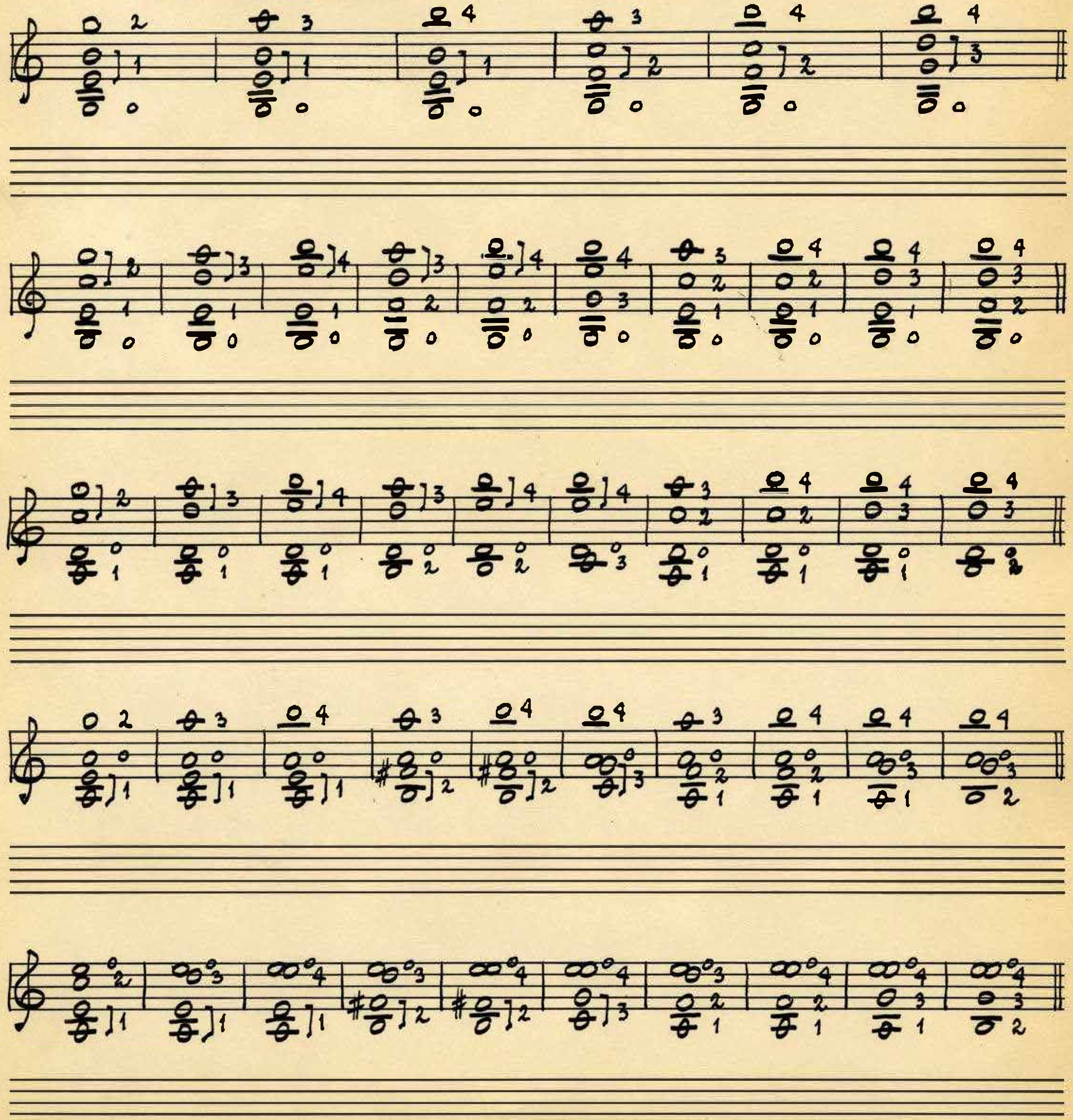
All other cases include 3, 2, 1 or no open strings. All left hand positions must be open. Such chords as S(5) in open harmonic (⇄) positions are quite easy because only 3 fingers participate (as the perfect fifth is played with only one finger).

(please see pages 23-25)

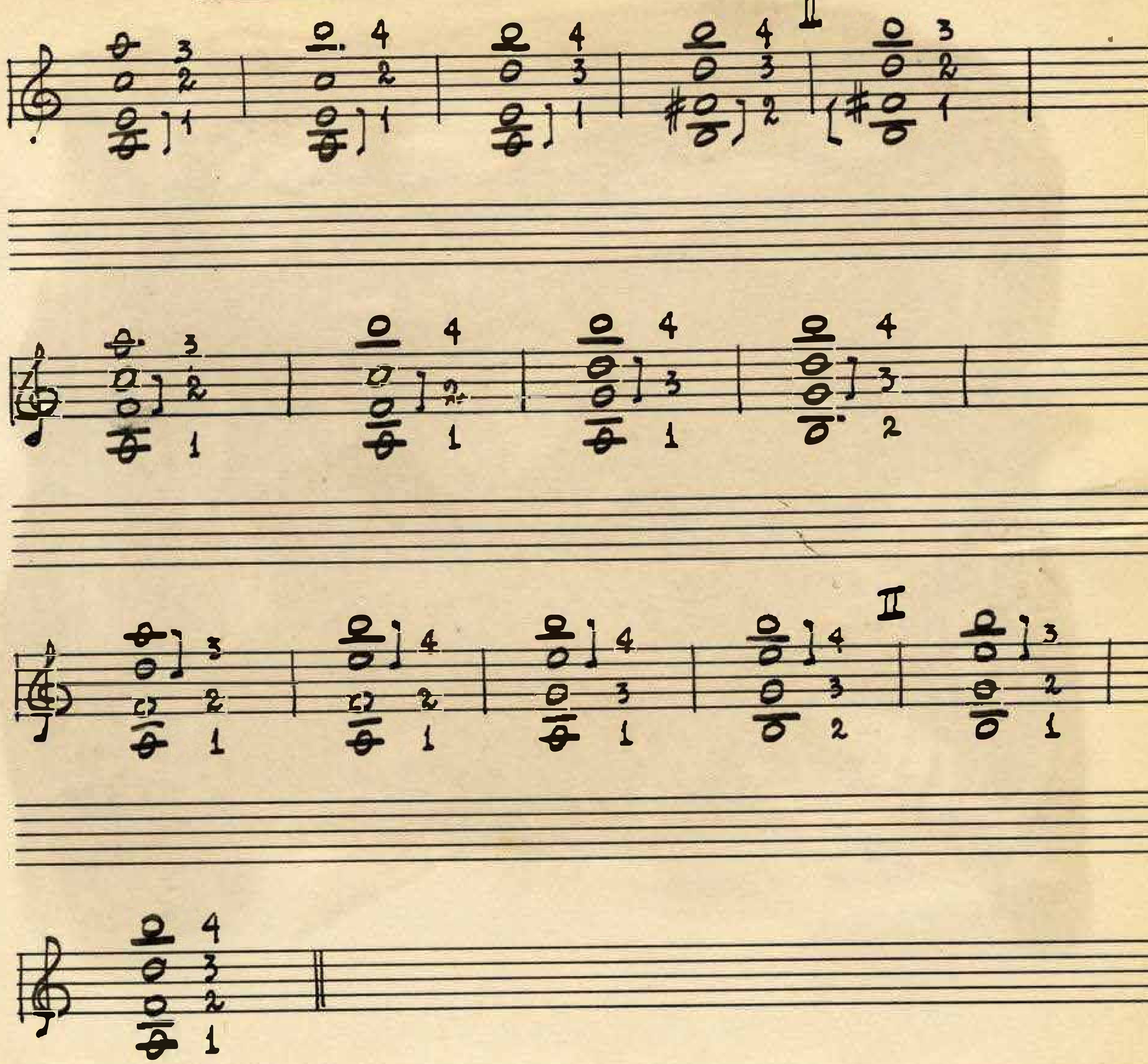
Three open strings:

Two open strings:

One open string:



No open strings:



The above tables are merely samples of the systematization of the material on fingering; they can be extended to higher positions (with or without participation of the open strings).

These forms of fingering are applicable to various instrumental forms.

As the bow can move simultaneously over not more

than <u>two</u> strings (some exceptional virtuosi can bow three strings simultaneously in forte; but such an accomplishment is exceptional and we cannot count on it while writing orchestral parts for the violins).

Thus I(2p) can be performed as:

ap and a2p in sequent combinations;

I(3p) can be performed as:

ap and a2p in sequent combinations;

I(4p) can be performed as:

ap and a2p in sequent combinations.

<u>Figure IX.</u>

<u>Examples of instrumental forms suitable for the violin</u>

Lesson CCLX.

The Right Arm Technique

Bowing is a process by which friction is produced between the horse-hair of the bow and the string. The various techniques, by which strings can be set to oscillate in different patterns, constitute the bowing attacks. Heavy bowing attacks cause large amplitudes and light bowing attacks, small amplitudes. In order to produce a continuous sound, without a renewal of attack, the bow must move in one direction. The duration of a period depends upon the pressure of the bow on the string. Thus the period of continuous bowing in one direction in piano is greater than in forte.

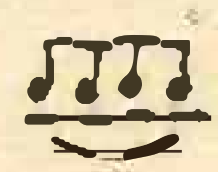
We shall now classify the forms of bowing as the forms of attack in relation to the durability of sound. We shall assume that the total scale of attacks lies between the two limits: the lower limit corresponds to the most continuous form of attack and the upper limit, to the most discontinuous, i.e., abrupt form of attack.

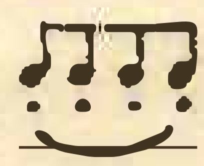
The movement of the bow in the direction from g-string to e-string is considered downward and, when necessary, is indicated as ⊓ ; the movement in the opposite direction is considered upward and is indicated as V . The upbeat groups are usually played V and the downbeat groups are usually played ⊓ . Otherwise composer must indicate the direction of the bowing which expresses his desire.

The Scale of Bowing Attacks

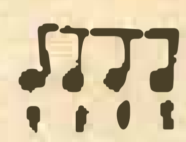
(1) legato: a group of notes united by a slur represents continuous bowing in one direction; large legato pertains to a long group, and small legato, to a short group;

(2) non-legato (detaché) or detached is indicated by the absence of slurs or any other signs: each note corresponds to an individual smooth bowing attack, i.e., the bow must be turned in the opposite direction after each note;

(3) portamento (in bowing) represents a group of slightly accentuated attacks, while the bow moves in one direction; it is indicated as follows:  ;

(4) spicato: abrupt bowing for each attack, while the bow moves in one direction:  ; it sounds somewhat lighter than staccato;

(5) staccato: abrupt bowing for each attack and changing the direction of the bow after each attack:  (no slurs);

(6) martellato (hammering): a vigorous downward or upward stroke indicated like this:  (no slurs; bow changes its direction after each attack, unless specified otherwise);

(7) saltando (jumping): a bouncing group of attacks obtained by one stroke (usually two, three or four attacks, which can be described as throwing the bow from above; bouncing is caused by the resilience of the string and the bow; saltando has a light percussive character and is usually employed in the accompaniments of the character of

Spanish dances: this effect is a mild version of castanets; saltando is indicated like this:  ;
(8) *col legno* (with the wooden part of the bow) is marked by these words above the part; no other indications are necessary; this effect is still more percussive in character than saltando: it is performed by an individual throw of the bow downward upon the string, each throw corresponding to an individual attack; the general effect of col legno is that of pianissimo.

To continue the abrupt forms of attack, we may add, at this point, the various forms of plucking the strings.

From the orchestrator's viewpoint there are two basic forms of *pizzicato:* (1) *pizzicato legato,* where the respective finger of the left hand is moved on a small interval (usually a semitone or a whole tone), after the string is plucked (this effect resembles the so-called "Hawaiian guitar"); (2) *pizzicato* (the usual form), where each attack, single (one string) or compound (several strings; this sounds like an arpeggio) is produced by individual plucking. The regular pizzicato is marked *pizz.* and the pizzicato legato is marked *pizz.* and also indicated by a *slur:* pizz.  . From the violinist's standpoint there is also a distinction between the right-hand pizzicato or the left-hand pizzicato (this is indicated by a cross [+] above the note; it is mostly used on open strings, and can be easily executed amidst rapid passages of bowing).

<u>Bowing positions in relation to the sections of the bow</u>

In relation to the manner of playing the bow may be considered as consisting of three sections: the nut (lower part), the middle section and the head (upper part), which in the international musical terminology corresponds respectively to:

(1) <u>du talon</u>; (2) <u>media</u> (or: modo ordinare) and (3) <u>a punto d'arco</u>.

When the specific sections of the bow are to be used, the composer must make the corresponding indications. However, du talon is associated with martellato, a punto d'arco is associated with high-pitched <u>bowing tremolo</u> in pianissimo and media simply serves as a symbol of cancellation of one of the previous special forms of bowing.

<u>Bowing positions in relation to the fingerboard and the bridge</u>

There are three such basic positions: (1) over the fingerboard (usually at its widest part), known and marked as <u>sul tasto</u>; this effect produces a delicate flute-like quality; (2) in the usual place between the fingerboard and the bridge (usually slightly closer to the bridge), indicated also as <u>media</u> or <u>modo ordinare</u> , used mostly for cancellation of the preceding or the following effect; (3) very close to the bridge, marked as <u>sul ponticello</u>, which is mostly used in the <u>bowing tremolo</u>; this produces a nasal "double-reed" quality.

It is possible, while performing the bowing tremolo,

to move the bow _gradually_ from sul tasto to sul ponticello or back. This is a neglected but very valuable technique, by which a gradual modification of quality (tasto corresponds to flute, ponticello, to double-reed) can be obtained on all the stringed-bow instruments.

Bowing tremolo (i.e., rapid forward-backward movement of the bow) must not be confused with _tremolo legato_, which is a finger-tremolo (like the trill, only in a wider pitch-interval).

3. _Range_

The range of the violin, as employed by the composers, _grew upward_ during the XVIII and XIX Centuries. It was the desire of some of the outstanding composers to employ the pitch beyond the range known to their predecessors. This evolution of the range must be considered now to be completed, so far as the known type of violin is concerned. The reason for this is that Rimsky-Korsakov employed (as a pedal point), at the very opening of his opera "Kitezh", _b_ of the _third octave_ (the highest _b_ on the piano keyboard), which happens to lie (that is the point of finger-pressure) at the very end of the fingerboard. During Beethoven's time, the upper limit was at _c_ of the same octave.

Only e-string is used in such a wide range; all other strings are used within the range of a _ninth_ (14 semitones); however, the range of g-string is frequently extended to a _twelfth_ and even more (the purpose of this is to obtain

the specific quality of high positions on that string).

Figure X.

Range of the Violin

(1) represents the limit for cantabile in unsupported unison (i.e., without octave doubling) and corresponds to the upper limit of the highest human voice, i.e., coloratura soprano; it is also the limit for pizzicato, after which limit the sound becomes too dry;

(2) Haydn's limit;

(3) Beethoven's limit; also the limit of free orchestra-playing, beyond which only easy passages in single notes and sustained notes (single or double) can be used;

(4) the limit in the early scores of Wagner reached e below this g♯; the latter was introduced in the "Ring";

(5) Rimsky-Korsakov's "Kitezh"; no fingerboard beyond this point.

4. Quality

The basic resources (besides the ones which we have already described) of special tone-qualities on the stringed-bow instruments and decidedly contrasting with each other are the mute (double-reed quality, marked con sordino) and the harmonics or overtones (purest quality: sine-wave; no vibrato). The mute can be put on (con sordino) or taken off (senza sordino) wherever the composer desires, providing he gives enough time to the performer to make such a change.

Lesson CCLXI.

Harmonics on the violin are produced by touching instead of pressing the string. The scale of harmonics can be only approximated in our system of musical notation. Harmonics are a natural phenomenon corresponding to what is known in mathematics as "natural harmonic series", i.e., 1, 2, 3, 4, 5, 6, 7, 8, 9, ...

The sound of harmonics corresponds to simple ratios of frequencies and to the partial distribution of a sounding body. In the case of strings, harmonics correspond to the division of a string into uniform sections. These sections are in inverse proportion to the order of a harmonic.

Thus, in order to get the fundamental (which is considered the first harmonic), it is necessary to let the entire string vibrate. In order to get the second harmonic, it is necessary to let the two halves of the string vibrate separately. The zero point between the two halves is known as "knot". The finger must touch (not press) at the point of the knot. Thus breaking the entire length of the string into two halves, you allow the upper half (which is closer to the bridge) to vibrate.

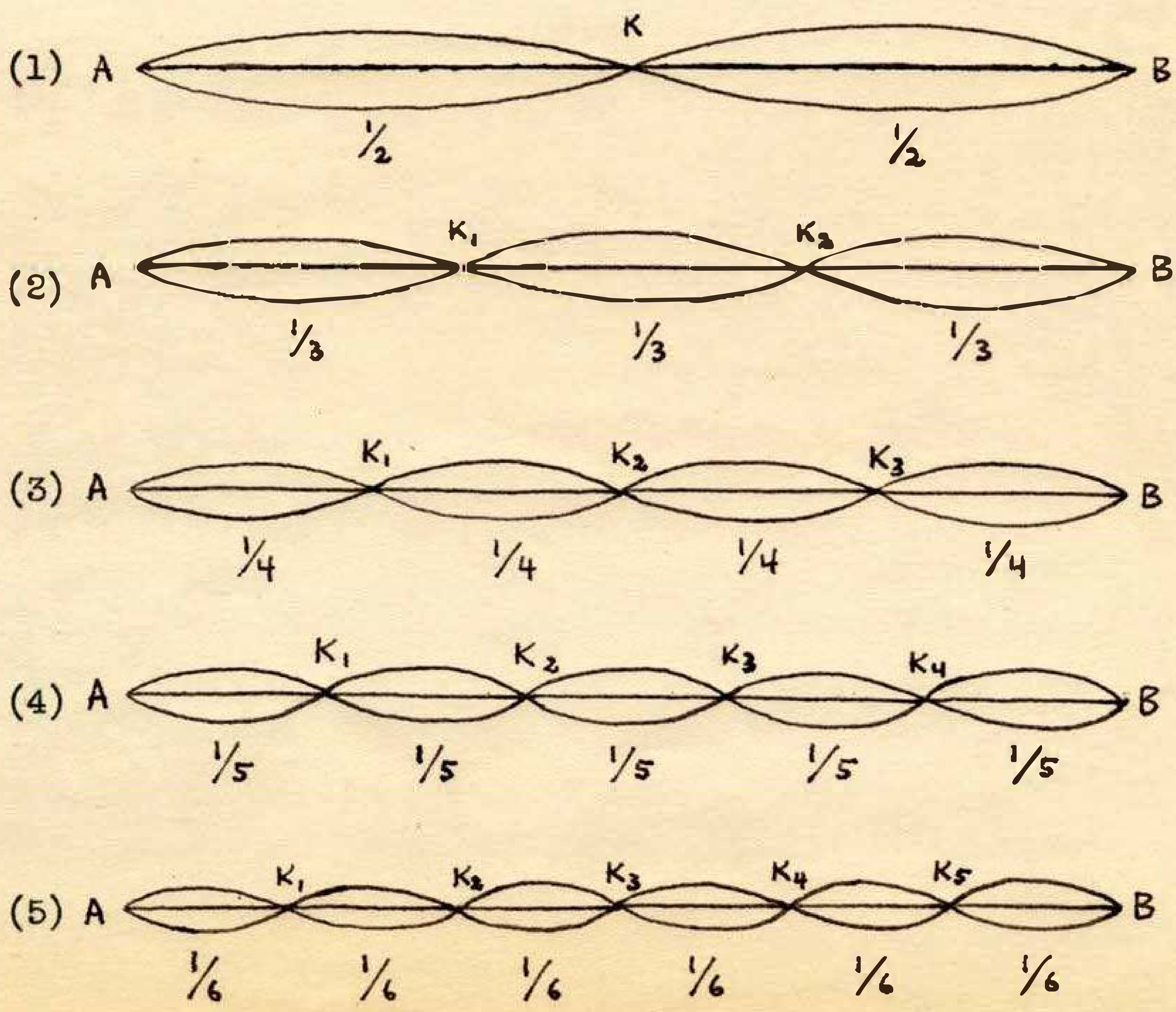
The higher the harmonic, the shorter the partial division of the string (and the higher the frequencies).

The correspondence between the divisions of the string and the order of harmonics is as follows.

Division of the string.	Order of the harmonic.
1	1
$\frac{1}{2}$	2
$\frac{1}{3}$	3
$\frac{1}{4}$	4
$\frac{1}{5}$	5
$\frac{1}{6}$	6

Beyond this limit harmonics produced on the stringed bow instruments become impractical, except perhaps for the double-bass seventh harmonic. What violinists usually do not know, and what the composer should know is that <u>every knot</u> in the same subdivision (denominator) produces identical harmonics.

Figure XI. String



The practical consequences of this situation are the diversified ways of getting a harmonic in a passage where a violinist may think it impossible. Imagine a regular rapid passage which brings you to the upper (closer to the bridge) part of the fingerboard. Now assume you want to use the third harmonic. A violinist would try to reach the point K_1 in Fig.XI (2), while touching the string at the point K_2 would produce the same harmonic.

As more careful composers (Wagner, for instance) indicate in musical notation by a diamond-shaped note (◇, ◇, ◆, ◆, etc.) the point of the finger-contact with the string, it is possible to carry out the above principle to a practical end.

Each string is subject to the same physical conditions, so far as harmonics are concerned. The longer the string, the more pronounced the harmonics. Thus, the <u>quality of harmonics increases</u> in the following order of instruments:

(1) Violin

(2) Viola

(3) Cello

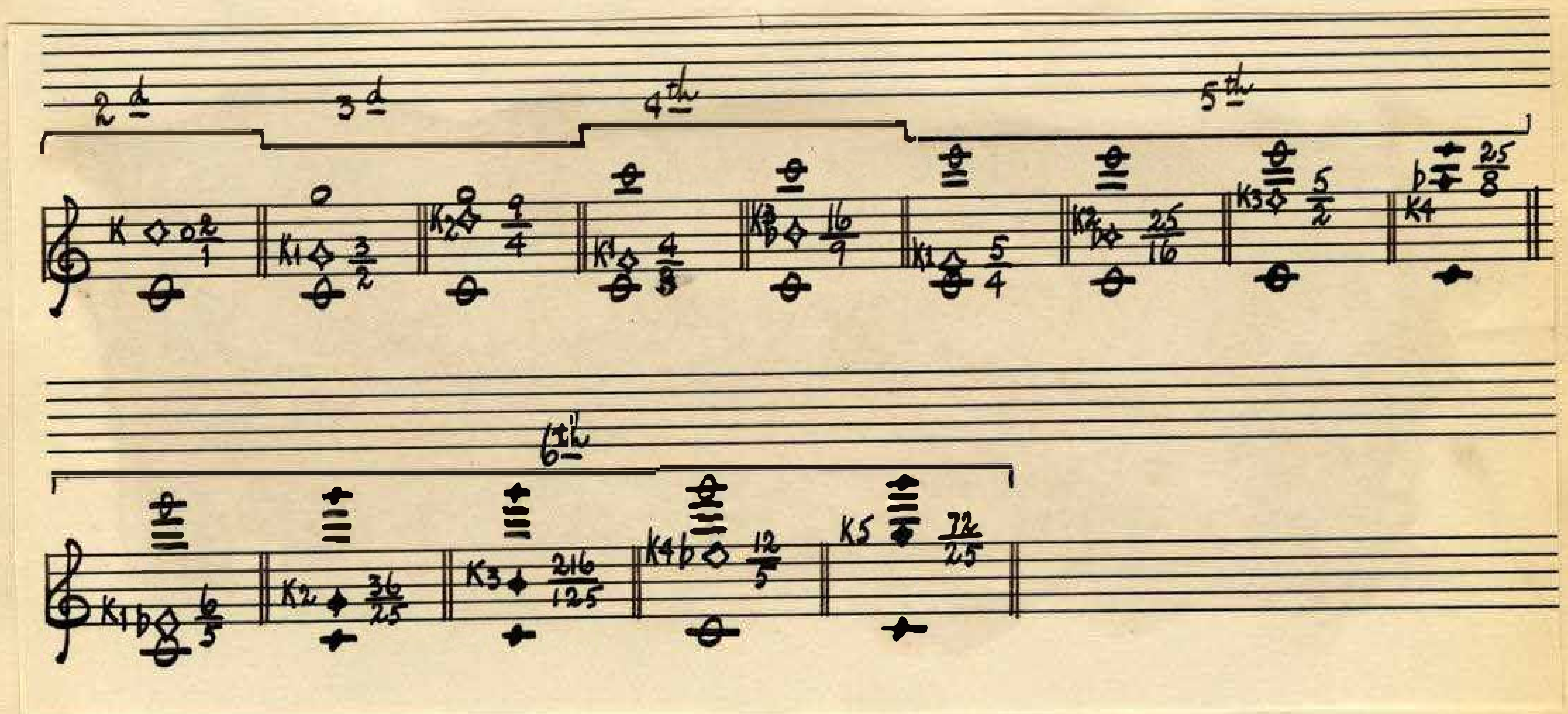
(4) Bass

The lower the order of the harmonic, the richer it sounds. This means that lower harmonics still form physically their own harmonics (or the harmonics of the second order). Thus it is correct to state that, let us say,

the third harmonic of the Bass is denser than the third harmonic of the 'Cello, and that the latter is denser than the third harmonic of the Viola, etc. But the sixth harmonic of the 'Cello may be not as dense as the second harmonic of the Violin.

Here is a complete table of harmonics for the string tuned in c, which can be transposed to any other tuning. The large notes indicate the sound of the open string, the diamond notes indicate the point of finger-contact with the string and the small notes indicate the resulting pitch of the harmonic.

Figure XII.



Fractions indicate the frequency ratios. All black notes single out the impractical cases.

With regard to equal temperament the corresponding contact points (K) are practically exact:

$$\frac{2}{1}, \frac{3}{2}, \frac{4}{3}, \frac{16}{9}$$

$\frac{16}{9}$ is very slightly lower

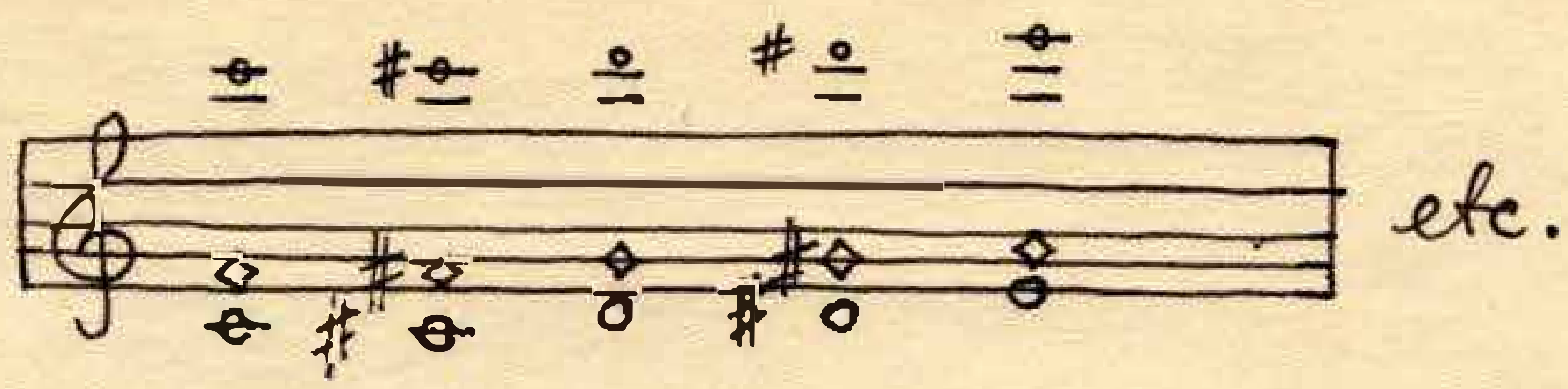
$\frac{5}{4}$, $\frac{25}{16}$, $\frac{10}{4}$ are slightly lower

$\frac{6}{5}$ and $\frac{12}{5}$ are slightly higher

In addition to all these harmonics, usually called "natural harmonics", there are harmonics produced by pressing the string with one finger and touching with another. The latter are called by the violinists "artificial harmonics". In reality harmonics cannot be artificial. It is a phenomenon. What would you think of an "artificial sunset"?

The pressing finger shortens the string and the touching finger produces the respective partial subdivision. There is only one harmonic which is practical under such conditions: <u>the fourth harmonic. The pressing finger is always the first finger and the touching finger is always the fourth.</u> The practical advantage of this device is its chromatic universality, which permits the performance of any melodies in the form of harmonics.

Figure XIII.



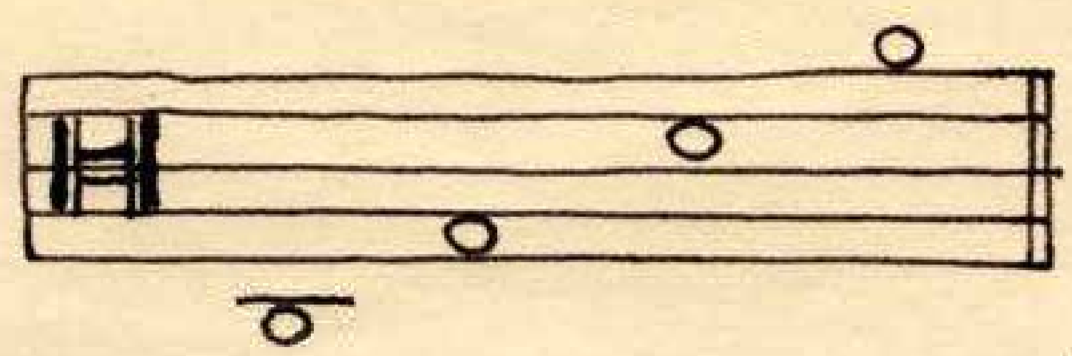
B. Viola

Viola differs from violin mainly in its tone-quality and in the possibilities for virtuosity. The tone quality is "somber" as compared to that of the violin. The technique of performance is more difficult than on the violin. The reason for this is that though the dimensions of the viola are greater, the system of fingering remains the same. Thus, playing viola requires greater stretching of fingers. In most cases, the unsuccessful but broadhanded and practically-minded violinists become violists. It is interesting to mention that one of the best composers of today, Paul Hindemith, is one of the best violists of today. For many years he was the leader and the violist of the excellent "Amar-Hindemith Quartette". He composed works for this neglected instrument in the form of a concerto, sonata and unaccompanied suite.

The tuning of viola is one fifth lower than that of the violin. The alto and the treble clefs are used in notation of the viola parts.

Figure XIV.

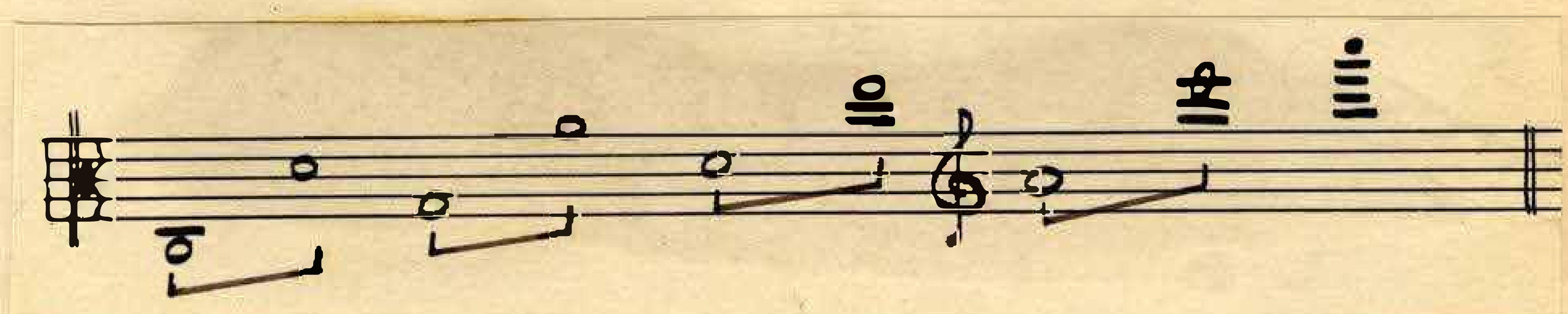
Tuning



The range of viola for the orchestra use shall not exceed a ninth from each of the lower three strings (C, G, D) and be not more than a twelfth from the upper string (A). In writing for viola solo, the upper string can be used within a range of two octaves.

Figure XV.

Range



It is correct to say that viola is related to violin as two to three.

All forms of technical execution correspond to that of the violin. The parts written for the viola shall not be limited in any respect, as the limitations of virtuosity do not concern orchestral parts.

Lesson CCLXII.

C. Violoncello

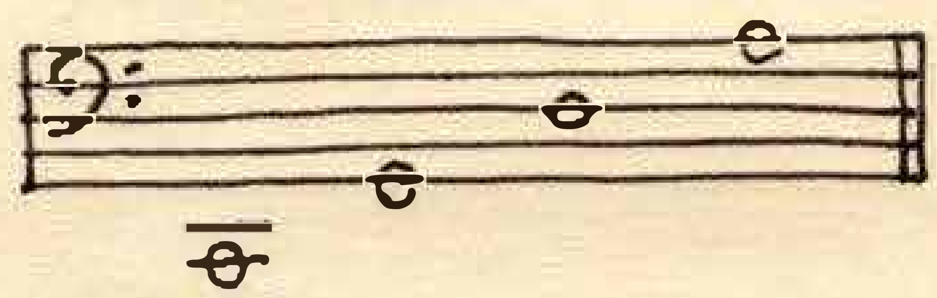
Violoncello means a small violone, which was the bass viol of the viol family. This is why it has a diminutive name in spite of its size. This instrument is commonly called cello, which does not make any sense, but conveys the association through the established use of this word. It is better to write "'cello"(with apostrophe in front).

Being held in a different position from the violin and the viola and exceeding the latter in size ('cello is related to viola as one to two and to violin as one to three), 'cello requires a different type of technique in fingering. The intervals on the fingerboard are wider, and the stretching is greater. Though the thumb does not have to support the instrument, it seldom participates in playing and is used on special occasions only (mainly for pressing the string while playing harmonics). The thumb is indicated as " ♀ ". All other fingers are numbered in the same way as on the violin.

'Cello is tuned in fifths and one octave lower than viola. Bass (F), tenor (C) and treble (G) clefs are commonly used. Contemporary composers in most cases have abolished the tenor clef, but the 'cellists have to know it well, because most composers of the past used it in their scores.

Figure XVI.

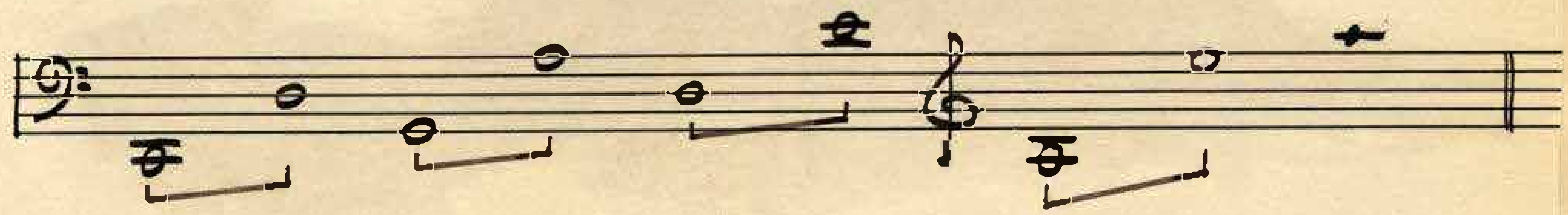
Tuning



The range of 'cello for orchestra use shall not exceed a ninth from each of the lower three strings (C, G, D) and a twelfth from the upper string (A). In solo playing, however, the latter can have a two-octave range.

Figure XVII.

Range



It is customary in an ordinary passage-playing to make transitions from string to string in one position, rather than to change positions on one string. In case of chromatic scalewise passages positions are frequently changed.

The usual fingering for the lower positions is based on the following principle:

(1) semitones are played by adjacent fingers;

(2) whole tones by alternate fingers;

(3) chromatic scales are played with continuous changes of positions, each position emphasizing three fingers: the first, the second and the third;

(4) all executions of double-stops, chords and rapid arpeggio are based on the above forms of normal fingering; as a consequence, the chords which are easy to play are either in open positions or contain open strings;

(5) perfect fifths are played with one finger on two adjacent strings;

(6) all "artificial harmonics" are played with the thumb (pressing) and the third finger (touching).

<u>Examples of fingering</u>

<u>Figure XVIII.</u>

All the forms of bowing, practical for the violin, are practical for the 'cello. As the bow of the 'cello is proportionately shorter than that of the violin, the composer must use long durations of single notes and of passages, emphasized by the bow moving in one direction, with discrimination.

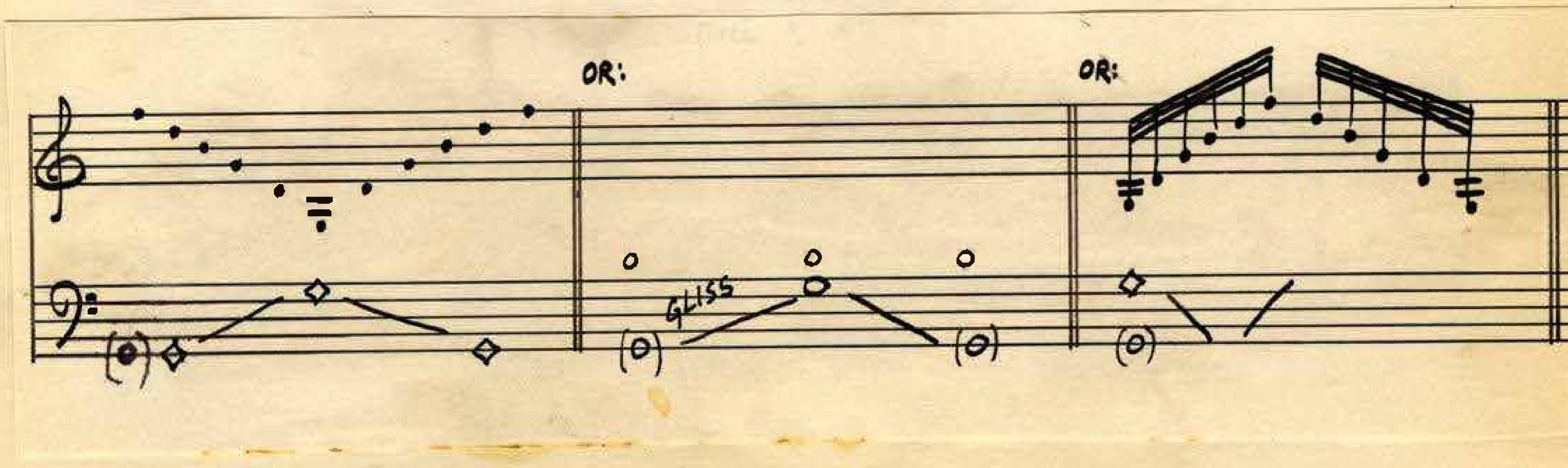
One of the 'cello's features are harmonics. Due to long strings, they are very sonorous. For the same reason pizzicato is richer on the 'cello than on the violin. Pizzicato glissando (marked: pizz. and a slur over the two bordering notes), an effect similar to Hawaiian Guitar is very colorful. See "Four Hindus Songs" for voice and orchestra by Maurice Delage.

Glissando of harmonics is another effect to which 'cello is particularly suited. In order to execute it, touch the string at the nut and move the finger quite fast toward the central knot of the string. This causes a sequence of harmonics from high to low ones. Moving in reverse, i.e., from the central knot to the nut, causes the reversal of the sequence of harmonics. There is no need to move the finger beyond the central knot as the string has an axis of symmetry for all the knots, and such a finger movement would produce the same harmonics as when moved from the central knot back to the nut. The resulting effect has great color value and has been used by the best orchestrally minded composers. It sounds like a rapidly moving arpeggio of a large seventh-chord.

A combination of such harmonics glissando played by several 'cellists on different strings, and also in different directions if desired, produces a shimmering effect of fantastic harps, subtle and fragile.

The adopted notation of this effect is as follows (black notes show the <u>main points</u> of the actual sounds, as all the points cannot be expressed in our musical notation).

<u>Figure XIX.</u>



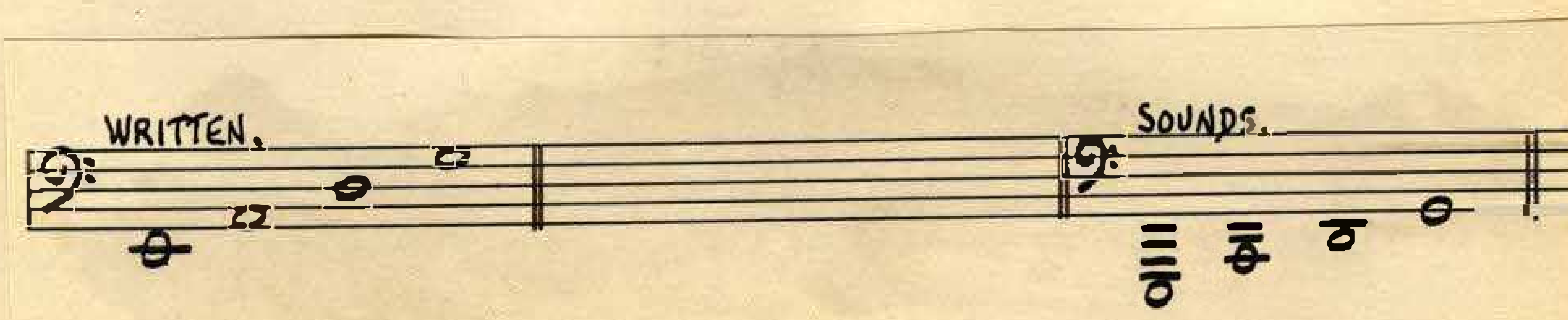
See Rimsky-Korsakov's opera "Christmas Night".

D. <u>Double Bass (Contrabass)</u>

Double bass (corresponding to the antiquated violone) has <u>four</u> strings usually. They are tuned by fourths.

<u>Figure XX.</u>

<u>Tuning</u>



In XVIII and XIX Centuries when a lower note was required, the bassists re-tuned the lower string to E, to E♭ or to D. In the XX Century the problem was solved by the addition of a fifth string (below the fourth regular string), which is tuned in C. All large symphonic and operatic organizations have at least half of their string basses equipped with five strings.

High positions are more seldom used on the string bass than on any other stringed-bow instrument.

The range, practical for orchestral uses, is as follows. Double bass always sounds one octave lower than the written range.

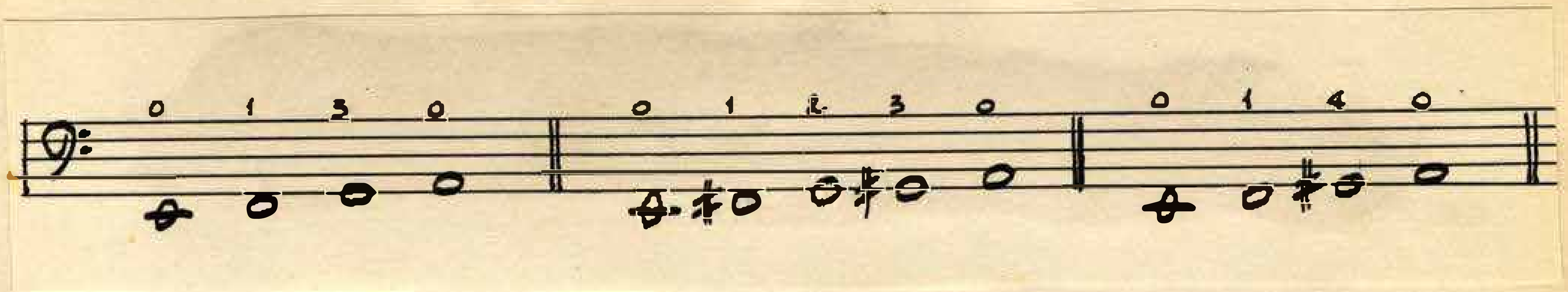
Figure XXI.

All forms of bowing and effects, including the use of mutes, pizz. glissando, harmonics and harmonics glissando are perfectly suitable for the bass, and are unjustly neglected.

Fingering technique and intonation are the chief difficulties of this instrument.

The fundamentals of fingering are as follows.

Figure XXII.

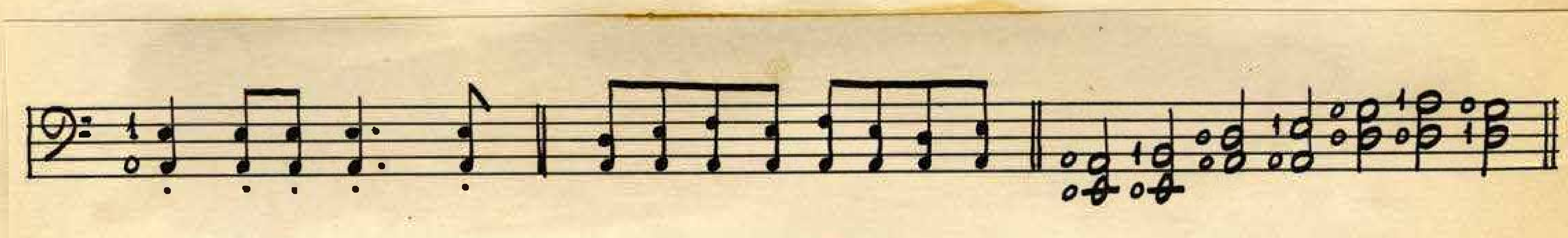


The last case is quite difficult and must be avoided, unless absolutely necessary.

As higher positions require closer spacing, it is easier to play the bass in the higher positions. The purity of intonation increases, but it becomes more and more difficult to get a pleasing tone. It is best not to use the double-stops at all as they sound muddy in low register anyway. However, certain forms of pedal and strata can be used.

Figure XXIII.

Example:



Chords are impractical, even when possible. Some composers have written solo passages and phrases for the bass and exceeded on such occasions the established orchestral range.

See Rimsky-Korsakov's opera "Coq D'Or", where a bass solo is written in the alto (C) clef.

There are very few outstanding bassists who appear

as soloists. Probably the best of all bassists in the whole history of this instrument is Sergei Koussevitsky (at present the conductor of the Boston Symphony Orchestra). When Koussevitsky was younger he frequently gave recitals on the Double Bass, as well as played concertos with his own orchestra (which was known as Koussevitsky Orchestra in Moscow, Russia). As the bass literature is limited, Koussevitsky often played his own transcriptions of concertos written for some other neglected instruments. Thus, one of his favorites was Mozart's concerto for a Bassoon (Fagotto) with orchestra. Another accomplished bassist (at present with Radio City Music Hall Orchestra in New York) also comes from Russia. His name is Michel Krasnopolsky. In Russia, when giving recitals, he played among other things my own "Suite for a Double-Bass and Piano" composed in 1921.

When used as a solo instrument, Double Bass must be tuned a tone higher and read a minor seventh down. It really becomes a bass in D. Some of the outstanding violin-makers in Italy made a few excellent basses, which are slightly smaller in size and permit the tuning one tone higher. They are better in tone too.

In Jazz double bass is used mostly as a percussive instrument: it is plucked (pizzicato) and slapped. It is interesting to mention that in Jazz playing, where virtuosity on some orchestral instruments leaves the classical way of playing far behind, the development of the performer's

technique influenced mostly the right and not the left hand and, even then, not in bowing.

This particular form of virtuosity produced some proficient performers.

There are two duets for piano and double-bass on Columbia records: "Blues" and "Plucked Again" (Columbia, Jazz Masterwork, 35322), with Jimmy Blanton (bass) and Duke Ellington (piano).

Lesson CCLXIII.

WOOD-WIND INSTRUMENTS

I. The Flute Family

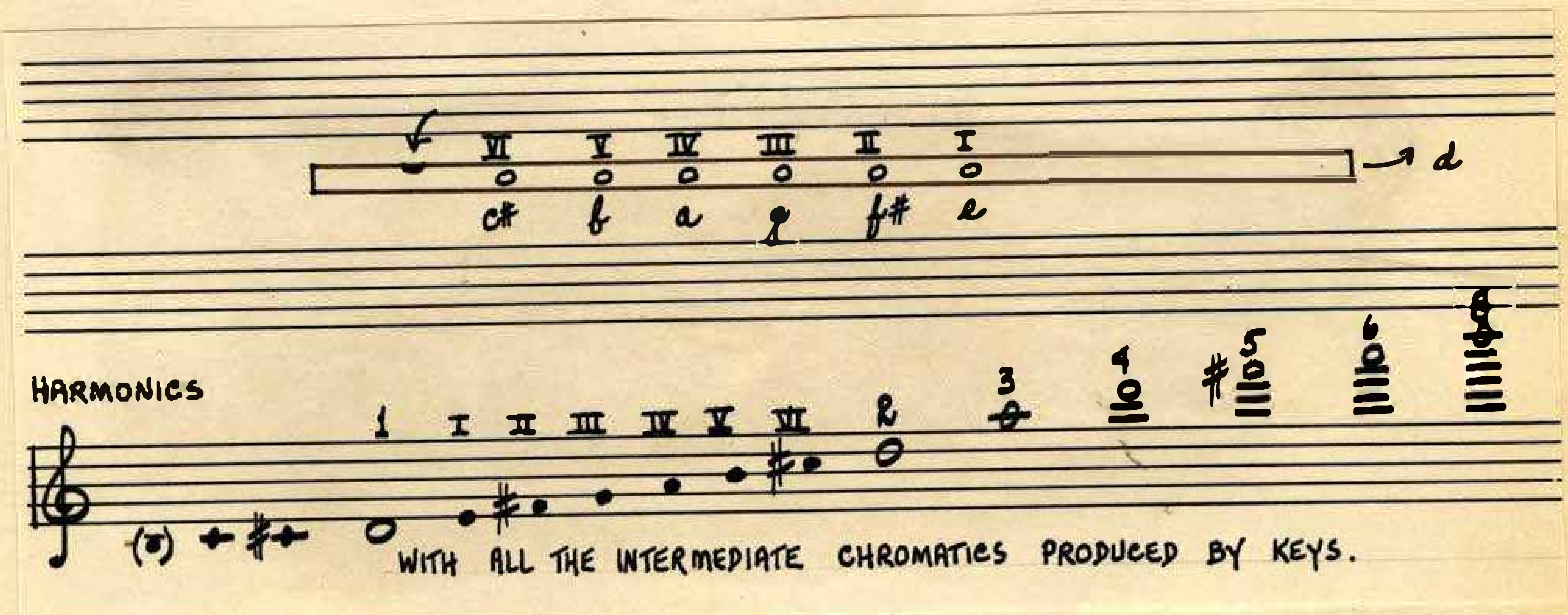
A. Flauto Grando (Flute)

This instrument, known as a "large flute" in juxtaposition to the smallest member of this family known as a "small flute" or Flauto Piccolo or just plain "Piccolo" (which is as bad as "cello"), is a D- instrument without transposition. This means that, whereas its acoustical scale (the natural tones, i.e., the tones produced by modification of blowing, and not by using holes and keys) is D, the tones sound as they are written. Tones which are not in the acoustical scale are produced by means of six holes and a number of keys (depending on the make). Gradual opening of the holes from the bell up shortens the air column and produces the tones of the natural major scale in D, i.e., d, e, f#, g, a, b, c#. The following d is the second natural tone (harmonic) from which the scale can be executed further in a similar fashion. All chromatic intervals are filled out by means of keys. The two (in some makes, three) tones below the fundamental d are executed by extending the bore with a pair of specially designed keys, which close instead of opening the holes.

Being cylindrical on the outside, the bore of a flute is an inverted cone inside (with a very slight deviation from a cylinder, though). The shape of the bore and the form

of exciting the air column directly (through an open hole), instead of through a mouth-piece of any kind, attributes the flute its whistle-like tone-quality.

Figure XXIV.



As the consequence of this construction, the easiest keys for the flute are D, A, G, etc., i.e., keys adjacent to D through their signatures.

Flute is particularly suited for scalewise passages (which can be played at any practicable speed) and close forms of arpeggio (E_1). The finger technique is highly developed among flutists. All forms of tremolo legato (arpeggio of couplings), trills, rapid grace-note scalewise passages are typical of a flute.

Another flute specialty is the multiple-tongue effects: double, triple and quadruple, which as the name shows, are accomplished by a rapid oscillatory tongue movement. There is no special notation for this effect, and

every flutist knows it should be used when there is a rapidly repeating pitch.

It must be understood that the term "legato" (indicated by a tie), as applied to flute as well as to all wind instruments (including woodwind and brass), means a group of notes executed in one breath. As non-legato, staccato etc. are also executed in one breath for a group of notes, legato means one breath without a renewal of the tongue-attack.

The increase of the quantity of attacks augments the volume of the instrument and should be used in all cases when the natural volume is weak, yet harder blowing may produce the next natural tone. As a special device for both increasing the volume and giving the tremolo effect frulato (flutter-tongue) is used. In order to execute frulato (which is only practical in the high register) it is necessary to pronounce (in a whispering manner) a continuous rolling of frrr. The notation for frulato is: ~~~~ for the period of duration of the note.

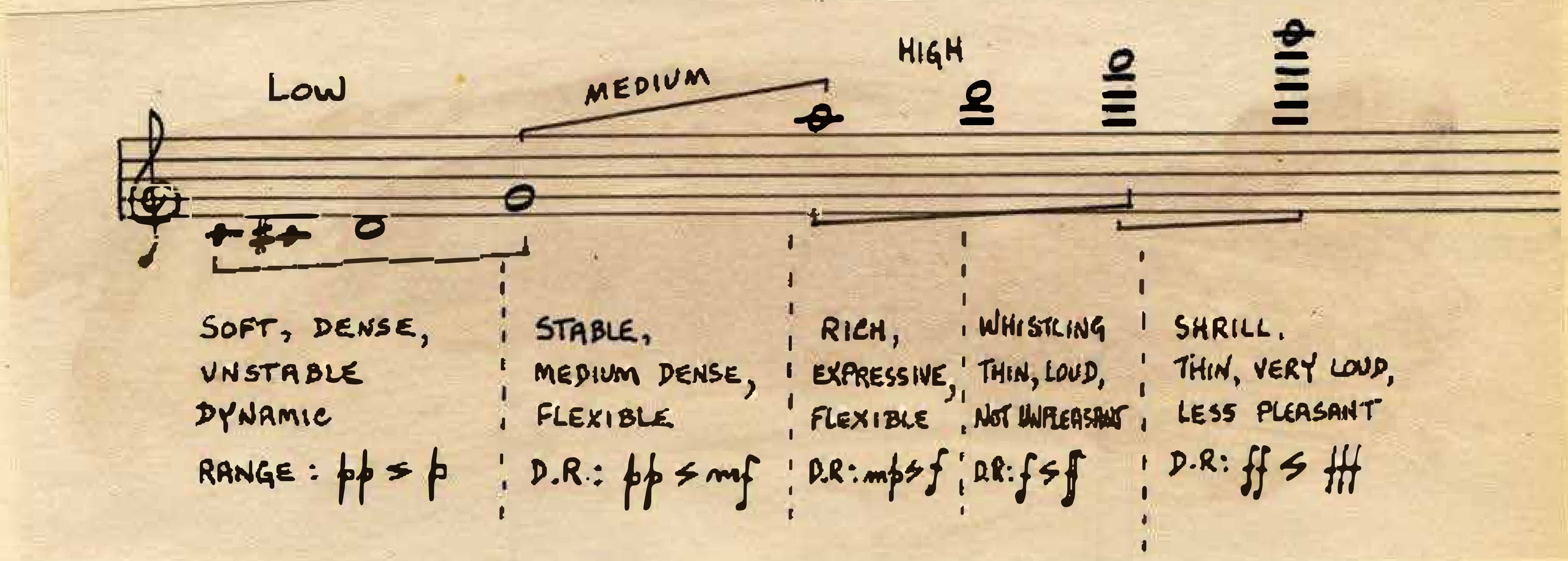
Because blowing on the flute is immediate, the air column in the bore is quite unstable. This causes great sensitivity of registers. Each register has its own dynamic characteristics. The consideration of the latter is of the utmost importance in orchestration. Contemporary manufacturers are constantly seeking a scientific solution for equalization of registers. To put it plainly, each register, unless very

skilfully handled, sounds like a somewhat different instrument. When one melodic group occupies more than one register, the contrast between the registers becomes very undesirable. Some old-fashioned minds think it desirable to have nearly each tone in a different flavor, because they believe it attributes individuality to the instrument. This assumption is psychologically wrong, because each sound does not sound per se, but in connotation with the preceding and the following sounds. Imagine a book where each character is printed in a different type. It certainly attributes individuality to each letter, but at the same time makes the process of reading far from being pleasurable.

This argument about uniformity of tone-quality throughout the entire range is the main weapon of attack against electronic instruments, because such instruments have a much superior qualitative stability than the woodwind instruments. In other words, electronic instruments are condemned by the reactionaries, whereas Yasha Heifetz tries hard to make it unnoticeable when his bow changes from one string to another (which is equivalent of the changes of registers).

Figure XXV.

Range and Registers of the Flute



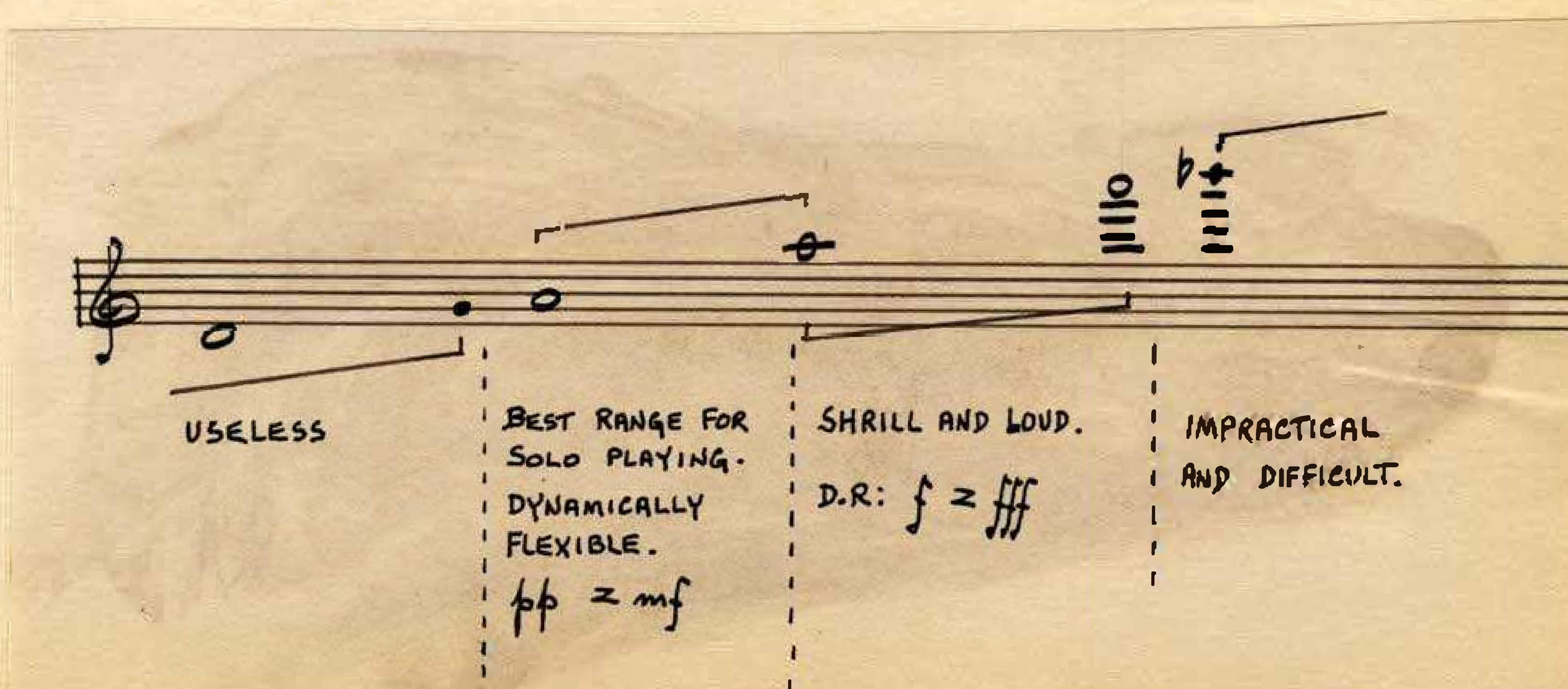
B. Flauto Piccolo (Piccolo)

F.P. is a diminutive flute and possesses all the main characteristics of the large flute. Its acoustical scale is also in D, but its range is much more limited. The lower register is practically useless, except for some humorous effects. The agility of this instrument is truly remarkable, and particularly so in the scalewise passages.

Figure XXVI.

Range and Registers of the Flute Piccolo

(Sounds one octave higher than written)



C. Flauto Contralto (Alto Flute)

F.C. comes in two sizes (or types):

(1) Fl. Contralto in G (used more than in F)

(2) " " " F (used less than in G)

Both types are used a great deal in operatic and symphonic scoring.

The main value of the alto flutes lies not in extending the range below the ordinary flute, but in giving a better quality and a more stable range corresponding to the low register of flauto grando.

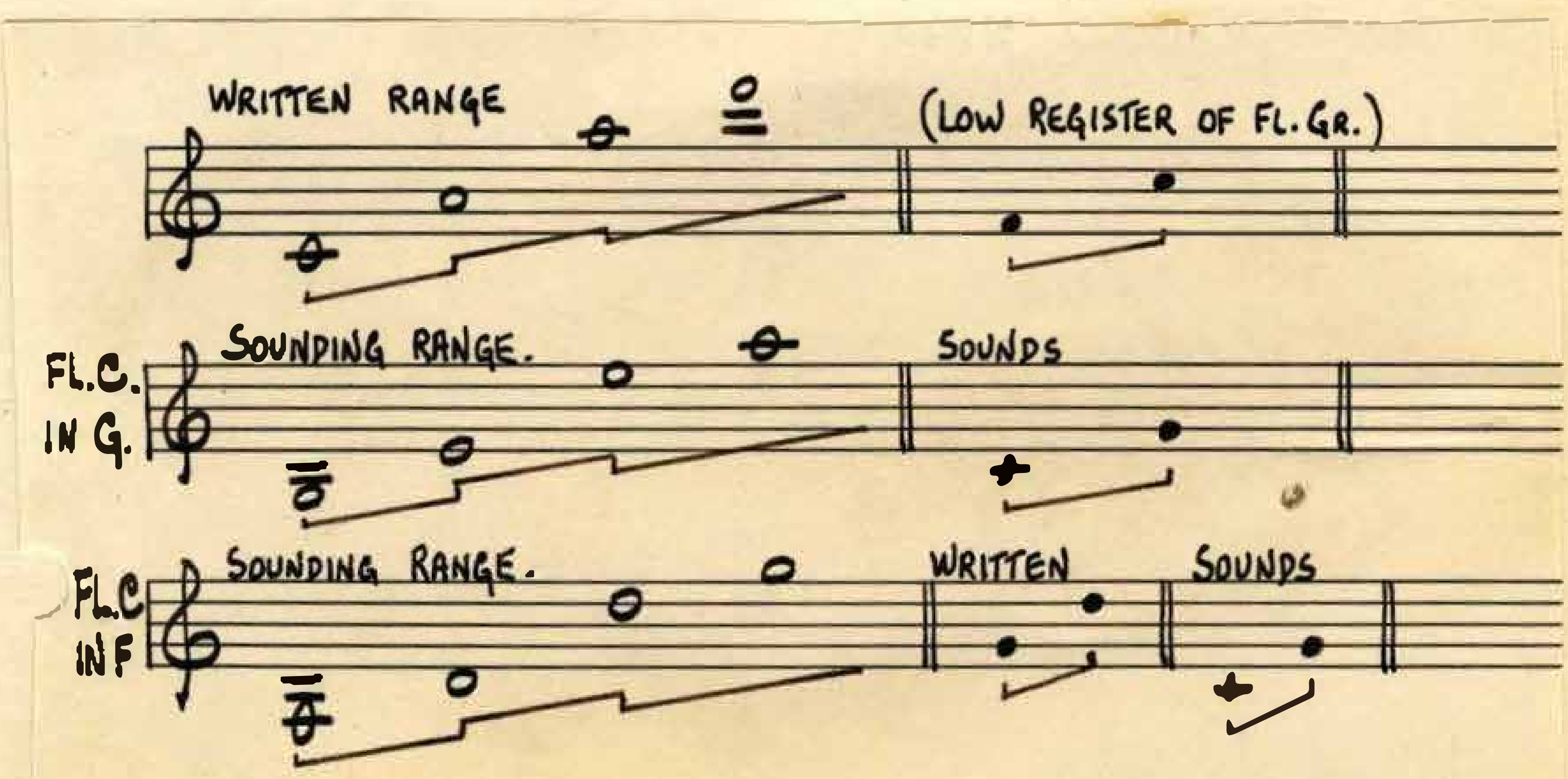
Fl. Contralto in G sounds a perfect fourth (5 semitones) lower than the written range.

Fl. Contralto in F sounds a perfect fifth (7 semitones) lower than the written range.

The first of the two has a better tone quality.

Figure XXVII.

Range and Registers of the Alto Flutes



There is no need to use high register of alto instruments, as the regular type gives a better tone-quality.

Other types, such as Bass Flutes, are obsolete nowadays. They produce tones in quality somewhere between ocarino and an empty bottle.

Lesson CCLXIV.

II. The Clarinet (Single-Reed) Family

A. Clarinetto (Clarinet) in B♭ and A

This instrument has a cylindric bore, which causes, according to Helmholtz, the appearance of only odd (1, 3, 5, 7, 9, ...) harmonics. The pair-numbered harmonics are absent. This situation creates a gap of 18 semitones between the fundamental and the next (i.e., the third) appearing harmonic. Somehow the designers of this instrument succeeded in reducing the number of holes and keys considerably (usually 13) though theoretically it would be required to have all the 18, in order to produce a chromatic scale covering the gap.

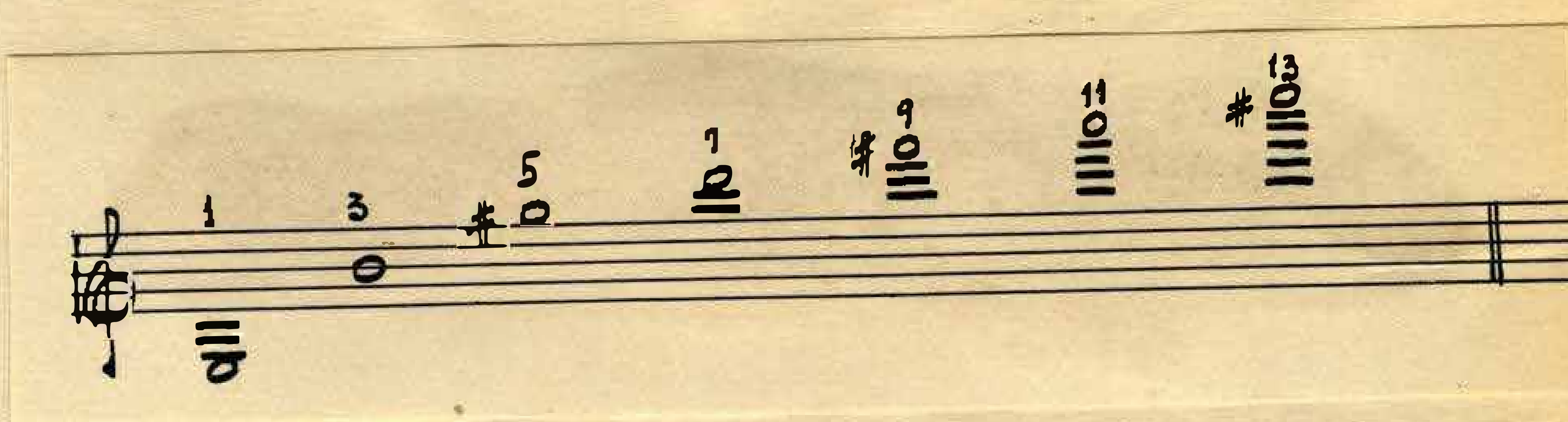
From the performer's angle, clarinet is a difficult instrument to master. However, this should not worry the composer, as accomplished clarinetists are really in abundance. The main consideration concerning the composer is that while approaching the third harmonic, the tone of the clarinet weakens for about the last 6 semitones. The register between the fundamental and the third harmonic is known as chalumeau (French, from Latin "calamus" - reed; originally - a single reed instrument, with a built-in reed, now obsolete; probably the ancestor of clarinet). A special tone-quality, in addition to the usual one, and which is hard to get, corresponds to the chalumeau register and is known as subtone (soft, delicate and tender).

Starting with the third harmonic and going up, the tone-quality of a clarinet changes noticeably. Of course it is the task of an accomplished performer to neutralize this difference.

The sound on the clarinet is produced by blowing into a detachable mouth-piece, to which the reed is attached. A complete chromatic scale is produced by the various types of keys and by holes which are covered by fingers (by special keys on the bass clarinet). The clarinetists of American dance orchestras are able to produce a glissando (i.e., continuous pitch modulation between two frequencies). This is accomplished by the ambouchure (which usually means "the assumed position of lips combined with lip-pressure"). Symphonic and operatic clarinetists are not trained to play glissando.

All clarinets are usually written as clarinets in C. Under such conditions, the scale of natural tones appears as follows:

Figure XXVIII.

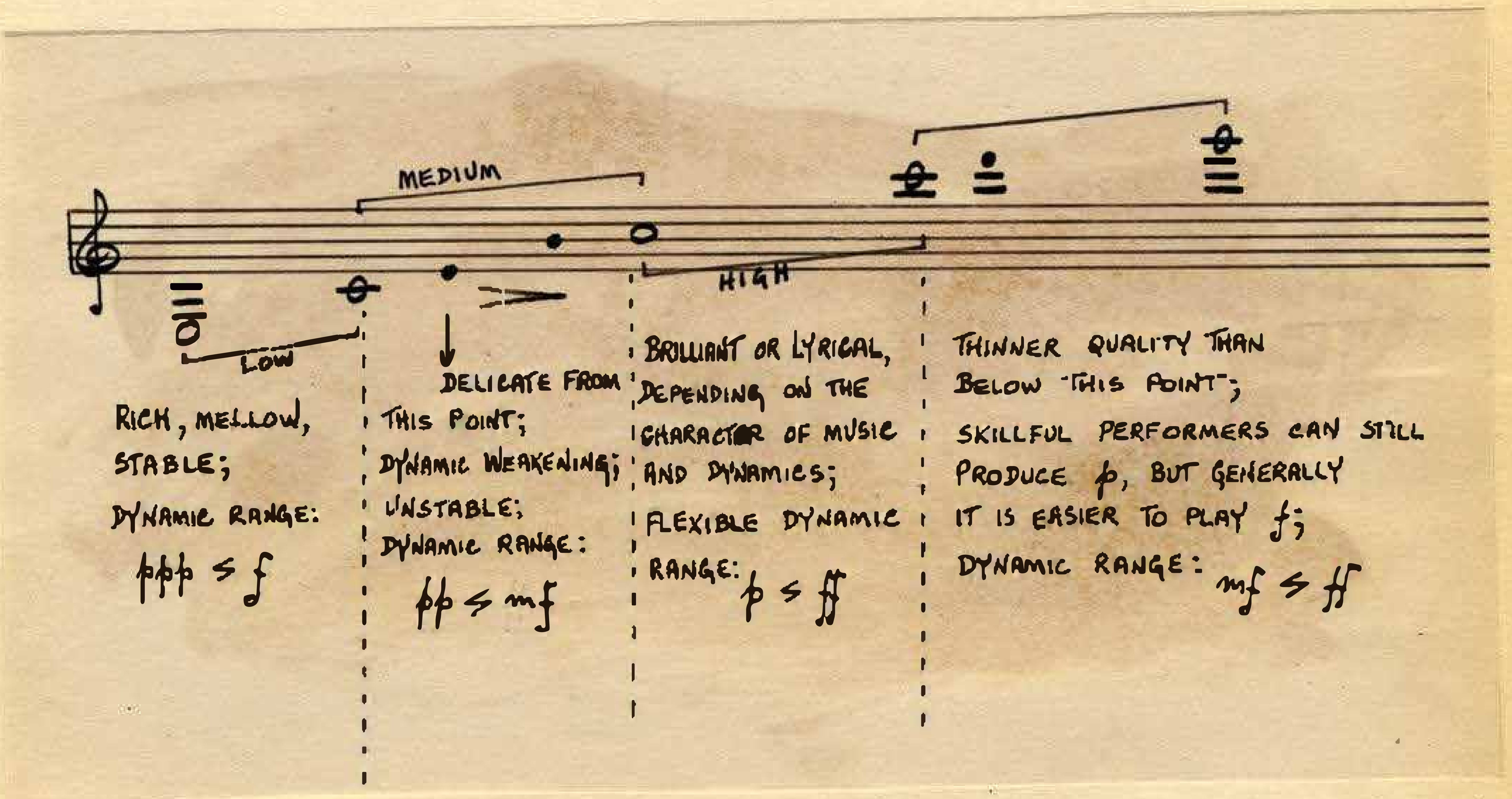


The clarinet in C was discarded a long time ago, as its tone quality was not as satisfactory as that of the clarinets in B♭ and in A (some contemporary manufacturers make an extra hole and key to compensate the lower semitone on the B♭- clarinet; thus it can play the parts written for the A- clarinet; in some other instances, mechanical adjustments have been made in order to obtain a combined version of the B♭ and the A clarinets).

Though some individual performers get far beyond the common range, there is a silent international code of ethics, by which composers limit themselves by the written g of the second octave.

Figure XXIX.

Range and Registers of the Clarinet



For the clarinet in B♭- flat the above table sounds one tone lower. This means that the composer must write his parts for the B♭ instrument one tone higher than he expects to hear the actual sounds. For instance, the part which sounds in the key of C must be written in the key of D. Thus clarinet in B♭ acoustically is a D instrument, as its fundamental tone (by sound) is d.

Likewise the parts for the clarinet in A must be written three semitones higher than they are expected to sound. Thus the above table sounds three semitones lower. Parts expected to sound in the key of C must be written in the key of E♭. Thus clarinet in A acoustically is a C# instrument, as its fundamental tone (by sound) is c#.

It was believed in the XIX Century that the B♭-clarinet represents the masculine quality, that it is more substantial but less delicate than the feminine quality of the A- clarinet. However, today skilful performers can obtain both characteristics on B♭- clarinet.

Considering the quality of manufacture and the skill of contemporary performers, we can say that clarinet can play practically everything. Its specialities are: rapid diatonic and chromatic passages, tremolo legato and trills. Staccato is preferable in its soft form. Arpeggio of the E_1 form is very grateful both upward and downward.

B. Clarinetto Piccolo in D and in E♭.

The first instrument (D) is used in symphonic and

operatic orchestras and the second ($E^\flat$), in the military bands. Both these instruments are inferior in their tone quality, as compared with the clarinets in $B^\flat$ and A.

The acoustical range of the D- clarinet is in $F^\sharp$. It is written one whole tone lower than it is expected to sound. The parts which are written in the key of $B^\flat$, sound in the key of C.

The acoustical range of the $E^\flat$-clarinet is in G. It is written three semitones lower than it is expected to sound. The parts which are written in the key of A, sound in the key of C.

Except for the tone-quality, the piccolo clarinets can be favorably compared with the regular clarinets: their mobility is as high.

C. Clarinetto Contralto (Alto Clarinet) and Corno di Bassetto (Bassethorn).

Clarinetto contralto is usually an $E^\flat$, but sometimes an F instrument. Thus it should be written a major sixth and a perfect fifth higher, respectively, than the sounding keys. This instrument is so constructed that its lowest written note is c below the usual e. Its tone-quality can be described as more "hollow" than the tone of a regular clarinet.

Corno di bassetto has a narrower bore than the clarinet. It looks somewhat like the miniature version of the clarinetto basso (bass clarinet). Its tone-quality is more "reedy" than that of the clarinet. Bassethorn is an instrument

in F: it is written a perfect fifth higher than it sounds. Today bassethorn becomes more and more obsolete: alto clarinet in E♭ takes its place.

D. Clarinetto Basso (Bass Clarinet) in B♭ and A

The A instrument is seldom used outside of Germany. Both these instruments sound one octave below their respective regular clarinets. This means that the B♭- basso is written a major ninth higher than it sounds; A- basso is written a minor tenth higher than it sounds. In German scores often both treble and bass clef are used.

The rule is that when using the bass clef, write one octave below the corresponding note of the treble clef. That is the transposition of sound from the bass clef is only a whole tone, or a tone-and-a-half down.

Both these instruments are manufactured with and without the lower extension from e to c.

The B♭- basso without lower range extension is used by the dance orchestras, whereas the B♭- basso which reaches the lower c (b♭- by the sound) is used in symphonic and operatic scoring.

These instruments have quite a sinister tone in their lower register. It is wise not to write for the bass-clarinet above d of the second octave. Bass-clarinet possesses somewhat less mobility than the smaller clarinets.

There is also a contrabass or pedal clarinet, a monstrous affair which has to be suspended on special stands

and which is very hard to play. Richard Strauss used one in his "Electra", and only Germans could play this instrument. It sounds one octave below the bass clarinet (it is also in B♭) and has an awe-inspiring quality.

III. <u>The Saxophone (Single-Reed) Family</u>

Saxophone is one of the numerous creations of Adolf Sax, an eminent instrument designer of XIX Century. This instrument is a crossbreed of oboe (due to its conic bore) and clarinet (due to its single-reed mouth-piece).

Very few composers used this instrument in the XIX Century (one of them was George Bizet) and eventually it became quite obsolete, with the exception of the military bands in France and Belgium, which have been using saxophones widely.

The original saxophone family consisted of the instruments in C and in F.

Soprano	Saxophone	in	C
Alto	"	"	F
Tenor	"	"	C
Baritone	"	"	F
Bass	"	"	C

American manufacturers rejuvenated interest toward this instrument. They succeeded in constructing saxophones of a more improved design. American saxophones as played by American saxophonists introduced a whole new style of music and musical execution.

American-made saxophones are so flexible that any

type of part can be written for it. Rapid scales, arpeggio, tremolo legato, trills, staccato, glissando are all possible and grateful on this instrument. The last two or three decades produced a number of outstanding virtuosi, many of whom are Negroes, and many of whom are skilful improvisers. It is due to the wide influence of Jazz and Jazz-playing that saxophone manufacture became a considerable industry.

The standard dance-band combinations customarily use 4 or 5 saxophones. In some instances this quantity varies. It is quite common that a saxophonist is at the same time a clarinetist. Some of these performers are equally as good on both instruments.

In the earlier days of American Jazz (and also in some instances in Europe) there were some ensembles consisting only of saxophones, but they have not survived.

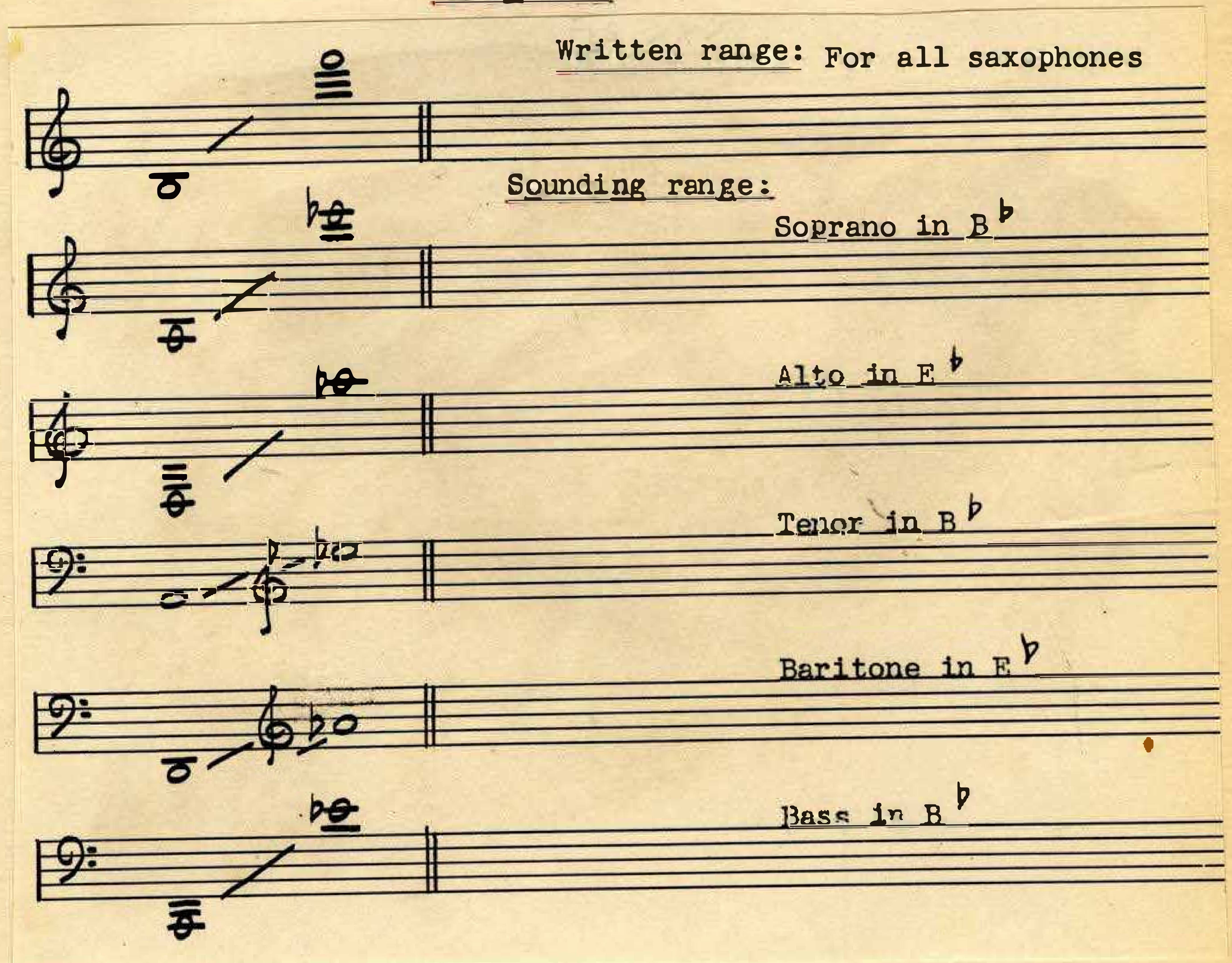
The American family of saxophones is tuned in B♭ and E♭.

Figure XXX.

(please see next page)

(Fig. XXX)

Saxophones



The soprano and the bass are seldom used today.

All saxophone parts are written in the treble clef.

There is no noticeable difference of registers in a good performance, and it is for this reason that we have omitted the range subdivisions.

Lesson CCLXV.

IV. The Oboe (Double-Reed) Family

A. Oboe

Oboe is an instrument of ancient origin. In its primitive form it has been in wide use throughout Asia. One of the oboe's ancestors was the Hellenic aulos, which was used for the expression of passion.

Blowing through a narrow opening of the flatly folded reed (usually called double reed) requires strong lungs and a peculiar technique of breathing. Some of the Asiatics (Persians, for example) can play the oboe-like double-reed instruments with uninterrupted sound (like the Scottish bagpipe). These performers usually hold a reserve supply of air in one cheek, which is exhaled, i.e., blown into the reed, while the lungs are inhaling the future supply of air.

The contemporary oboe has a conic bore, which characteristic stimulates the appearance of the full scale of natural tones (harmonics).

Without additional keys, oboe acoustically can be considered an instrument in D, like the flute. Oboe, like the flute, is not a transposing instrument. Most oboes of European manufacture have b of the small octave as its lowest tone. American-made oboes reach b♭, immediately below it. It is customary not to use the oboe above f of the second octave. Due to its construction oboe is a slow-speaking instrument. Only passages of moderate speed are possible on

this instrument. Oboe is valued mainly for its characteristic tone-quality, which can be described as "nasal" and "warm".

All types of passages are possible, including tremolo legato and trills, providing they are executed at a speed which seems moderate compared to flutes and clarinets. One of the most valuable characteristics of the oboe is the versatility and distinct character of the attack forms. The legato, the portamento, the soft and particularly the hard staccato appear on the oboe with a clear distinction.

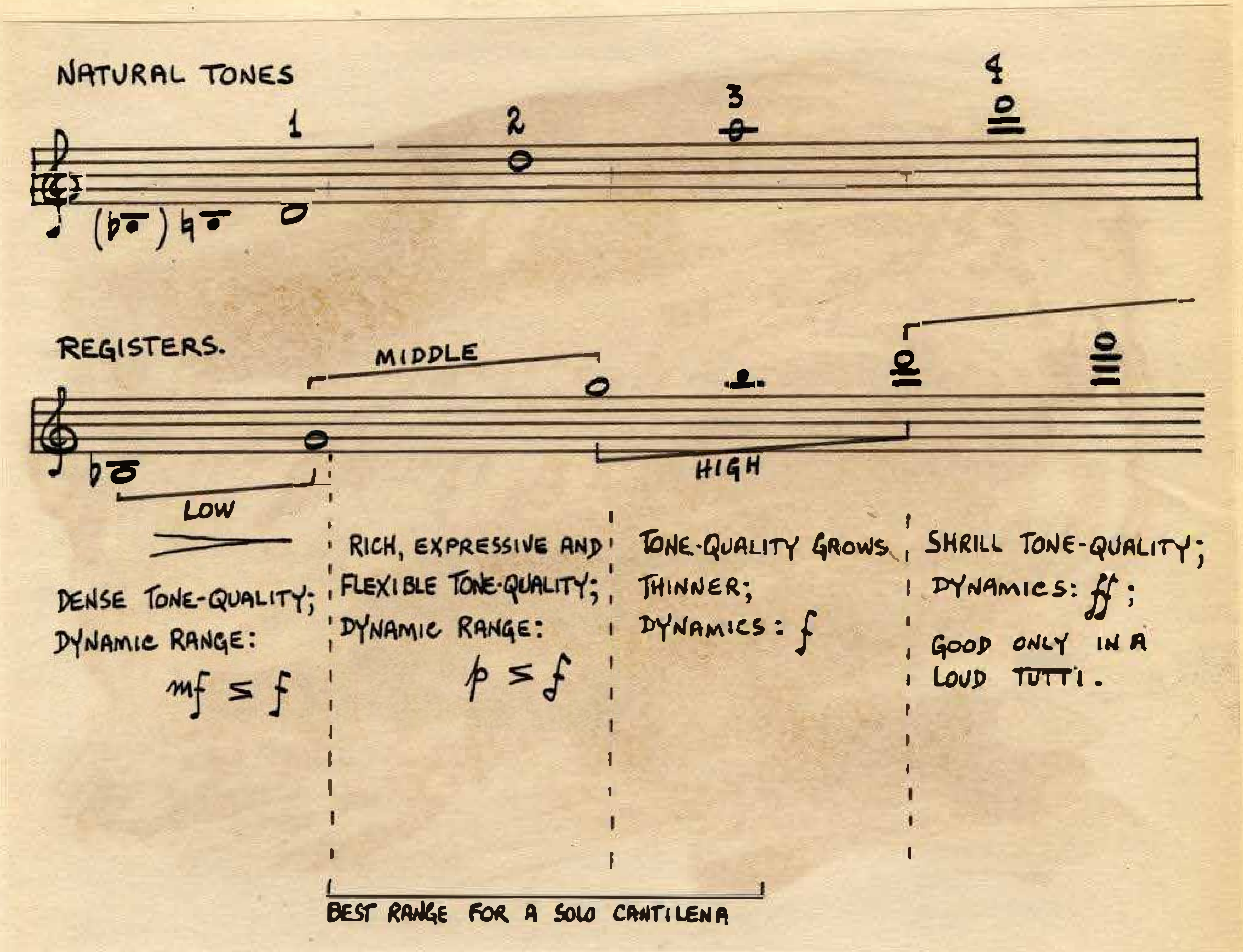
The density of the oboe's tone decreases considerably in the upper part of its range. The low register is somewhat heavy and has a natural volume increase in the direction of decreasing frequencies. The most flexible and expressive part of the range is the middle register. High tones are thin and shrill.

Figure XXXI.

Range and Registers of the Oboe

(please see next page)

(Fig. XXXI)



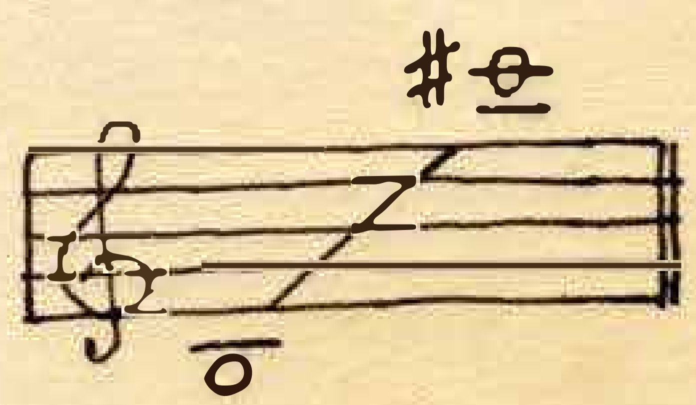
B. Oboe D'Amore

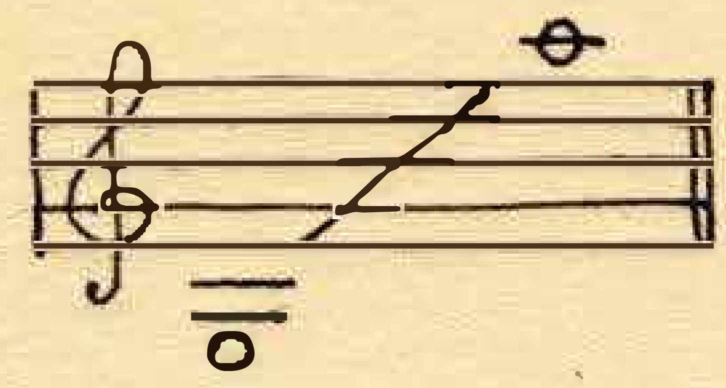
A mezzo-soprano type of oboe which is now extinct. J.S. Bach used it in his "Christmas Oratorio". It was revived by Richard Strauss in his "Sinfonia Domestica". This is a transposing instrument in A♭.

Figure XXXII.

Range of Oboe D'Amore

Written: Sounds:





C. Corno Inglese (English Horn)

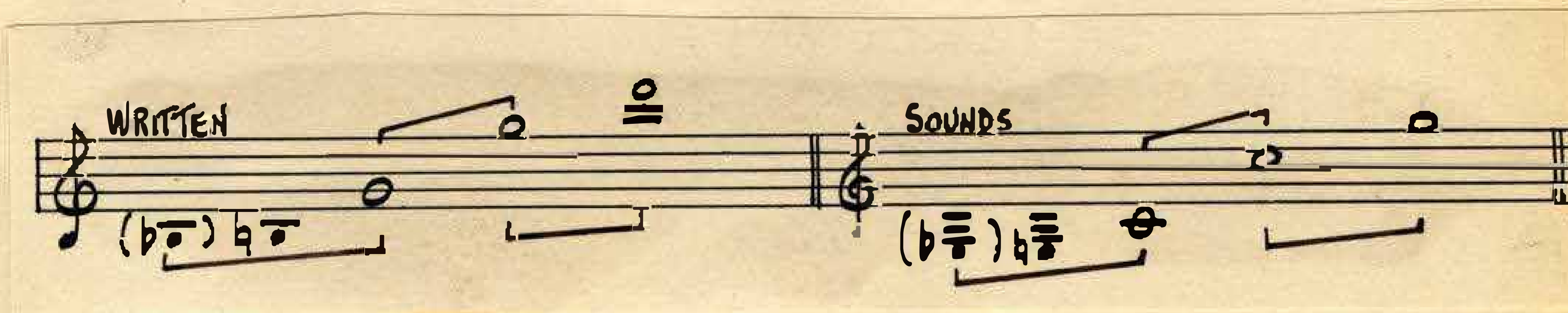
The immediate predecessor of this instrument is oboe di cacchia (hunter's horn), now obsolete. The contemporary version of corno Inglese (also known as oboe contralto) represents an instrument similar in most respects to oboe, but sounding one perfect fifth lower. It is a transposing instrument in F.

The middle octave is its best register for an expressive solo. The low register is still denser and heavier than that of an ordinary oboe. The high register is seldom used beyond the written d (sounds g) of the second octave. All other characteristics correspond to oboe. It is still somewhat slower-speaking instrument than the oboe.

English horn is exceptionally suitable for the expression of passion and suffering. In orchestral scoring it is often given a solo. One of the famous solos is in Wagner's "Tristan and Isolde" (Prelude to the third act).

Figure XXXIII.

Range of Corno Inglese



D. Heckelphone (Baritone Oboe)

The baritone oboe is an instrument of German manufacture (made by Heckel) and in its perfected form was introduced in about 1905 A.D. It has a quality of overwhelming richness and expressiveness. Richard Strauss used it first in his opera "Salome"; Ernst Krenek in his opera "Sprung Ueber den Schatten" ("Leap Over the Shadow"). It is an instrument well deserving wide use together with oboe and English horn.

Heckelphone is made to sound one octave below oboe; it sounds one octave below the written range. Its size is so big that the bell of the instrument rests upon the floor, while the performer is playing in sitting position.

The key and hole system is designed to resemble that of an ordinary oboe, which construction makes it easy for an oboist to master the heckelphone.

As the range and the registers of this instrument exactly correspond to that of an oboe (the lowest tone is b♮),

but sound one octave lower, there is no need for a table of range and registers.

V. The Bassoon (Double-Reed) Family

A. Fagotto (Bassoon)

The name "fagotto" derives from "faggot": a bundle of sticks; the name "bassoon" from the association with bass register.

Bassoon is an instrument with a very long conic bore (about eight feet), which is folded upon itself, somewhat in a manner of letter "u". This u-shape makes it possible to have a system of accessible holes and keys. Some of the key-holes produce only one tone (the lower keys) and some, two (octave variation by lip-pressure which is easy to produce and which is typical of a bassoon).

Being an instrument with a conic bore and a double-reed mouth-piece, the bassoon may be considered as a bass of the double-reed group, i.e., it is a natural bass to the oboes.

The main difference between the oboes and the bassoon lies in the fact that the latter has an additional section, which extends its low register.

Under the same conditions of fingering (with the basic six holes closed), the bassoon is one perfect twelfth below oboe, i.e., under the conditions which produce the middle d on oboe, bassoon produces g one twelfth below.

The range of the bassoon (for all practical

purposes) begins with the b♭ of contra-octave and ends with d of the first octave. The b♮ tone at the lower end is of somewhat inferior quality than all other tones of the low register.

This instrument is capable of mobility noticeably greater than that of an oboe. Various forms of arpeggio (practically in all expansions), octaves and leaps in general, as well as rapid scalewise passages, tremolo legato and trills constitute the versatile technique of this instrument. The attacks are distinct. Legato, portamento, soft and hard staccato (the latter being bassoon's specialty, and possible at a considerable speed) can be executed with quick changes.

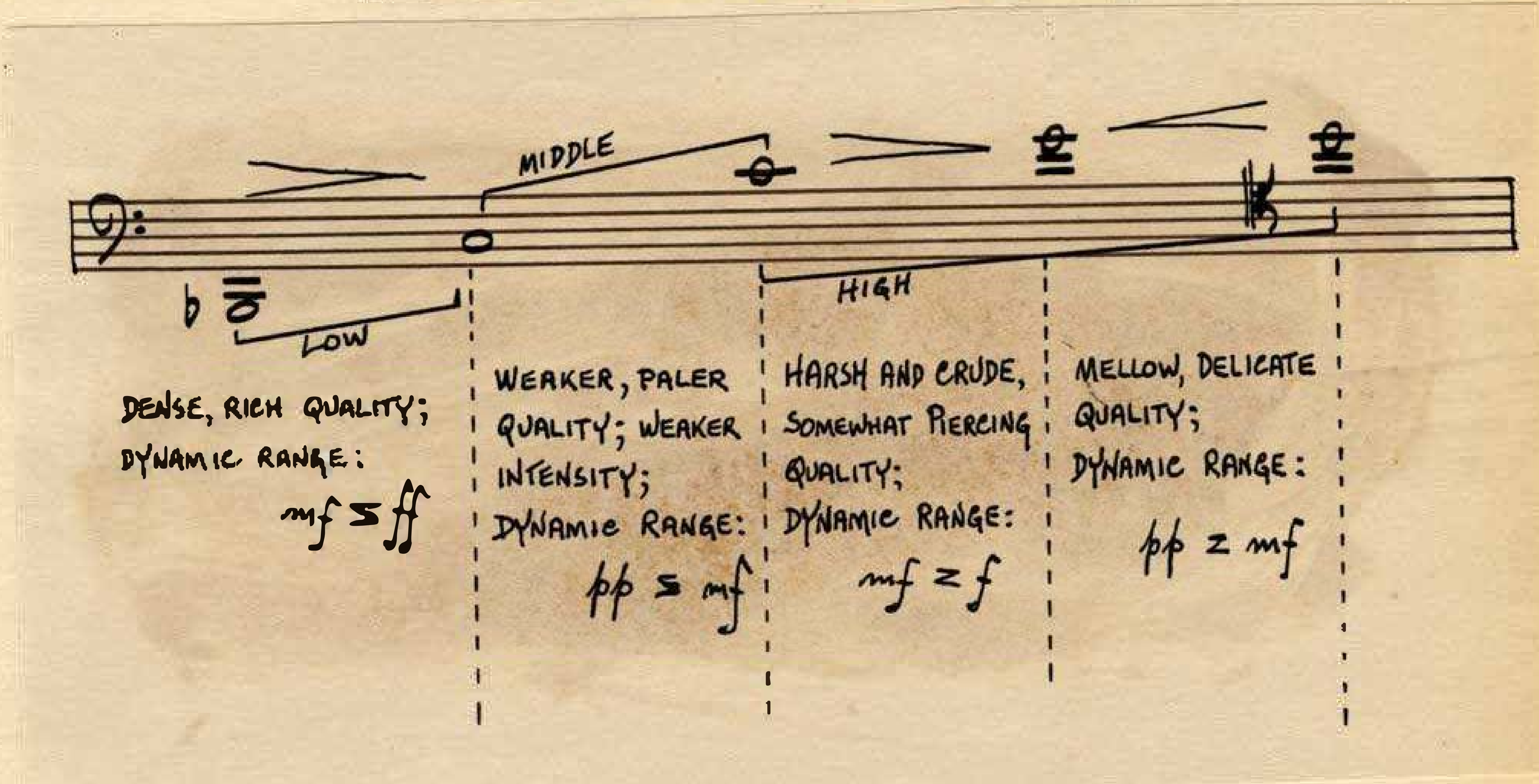
Bassoon parts are written in the bass and the tenor (though alto-clef may be used as well) clefs. It is not a transposing instrument.

The dynamic peculiarities of the bassoon require a particular attention on the part of the composer. The low register (from b♭ of the contra-octave to c of the small octave) is the most powerful part of bassoon's range. It weakens slightly toward the middle register (this begins with c of the small octave and ends with c of the middle octave), which is considerably weaker than the low register. The high register, from c to g of the middle octave is somewhat harsh; it becomes very mellow from g of the middle octave to d of the first octave. Stravinsky is one of the

few composers who utilized effectively this upper region (the opening bassoon solo at the beginning of the "Rite of Spring").

Figure XXXIV.

Range and Registers of the Bassoon



B. Fagottino (Tenoroon, Quintfagott, Tenorfagott)

This instrument (now practically obsolete) was built a perfect fourth and a perfect fifth above the regular bassoon. Both types are transposing instruments: tenoroon in E♭, sounding one perfect fourth higher than written and tenoroon in F, sounding one perfect fifth higher than written.

The tone-quality of these instruments was inferior to that of the regular bassoon.

C. Contrafagotto (Double-Bassoon, Contra-bassoon, Contrafagott).

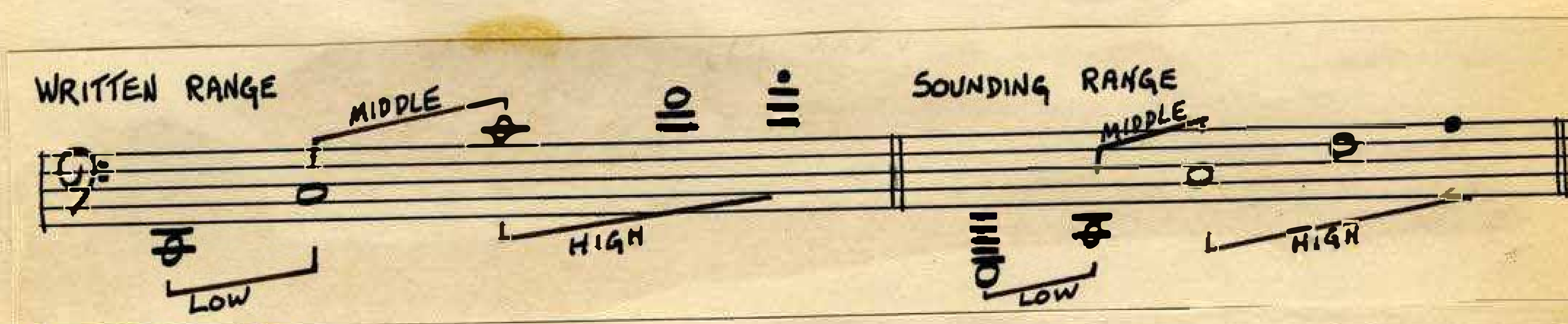
This instrument still of greater dimensions is meant to be the lower octave-coupler to an ordinary bassoon. The engineering quality of this instrument, being inferior to that of a bassoon, causes inferior tone-quality and less exacting intonation. The tone of this instrument is somewhat dry and does not sound as healthy as the tone of the bassoon. Its alertness is also somewhat lower.

As contrabassoon is an instrument built mainly to produce low frequencies, it must not (except for some special purposes, such as creating associations of "humorous" or "painful") be used beyond its regular middle register.

Contrabassoon is a favorite instrument with many composers. Its sounding range is one octave lower than written. Its lower register is considerably weaker than that of a bassoon.

Figure XXXV.

Range and Registers of the Contrabassoon



Lesson CCLXVI.

BRASS (WIND) INSTRUMENTS

I. Corno (French Horn)

Horn is an instrument with a long and rich history.

The immediate predecessor of the contemporary three-valve chromatic French horn was the so-called natural horn, capable of producing only the natural tones. All other tones on the natural horn were obtained by putting the fist of the left hand into the bell and varying the depth of its position within the bell. The deeper the fist is set, the lower the sound of the respective natural tone. This manner of altering natural tones is based on the physical principle of open and closed pipes: an open pipe sounds one octave higher than the same pipe closed. As the gradual conic pipe (which is coiled around itself) extends in a horn to about seven feet, the partial closing of this pipe by a fist, at the bell, lowers the respective natural tone only by one or two semitones. This device does not cover all steps chromatically, as the acoustical gaps between the second and the third, and between the third and the fourth tones are too great. It is for this reason that the parts written in the XVIII and early XIX Centuries were predominantly fanfare-like.

Eventually natural horns became obsolete. Rimsky-Korsakov used natural horns in his opera "May Night" (when chromatic horns were universally in use) for the sake of his own amusement, which he called "self-discipline".

In order to read scores by such composers as Mozart and Beethoven, not mentioning Bach or Haendel, it is important to have at least some basic information about the sizes and the transposition-keys of the various horns, used in not such a remote past.

Natural horns were constructed in two main size-groups: the alto horns and the basso horns. All horns transpose downward, i.e., they sound below the written range. Alto horns transpose directly to a designated interval, indicated by the transpositional name of the instrument. Basso horns, in addition to the alto transposition, sound one octave lower (compare with the clarinet in B♭ and the bass-clarinet in B♭).

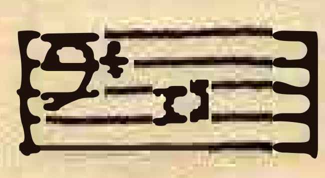
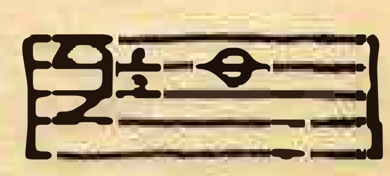
The alto horns were constructed in all chromatic keys, except G♭. The selection of a particular horn was in correspondence with the key in which a certain piece was written. Basso horns were used, where reaching of the lower register was essential. Basso horn parts are known only in three transpositions: the B♭- basso, the A- basso and the A♭- basso. There was no octave confusion in interpretation of the scores, because it was the alto horns that were usually meant. The use of basso horns was quite exceptional and the cases where they were used were generally known. For example, horns in B♭- basso were used in Beethoven's Fourth Symphony (written in the key of B♭).

Except for the use of valves, which secure the

entire chromatic scale, there is no noticeable difference in the construction of the present day French horns (including the conic mouth-piece).

Blowing through a long narrow channel creates such conditions, under which it is easy to "overblow" the fundamental tone of the scale. That is, the air-column tends to break into two halves. For this reason, the officially recognized range of the horn begins with the second tone. From there on, everything is practical up to and including the twelfth natural tone. The sixteenth tone is seldom used nowadays. As the frequency increases, the tone-quality becomes brighter.

We shall represent now the scale of natural tones for the hypothetical French horn in C. As chromatic horns used today are in F, the actual sounds appear one perfect fifth below the written range if the part is written in the treble clef; when using the bass clef, write the parts one fourth below the intended pitch, or, stating it differently, one octave below the treble clef. Thus the transposition of the French horn, when written in the treble clef, is exactly the same as that of an English horn.

Thus:  and  sound alike: 

This cumbersome octave-variation as well as the whole idea of pitch-transposition is a survival of an old tradition. The sooner it will be abolished, the better, as no one gains by this transpositional technique, which is a constant source of complications and confusion.

During Wagner's time and later, chromatic French horns in E were used together with that in F. They are abolished today, for the reason of superior tone-quality obtainable on the horns in F.

Figure XXXVI.

Scale of Natural tones of the French Horn

Only in very exceptional cases is the French horn written one or two semitones above the twelfth tone. The best tone-quality for solos and cantilena lies between the fourth and the twelfth natural tones. French horn is a direct continuation of tuba's timbre in its lower portion of the range. From its fourth to twelfth tones it acquires a gradually growing characteristic of lucidity; in its upper

range, French horn blends well with clarinets and particularly with flutes; in its lower range, with trombones, tuba and bassoons. In this sense, French horn is an intermediary between the wood-wind and the brass groups.

Chromatic scale, as already stated, is obtained by operating the three valves. All three-valve instruments are designed on the same general principle.

The first valve (operated by the upper key) *lowers the natural tone by two semitones.*

The second valve (the middle key) *lowers the natural tone by one semitone.*

The third valve (the lower key) *lowers the natural tone by three semitones.*

Valves are indicated by the respective Roman numerals:

I lowers by 2 semitones
II " " 1 semitone
III " " 3 semitones

These indications are not used in scores or parts, but merely for reference, when necessary.

The operation of valves is such that while blowing the written middle *c*, for example (the 4th tone which sounds *f*), and pressing key I, one obtains b♭ (sounds *e*♭); while blowing the same tone and pressing key II, one obtains b♮ (sounds e♮); while blowing the same tone and pressing key III, one obtains a♮ (sounds d♮).

All other intervals, by which a natural tone can be lowered, are obtained by a combined use of keys controlling the operation of valves.

Thus: I + II lowers the natural tone by 3 semitones;

I + III lowers the natural tone by 5 semitones;

II + III lowers the natural tone by 4 semitones;

the combination of all three keys lowers the natural tone by 6 semitones.

In the French horns of old make there were some deficiencies of intonation when the combined valves were used. They are abolished in present manufacturing by a special interlocking of air columns in the valves, which device rectifies the corresponding frequency-ratios.

Valves themselves are additional short pipes, connectable with the main channel by the operation of the keys. The latter affect the pistons or the rotary cylinders. Cylinders are more common on the present French horn. So far as tone quality is concerned, it does not make any difference which particular mechanism is used. Thus keys open the valves, thereby connecting them with the main channel, which results in the increase of the air column and, for this reason, lowers the pitch of a given natural tone.

As the change of embouchure (lip condition with respect to form and pressure) is never as alert as the finger technique, it is preferable to write rapid passages, when they

can be obtained mainly by the operation of keys. It is for this reason that the composer must have an exact knowledge of the key-valve operations. Even trills and tremolo legato are possible when they are obtained through the use of keys.

It follows from the above that the valve system is acoustically opposite to the hole system, used on all wood-wind instruments (i.e., on the brass instruments natural tones are lowered, on the wood-wind instruments they are raised).

French horn is a slow-speaking instrument, and for this reason speed is not limited by the finger-technique but rather by a slow tone-production. All forms of legato and staccato, as well as portamento, are available and distinct. The breathing process, as applied to this instrument, is normal and healthy. It is possible, for this reason, to execute sustained tones or passages of considerable period in one exhaling. Contrary to the double-reed practise, playing French horn is a healthful occupation.

Due to conical shape of the mouth-piece, double-tongue is not within the scope of this instrument. One of the French horn's specialties is the dynamic effect of <u>sforzando-piano</u> (sfp). This can be performed at any point from the 3d tone upward. French horn has a wide dynamic range but its lower part weakens considerably.

French horn is played either <u>open</u> (indicated as o) or <u>stopped</u> (indicated +). The first indication is not

used, except as a cancellation of the "stopped". The stopping is usually indicated above each attack.

Mutes are generally applicable to French horns, but used by the performers only under compulsion: they think the stopping "will do".

In volume (intensity), French horn occupies an intermediate position between the brass (in relation to which it is weaker) and the wood-wind instruments (in comparison with which it is louder, particularly when played high and ff).

Lesson CCLXVII.

II. Tromba (Trumpet)

Trumpet is a chromatic three-valve instrument. Depending on manufacture, either cylinders (more often) or pistons (more seldom) are used.

Of all the types of trumpets, the soprano (ordinary) type, in B♭ and A, is used more universally than the alto trumpet, in G and F, the piccolo trumpet, in D and E♭, and particularly the bass trumpet, in E♭ and B♭.

A. Tromba (Soprano Trumpet) in B♭ and A

Of these two designs, preference is given to the B♭- trumpet in the U.S.A., while in Europe both tunings are used for the respective parts. American dance-bands use the B♭- trumpet exclusively.

Some of the B♭- trumpets can be converted into A - trumpets, by drawing a special telescopic slide which lowers the range of the instrument by a semitone.

The hypothetical trumpet in C is transposed two or three semitones down respectively (like the clarinet).

Its scale begins with the second natural tone and ends, for all normal purposes, with the eighth. Outstanding trumpeters are able to blow the ninth, the tenth and even the twelfth tones. In this case the use of the piccolo trumpet becomes unnecessary, as the tone of the regular soprano trumpet is preferable. On the other hand, the composer must not rely on the presence of such a virtuoso in every orchestra,

even playing the part of the first trumpet.

Natural tones are produced by the ambouchure and the tones between them by fingers, i.e., by pressing the keys which control the valves. The trumpeters of American dance-bands produce many chromatic variations and glissando by the ambouchure. These virtuosi very frequently go beyond the eighth tone. In writing "improvised" solos (which in most cases are actually written out and studied) it is best to test the individual performer's range first.

Figure XXXVII.

The Range of the Trumpet

With the combined use of all three valves, the lowest tone of the trumpet is: f♯ (in C), e (in B♭), e♭ (in A). Tones below the second natural tone are generally weak. The natural intensity grows with the increase of frequency, but skilful performers have a considerable control over the dynamic range of this instrument.

The cup-shaped mouth-piece of the trumpet, the shape of the bore (slightly deviating from a cylinder to a cone) and the length of the bore make the transmission of the tongue attacks more immediate. For this reason the double and multiple tongue attacks become one of the main assets of the trumpeter's virtuosity (as in the case of a flute).

Rapid finger-work on the keys permits to execute trills and tremolo legato at a high speed, providing both component pitch-units are executed through the same natural tone (both pitch-units may be keyed, or one of them may be natural).

All forms of attacks are well defined on a trumpet: legato, portamento, soft and hard staccato.

Scales and even arpeggio can be executed at a considerable speed.

At one time the trumpet was considered as mostly suitable for a performance of signal-like and fanfare-like music, but this viewpoint (considered even by Rimsky-Korsakov) is completely outmoded. The prestige of this instrument has been amazingly restored and heightened by jazz.

B. Cornetto (Cornet) in B♭ and A

This instrument also known under the French name of cornet à pistons (i.e., a cornet with pistons; the name implies chromatic possibilities), strictly speaking, does not belong to the trumpet family. Its bore is more conical than that of a trumpet; this makes its tone-quality more mellow.

For this reason it is considered a more lyrical instrument than the trumpet. Today, however, the skill of performers is so great that accomplished trumpeters are able to imitate the sound of a cornet on a trumpet and the sound of a trumpet on a cornet.

In most cases American cornetists use the B♭ instruments. It is also customary that a trumpeter plays both trumpet and cornet.

Cornets are still made mostly with pistons, while trumpets, mostly with cylinders.

The scale of natural tones, the range and the whole mechanism of execution is practically identical with that of a trumpet.

It is generally considered being somewhat less alert than the trumpet.

Tone-quality on both trumpet and cornet can be altered by means of a mute inserted into its bell. The use of the mute is marked "con sordino"; the cancellation of this effect, "senza sordino".

American jazz created a real mute-o-mania, resulting in a great variety of new mutes (straight mute, cup-mute, harmon-mute etc.). Another device, closely related to mutes is the "hat" (usually made out of metal, in the shape of a trench helmet or a derby). It is used for glissando "vow-vow" effects (acoustically, a modification of the open pipe into the closed pipe).

This instrument is the prima-donna of a brass band, but it found its way into symphonic, operatic and particularly dance scoring.

C. Tromba Piccola (Piccolo Trumpet) in D and E♭

This instrument is considerably smaller in size than the ordinary trumpet. The D-type is mostly used in symphonic scoring (for example, Stravinsky's "Sacre"), but relatively very seldom. The E♭- type is much more common with the brass bands.

The tone-quality of both is decidedly inferior to that of a regular trumpet.

The transposition of this instrument is analogous to clarinet piccolo, i.e., two and three semitones up respectively. Thus the eighth natural tone (c) sounds d and e♭ respectively. As this instrument requires an excessive lip-pressure it is very difficult to produce any tone above the eighth. For this reason there seems to be no practical advantage in the further use of this instrument.

D. Tromba Contralta (Alto Trumpet) in G and F

This is a very useful instrument not only for the extension of the regular trumpet's range downward, but also (and mainly so) for obtaining better quality tones within the lower register (from the third natural tone down) of a regular trumpet.

Rimsky-Korsakov made a very extensive use of this instrument in his operas.

It is a softer instrument compared to the B♭ and A - trumpet.

The lowest possible pitch on the alto trumpet is the written f♯ (three keys pressed: all valves open), which sound c♯ (on the G - trumpet) and b (on the F - trumpet) respectively, i.e., it transposes down, like the alto flute.

It is quite customary that the performer of the third trumpet part doubles on the alto trumpet.

E. Tromba Bassa (Bass Trumpet) in E♭ and B♭

Strictly speaking, this instrument is not a trumpet but a miniature tuba and, therefore, belongs to the so-called saxhorn family (the dominant brass group of the military bands). It is also known as tenor tuba or Wagnerian tuba.

In many instances the parts written for this instrument are played by the French horns.

The E♭ instrument sounds eight semitones below the written range; the B♭ instrument, one octave below the soprano B♭ trumpet.

Undoubtedly this instrument becomes obsolete.

There is also a bass trumpet in C - basso which is very seldom used. It sounds one octave below the written range.

Lesson CCLXVIII.

III. Trombone (Trombone)

The type of this instrument which is commonly used today is known as Tenor-Bass Trombone.

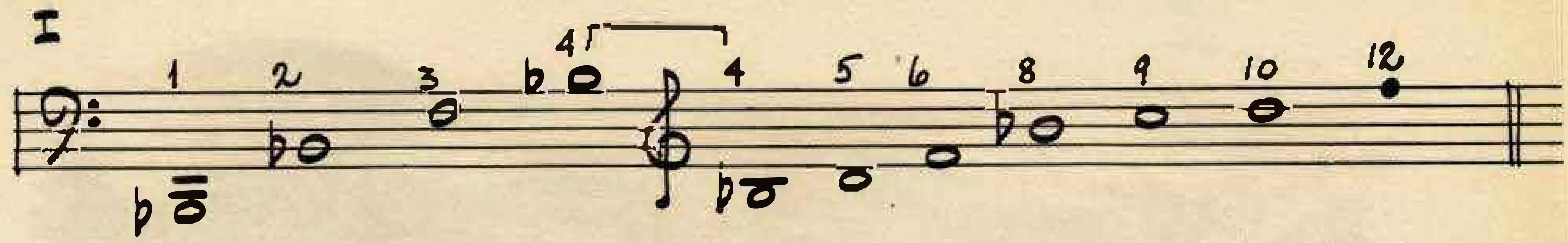
Trombone is one of the most remarkable instruments in the orchestra. Its design is based on an ingenious yet very simple principle: it has an air column, whose length can be varied by means of a slide, which is a part of the instrument proper. As a result of such construction trombone produces a complete chromatic scale consisting of natural tones only.

The pulling out of the slide increases the volume of the air-column and produces the standard seven positions. The position with the slide pulled all the way in is considered the first position. The opposite position, with the slide pulled out (to the limit, but still producing a continuous bore or air-column, as the slide can be pulled out completely, disjoining the instrument into two individual sections) is considered the seventh position. All other positions are between the two extreme positions. Thus the slide actually converts seven natural instruments into one chromatic instrument.

As different positions possess different acoustical characteristics we shall describe each position individually.

The first position has the following natural scale:

Figure XXXVIII.



The second, the third and the fourth positions have similar acoustical characteristics.

Tones produced by the fundamental are often called pedal tones.

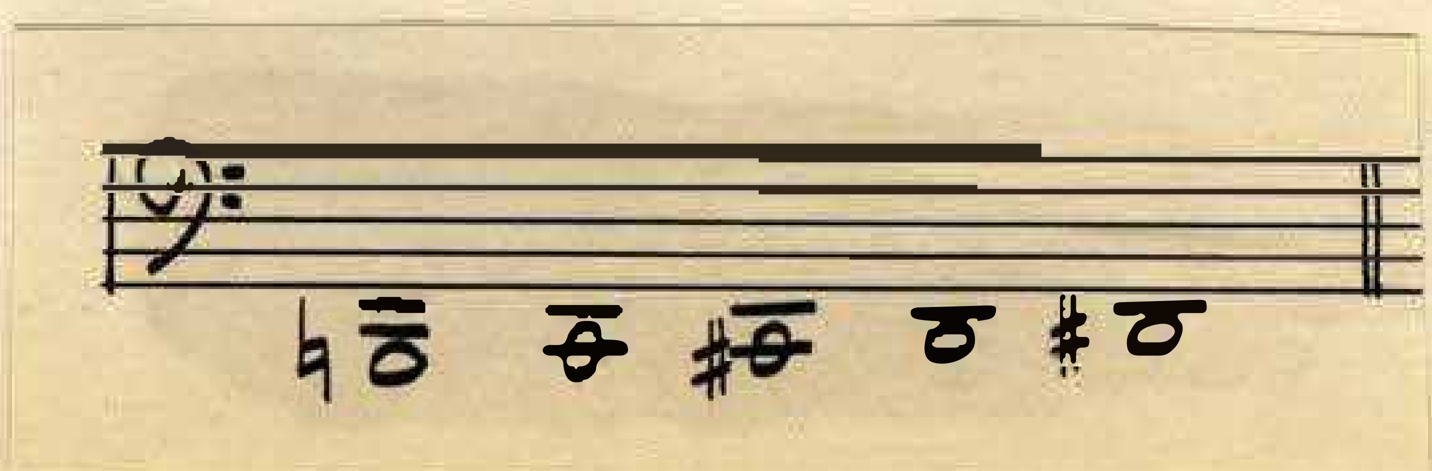
Beginning with the fifth position, the air-column breaks up into two halves, thus making the production of the fundamental impossible.

The fifth, the sixth and the seventh positions have the following natural scale:

(Fig. XXXVIII, cont.)

It is easy to see that after the natural tones of all seven positions are combined, there appears to be a gap between the second natural tone of the seventh position and the fundamental of the first position:

Thus, the following pitches are not available on the trombone of this type:



The ability to produce the natural tones above the tenth depends upon the skill of the performer. It is advisable, in writing orchestral parts, not to exceed the eighth tone, reserving the use of the ninth and the tenth for exceptional effects.

To compensate the absent pitches within the gap, an instrument with a special valve has been designed. This valve, operated by a string attached to a ring controlling the opening of the valve, lowers any natural tone by five semitones (perfect fourth). For this reason a trombone supplied with such a device is known as a <u>tenor-bass trombone with a fourth valve.</u>

By means of this device, d♯, d♮, c♯ and c♮ can be obtained from the second natural tones of the III, IV, V and VI positions respectively.

Figure XXXIX.

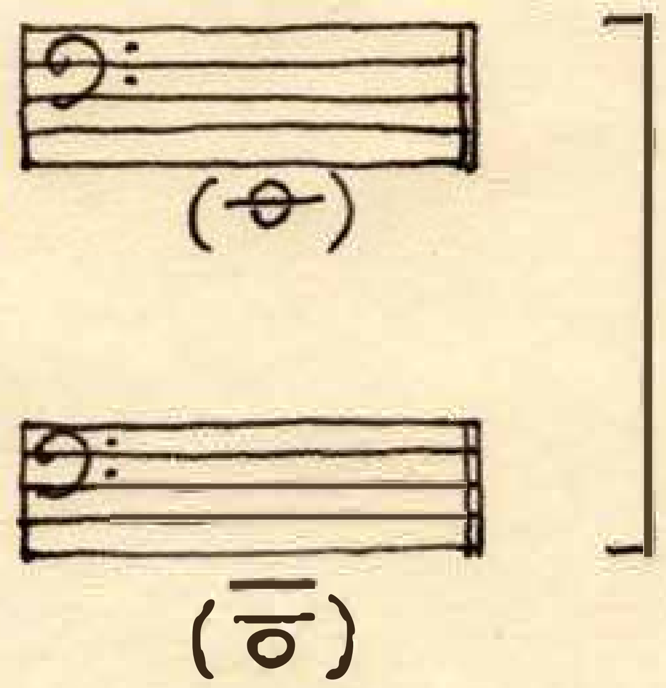
The slide positions

Pitches produced by the open valve

The lowest pitch of the gap (b♮) still remains unobtainable, due to the fact that the air-column of the

seventh position, augmented by the valve, becomes so great that it breaks itself into three thirds of the total volume, thus causing the third natural tone:

slide



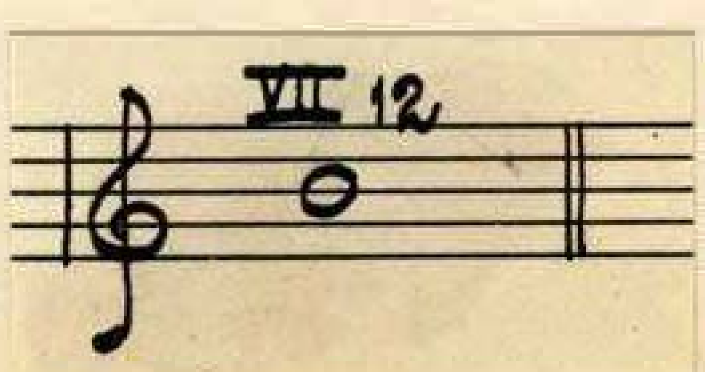
valve

impossible

It follows from this description, that not only the entire chromatic scale is available, but that some of the pitches are even duplicated: they appear as the different natural tones of the different slide-positions. The preference in such cases depends upon two conditions:

(1) the positional distance from the preceding to the following pitch; if such positions are too remote and there is a possibility of obtaining the same pitch on a different natural tone of a nearer position, it is the <u>positional</u> distance that becomes a decisive factor;

(2) the difficulty of producing higher natural tones in the lower positions as compared to lower natural tones in the higher positions; for example 

is easier than 

Trombone has a cup-shaped mouth-piece. Its tone-quality greatly depends on the manner of playing. Some trombonists have a bold, powerful tone, some have a mellow lyrical tone and some have both. The character of tone greatly depends upon the form of vibrato (tremulant). All forms of vibrato on the trombone are vibrato by pitch (obtained by oscillating the slide within a small pitch interval, as on the stringed-bow instruments), while the trumpet vibrato is vibrato by intensity and is caused by the variation of ambouchure.

Trombone is an instrument of a sliding pitch par excellence, easily comparable to the 'cello. For a long time composers misunderstood the true nature of this instrument. American jazz recaptured the real meaning of a trombone, though in many instances dance-band trombonists overdo both the vibrato and the sliding, which renders a sugary character to the whole performance.

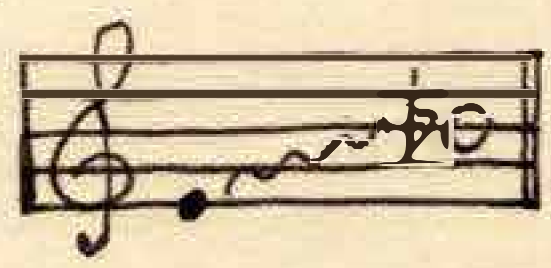
Glissando, which was received in the hearing of Stravinsky's scores as an innovation, in reality is very basic on a trombone and today became not only a common-place resource, but also a source of annoyance.

From the technical standpoint any glissando can be executed <u>only on the same natural tone,</u> while the slide is being gradually moved through its <u>continuous</u> (that is not only the positional but also interpositional) points. All other forms of glissando are made by the variation of ambouchure and

are not standardized.

A glissando can be performed either up or down. It is sufficient to indicate a glissando by showing the starting and the ending pitch of it, and connect the two by a straight or a wavy line:

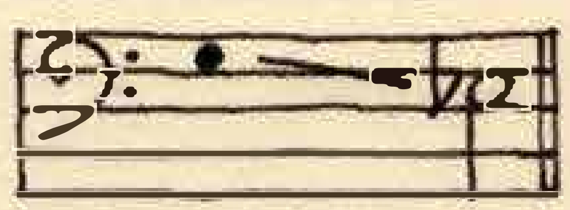
or



The term gliss. may be also added above the part, if desirable.

The passage just illustrated is executed on the eighth natural tone, while pulling-in the slide from the VII to the I position gradually.

If a passage falls on the different natural tones, it is impossible to execute it in continuous, i.e., glissando, form. For example:



The execution of this passage is impossible because $e^{\flat}$ can be only III_3, while if g is the third natural tone, its fundamental would be c, and there is no such

position on the trombone.

Mutes were very seldom used on the trombones in the symphonic music of the past. However, the development of jazz led to a very extensive and diversified (including "hats") use of mutes, in the same manner as it is being used on the trumpets.

Jazz also, besides raising the standards of performance on this instrument, created some outstanding virtuosi, among whom the greatest artist is Tommy Dorsey, particularly because of his unsurpassed tone-quality.

Some trombonists are capable of producing (as a special effect in the higher positions) simultaneously the fundamental and the third harmonic (actually sounding as a harmonic). In addition to this some jokers sing the fifth harmonic, thus obtaining a whole triad.

Trombone parts are usually written in the bass and the alto clefs, while the XIX Century composers preferred the tenor clef. Today it is practical to use treble clef for the higher register, as all trombonists can read these four clefs.

The tenor-bass valve trombone is usually employed as the third trombone in symphonic scoring, but is seldom used by the dance-bands.

All other types of trombones, such as alto trombone (in E♭, sounding a perfect fourth higher than written) or bass trombone (in F, sounding a perfect fourth lower than written) became completely obsolete.

The old three-valve trombones of various types were found unsatisfactory in their tone-quality, which was decidedly inferior to that of the natural (slide) trombone.

IV. Tuba (Tuba)

This instrument is also known as bass-tuba and belongs to the sax-horn family, which is fully represented in the large brass bands.

The tuba, which is used as the standard instrument of the symphonic and the operatic scoring, seldom appears in the dance bands. Dance bands use mostly the E♭ susaphone bass (a three-valved instrument, commonly used in infantry).

Tuba, acoustically, is an instrument in F, but does not require transposition. Its parts sound exactly as written.

Due to traditional use of a quartet consisting of three trombones and a tuba (usually the part of a tuba is written on the same staff with the third trombone), composers developed a habit of associating tuba with trombones. However, tuba comes closer to French horn than to trombone. Its pipe is conical, as that of a French horn, while the trombone's pipe is cylindrical until it reaches its bell.

The mouth-piece of the tuba is closer in shape to that of the trombone, not of the French horn.

The scale of the natural tones of the tuba is as follows:

Figure XL.

It is advisable to use the first six natural tones, resorting to the eighth tone only in exceptional cases. The tone-quality of the French horn in the high register of the tuba is preferable and it bears a close resemblance to the latter.

Tones below the fundamental are difficult to execute as there is a constant danger of overblowing the fundamental. It is best not to write below d which lies three semitones below the fundamental.

As there is an interval of a whole octave between the fundamental and the second tone, the design of tuba requires four valves. These four valves are evolved according to the standard three-valve principle, the fourth valve being capable of lowering a natural tone by 5 semitones. In addition to this, tubas used in symphonic and operatic orchestras have a fifth valve. The purpose of this valve is to give an acoustically more satisfactory semitone-valve for the lower register, as the second valve is not sufficiently large.

Tuba of the type being described here has a valve operation on cylinders. Pistons are to be found in an instrument serving similar purposes in the infantry bands, the ophicleid, which is carried over the shoulder while being played.

Thus the valve arrangement on the five-valve tuba is as follows:

I	lowers	the	natural	tone	by	2	semitones
II	"	"	"	"	"	1	"
III	"	"	"	"	"	3	"
IV	"	"	"	"	"	5	"
V	"	"	"	"	"	1	large semitone

Combined application of these valves produces any desirable interval between the first and the second tones.

Tuba is a slow-speaking instrument. Good intonation is one of the main difficulties of this instrument. The main asset of tuba is its rich tone quality. All forms of attack are available, but tuba is particularly suited for long sustained tones and slow passages in general. No mutes and no special effects are used on the tuba.

The Russian composer Shostakovich used, in his First Symphony, two tubas, instead of the customary one. As intonation on the tuba is usually less precise than on the other brass instruments, this score, at least when being performed in Russia, created considerable difficulties during rehearsal: one tuba is bad enough but two become unbearable.

Lesson CCLXIX.

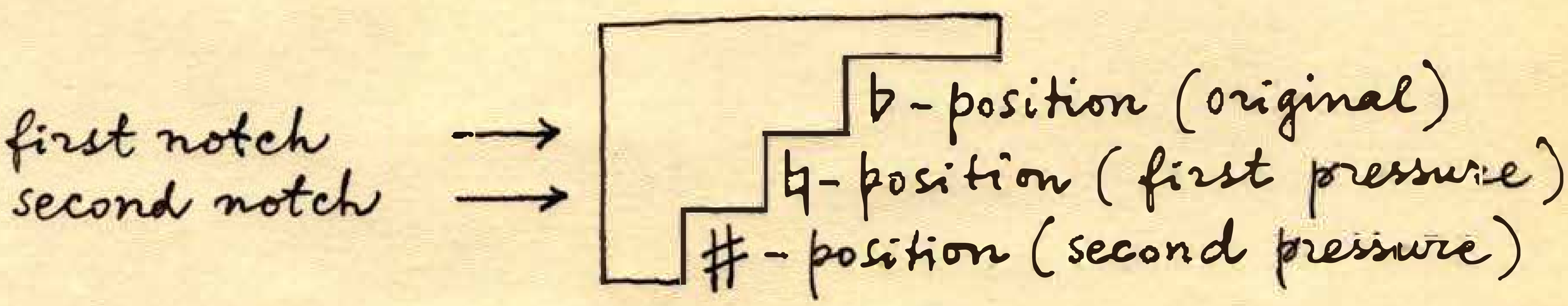
Arpa (Harp)

The origin of harp leads back to antiquity. In the bas-reliefs of ancient Egypt, dated as far back as 2700 B.C., court orchestras consisting mostly of flutes and harps are represented. In the last two or three centuries harp underwent many modifications. Some manufacturers built chromatic harps and some, diatonic. The contemporary harps are diatonic instruments with a triple tuning.

The contemporary harp is originally tuned in a natural major scale in $c^{\flat}$. There are seven strings to each octave. All octaves are identical. The main feature of the contemporary harp is a set of seven pedals, which control the tension of strings. The mechanism of pedals is devised in such a manner as to allow the modification of the same name-string throughout all octaves. Thus, by the first step pressure-position of the $c^{\flat}$- pedal, the pitch of all the $c^{\flat}$ -strings becomes $c^{\natural}$. By the second pressure-position of the $c^{\flat}$- pedal, the pitch of all the $c^{\flat}$- strings becomes $c^{\sharp}$. Similar mechanism affects the remaining six name-strings. The step-pressures are independent for each pedal. While one pedal is put into its first pressure-position, another pedal may be put into its second pressure-position. This is possible because all pedals have an independent operation. Pressure-positions are retained by the instrument until they are changed by the performer. This is possible because each

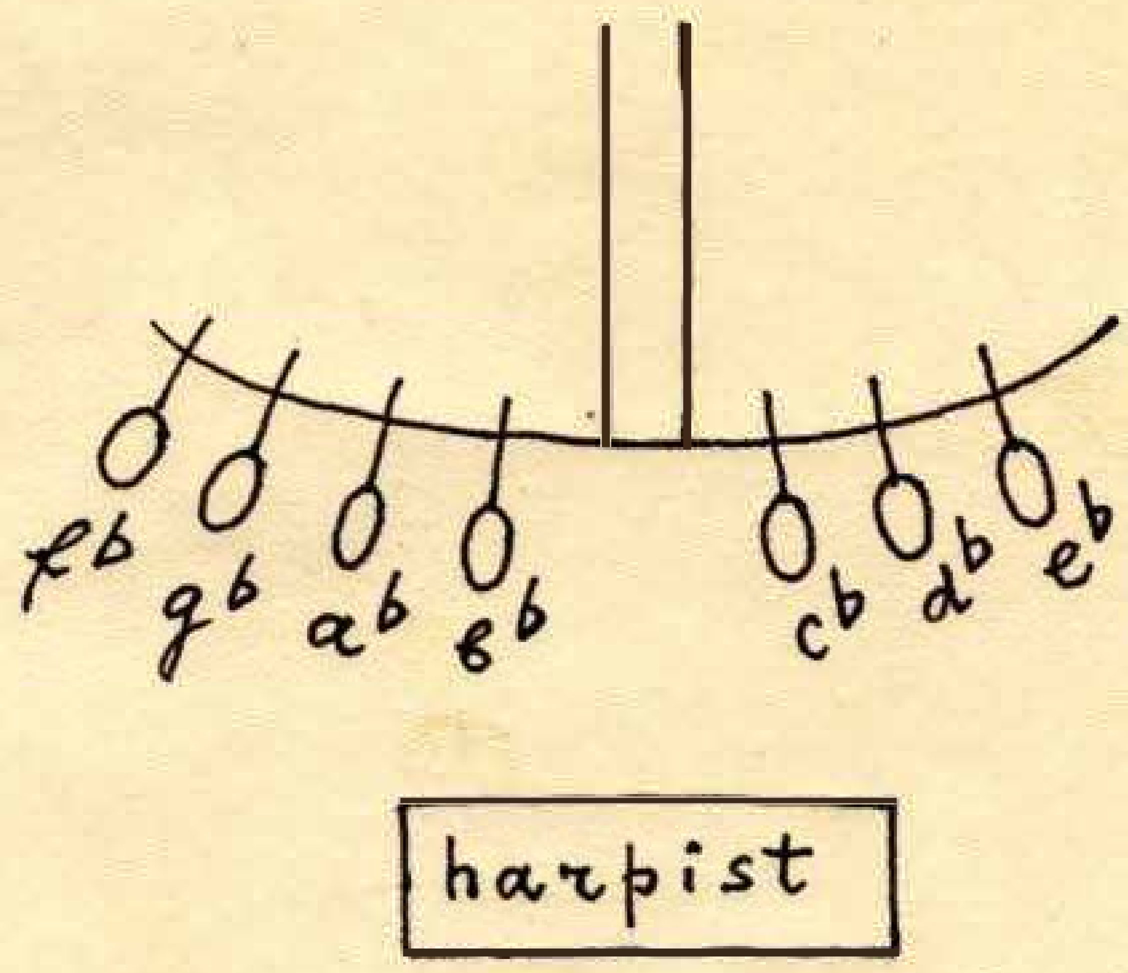
pedal has a locking arrangement in the form of two inverted steps:

Figure XLI.



Looking upon the harp from above the pedals appear in the following arrangement:

Figure XLII.



Accomplished harpists manipulate the pedals with great dexterity and can rearrange up to four pedals per second.

Harpists, the same as pianists, find the different

strings by tactile distance-discrimination. However, in some cases, strings of red color are used for all the c^{b}'s and of blue color, for all the g^{b}'s. This helps to find the remaining strings.

Harp is played by either plucking a string, or a group of strings, by the individual fingers:

(1) in sequence (arpeggiato), which is the normal form of execution of chords on a harp;

(2) simultaneously (non-arpeggiato), which should be indicated by this term.

In addition to this, harp is often played glissando, which is always a chord-glissando and is executed by sliding of one of the fingers over the strings. As glissando affects <u>all</u> strings within its range, the problem of tuning glissando-chords becomes of major importance. Glissando can also be executed in octaves and other simultaneous intervals.

As a special effect, octave-harmonics can be used on a harp. This is executed by touching the string at its nodal point (geometrical center) by the palm and plucking by the finger of the same hand. If the interval is relatively small, each hand can produce harmonics in simultaneous intervals.

Dynamically, harp is a delicate instrument. It gains in volume considerably through the use of glissando. This effect can be executed in various degrees of the dynamic range (from pp to ff), depending on the pressure exerted over

the strings and the speed of sliding over the strings: increase in speed and pressure results in the increase of volume.

It is important for the composer to understand that when the pressure-positions are alike for all the strings, only natural major scales in the following three keys result therefrom: C♭, C♮, C♯.

Original position: c♭ - d♭ - e♭ - f♭ - g♭ - a♭ - b♭
First pressure-position: c♮ - d♮ - e♮ - f♮ - g♮ - a♮ - b♮
Second " " : c♯ - d♯ - e♯ - f♯ - g♯ - a♯ - b♯

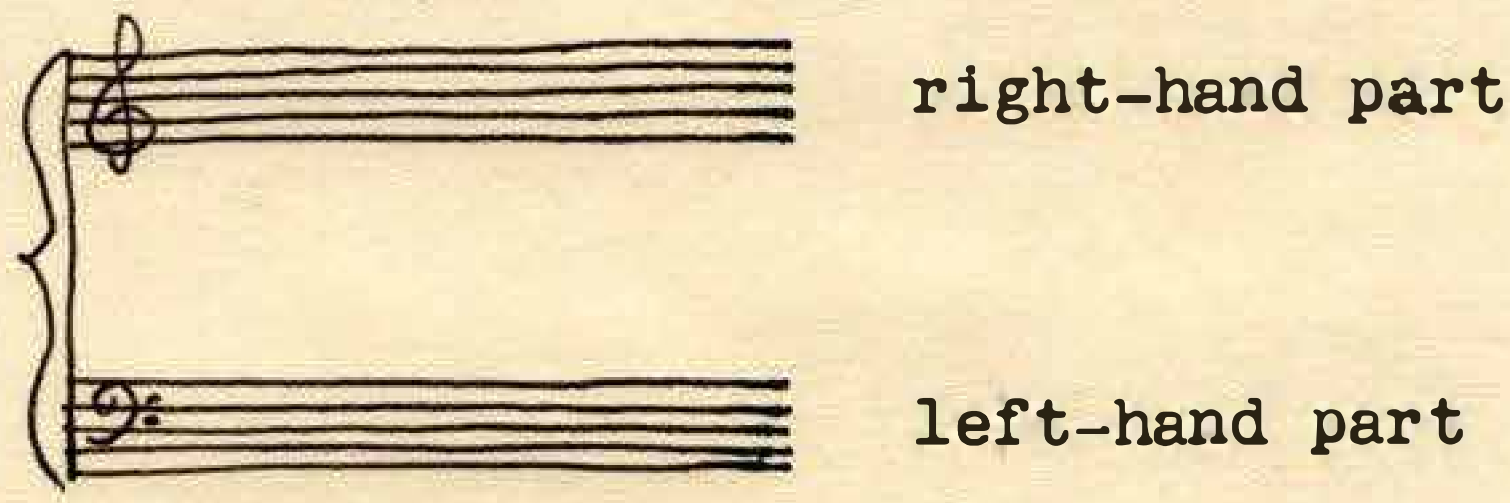
All other scale-arrangements require re-arrangement of the pressure positions.

It would be of great advantage to the composer to know that all the 36 forms of Σ (13), tabulated in the Special Theory of Harmony, are at his disposal. And any tonal expansions which derive from the above master-structures do not require any rearrangement of the pressure positions. This is possible because none of the above Σ (13) contain intervals greater than 3 semitones, which satisfies the pedal mechanism of the harp, when tuned in E_0.

As harp is a strictly diatonic instrument, it is desirable to use it as such. Quick modulations, containing several alterations, are quite impossible on this instrument. Many large scores contain two harp parts (used alternately for this purpose), in order to accomplish groups of modulating chords.

The parts of harp, like that of the piano, are written on two staves joined by a figured bracket. The clefs in use are the common bass (F) and treble (G):

Figure XLIII.



Instrumental forms suitable for the harp are quite similar to piano forms. Octaves, in each hand can be executed only at a moderate speed. Chords with wide intervals for both hands are more difficult than on the piano. Close positions are preferable to the open ones, though bass can be detached from the upper structures. Many effective passages can be accomplished by the alternation of both hands. Here the composer's inventiveness may bring many fruitful developments.

From the viewpoint of a thematic texture, harp can be looked upon as an instrument similar to piano, i.e., it can perform melody (in its various instrumental forms), harmony, accompanied melody, correlated melodies and accompanied counterpoint.

In orchestra it is frequently used as a coloristic instrument, which is due particularly to its capacity to execute effective and diversified forms of glissandi (upward,

downward, combined, rotary, etc.)

There is a wide selection of structures which can be executed glissando (such structures often contain repeated pitches, caused by the adjacent strings enharmonically tuned; but the speed of the slowest practical glissando is sufficiently great not to make these repeated pitches apparent to the ear). There is an easy way to determine whether a certain structure permits the performance of a glissando: if the structure does not contain major thirds, built on the degrees of a natural major scale in B♭, then glissando is possible. In other words, the structure in question shall not contain the following simultaneous intervals:

Figure XLIV.

Thus the following chords are possible in glissando:

because they do not contain the major thirds referred to in Fig. XLIV.

On the other hand the following chords are impossible for the reason that they contain such major thirds, as classified in Fig. XLIV:

The principle of major thirds of the B♭- scale saves the composer the trouble of empirical verification.

For example, let us see why d - f♯ - a - c is impossible in glissando:

d♭ -- d♮

e♭ -- is impossible to stretch to f♯.

In other words, e♭- string would be in the way, even if other strings could be tuned to the given chord.

On the other hand a chord like c - d - f - a♭ is possible:

c♭ -- c♮

d♭ -- d♮

e♭ -- e♯ (f♮)

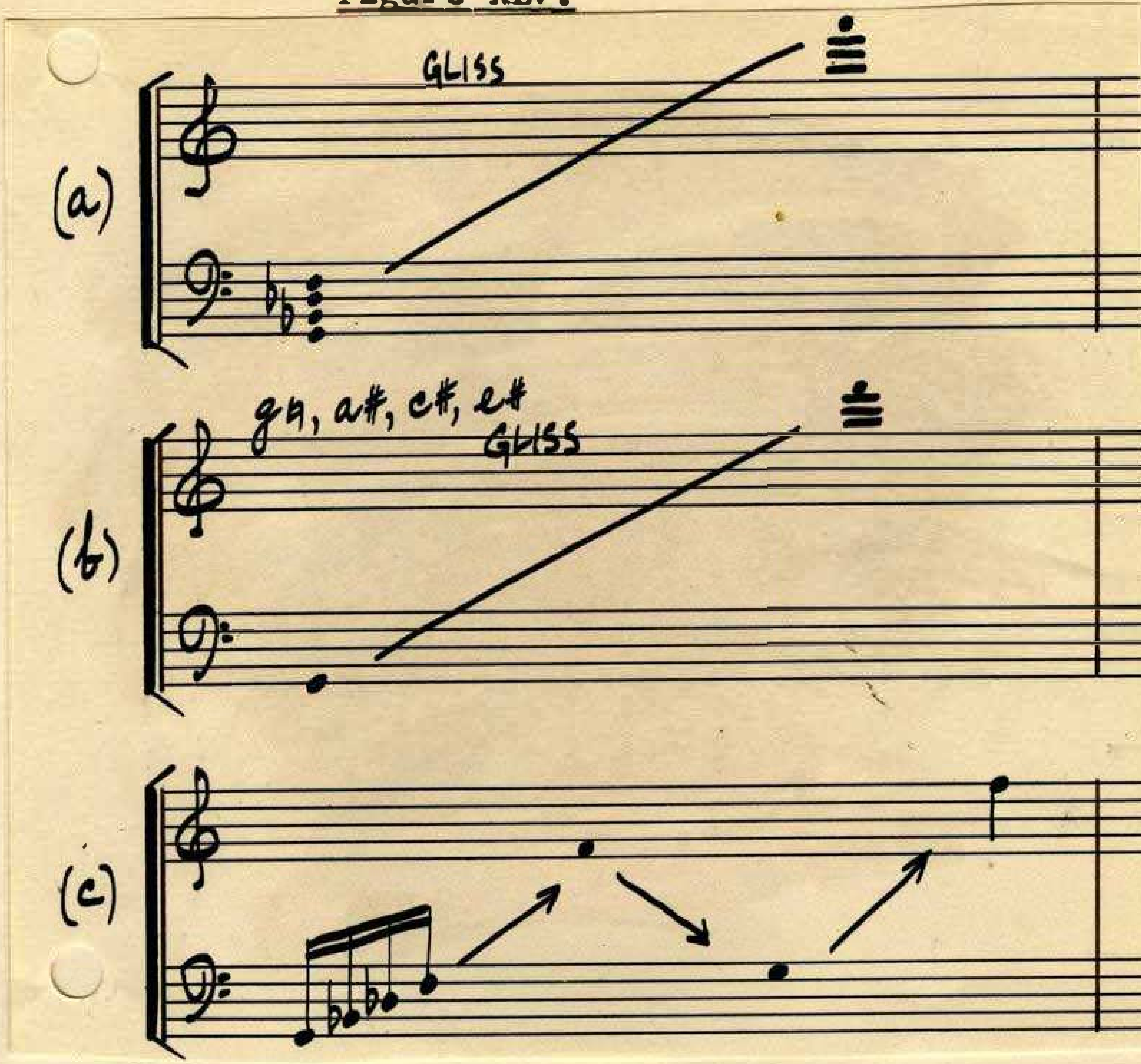
f♭ -- f♮

g♭ -- g♯ (a♭)

b♭ -- b♯ (c♮)

There are several different forms in use, by which a glissando can be indicated. Here are the most typical ones:

Figure XLV.



The tuning of pedals in general, particularly when parts are harmonically simple, does not require any indication. Cautious composers, however, often indicate the pedal changes. For example:

Figure XLVI.

In the fourth measure $b^{\natural}$ and $e^{\natural}$ do not require any change in tuning as $b^{\natural} = c^{\flat}$ and $e^{\natural} = f^{\flat}$.

Octave harmonics, which are the only ones used on this instrument, are indicated by zeros above the notes, which notes should sound as harmonics in the same octave as written.

Figure XLVII.

The forms of attacks on the harp correspond to that of a piano, i.e., legato, portamento, staccato, but the difference is less distinct than on the piano.

The basic timbre of harp resembles clarinet, which is due to the method of playing (i.e., finger-plucking, instead of a hammer-attack, as on the piano; piano strings when played by fingers, without the medium of keys and hammers also sound like the harp). Harp blends well with flutes and clarinets. The composer must not forget that harp is a self-sufficient solo instrument of a diatonic type.

In the orchestra, of course, it is mostly used as an accompanying and coloristic instrument. It is also extremely effective as a semipercussive rhythmic instrument.

Sometimes harp, doubling wood-wind instruments, produces a more transparent equivalent of the pizzicato of stringed instruments.

Carlos Salzedo, who is probably the most accomplished and the most versatile harpist of all times, has invented a number of new effects for this instrument. He and some of his accomplished students (he teaches at the Curtis Institute in Philadelphia) are capable of executing these effects.

Organ (Pipe-Organ or its electronic substitutes)

Pipe-organ is a more self-sufficient instrument than any other instrument known. This is due to the quantity of tones which can be simultaneously produced and their timbral variety.

The number of different tone-qualities depends on the number of stops which can be used individually or in combinations. More expensive organs usually have more stops, but price also determines the quality. Organs range from two-manual to five-manual models, in addition to which every organ has a pedal keyboard, generally meant for production of lower pitches.

The dynamic range of a pipe-organ is fully comparable with that of a full symphony orchestra.

This instrument underwent many evolutionary stages. The latest and most spectacular type of pipe-organ is the large theatrical organ. This type of instrument is

furnished with a very diversified selection of stops (including many percussive effects, like xylophone, chimes, etc.) not excluding all the essential stops of an ecclesiastic organ.

There are a number of pipe-organs in the world which can be justly considered masterpieces of acoustical engineering.

As organs widely vary in design, number of manuals, selection of stops etc. it is impossible to give a detailed description of a pipe-organ. Basically, however, all pipe-organs possess certain general characteristics which are in common. Some of these generalities are essential for the composer to know.

(1) The amount of pressure exerted by the performer upon the keys has no effect upon the intensity or character of sound.

(2) Forms of attack are effective: legato, non-legato, staccato are well pronounced.

(3) Physically, the tone is generated by a pipe or a group of pipes, which are often built-in at a considerable distance from the console; this produces an effect of delayed action: a very important detail to bear in mind, while using organ in combination with other instruments.

(4) Tone-qualities are classified into groups, representing timbral families: the strings, the flutes, the reeds, the chalumeaux etc. Each family has a number of distinctly different stops (e.g., tone-qualities).

(5) Each stop has a set of pipes covering a definite range; organists look upon ranges and registers as represented by the length of respective pipes. Thus they say: a 4' string stop, or an 8' reed stop, or a 32' pedal stop. The longer the pipe, the lower the pitch. Certain timbres are available only in certain registers, while others cover the entire (or nearly the entire) range.

(6) The massive tone-qualities characteristic of the pipe-organ are due to single, double, triple etc. octave-couplings. These couplings are executed by pushing the coupler-keys. Under these conditions, an organist can produce a powerful and massive tone by using only one finger.

(7) Volume (the intensity of sound) is controlled by a special pedal. Thus gradual dynamic changes are possible. A sforzando-piano (sfp) effect is also available on the organ.

(8) Composition of stops for the performance of a given piece of music is known as registration. The latter is seldom done by the composer (unless he is an organist). Even when the composer or the editor of organ parts indicates the registration, it is quite traditional for the performer to change the indicated registration to one of his own choice.

(9) It is customary to mix the stops belonging to different timbral families as well as couple them through several octaves.

(10) In addition to this, there are so-called organ-"mixtures", which are pre-set combinations of various couplings. When such mixtures are used, one key pressed by a finger produces a whole chord structure of one or another type. Thus melodies may be played directly in parallel chords. In some of the organs built in Germany, in the second decade of this century, mixtures producing some less conventional chords were introduced (in one instance, the mixture added to c produced c - d♯- f♯- b).

It is important for the composer to realize that as a consequence of couplings and mixtures, accompanying each individual note, what reaches the ear of the listener (including the organist himself) is quite different from what is written on paper. Not only the respective octaves and registers (in the general sense of this word) can be different than in writing, but they also can be accompanied by whole sets of new pitches, which even do not appear in the parts.

Often symphonic, operatic, oratorio and cantata scores contain an organ part.

The above-described characteristics of this instrument make it very difficult for the composer to use organ in an orchestra, or a mixed vocal-instrumental combination, properly, as often the principle of clarity as a necessary quality of instrumental and vocal scoring conflicts with the natural tendencies of this instrument. For this reason organ, in most scores, is either mis-used or plays a purely decorative

part.

In the old scoring organ was used, according to ecclesiastic tradition, as a duplication of the choir, and its part was often written merely as a figured bass, which the organist had to fill-in. This can be found in the scores of the leading composers of XIX Century.

Another important characteristic of the organ is its tone-quality with respect to vibrato. Organ can play non-vibrato or a vibrato by intensity (some instruments, particularly in the string-stops have also a mechanical vibrato of beats, produced by simultaneous pitches which are set at slightly different frequencies). For this reason, organ vibrati are mostly of a different type from orchestral vibrati. Simultaneous use of both often creates conflicts and discrepancies.

For more details see "Acoustical Basis of Orchestration".

Organ parts are mostly written on three staves: one for pedal, one for the main, lower, manual (known as great) and one for the upper manual (known as swell).

Figure XLVIII.

Lesson CCLXX.

ELECTRONIC INSTRUMENTS

This group of instruments is much more diversified than all other groups combined.

The term "electronic musical instrument" can define any instrument where electric current generates sound directly or indirectly.

There are two basic subgroups of electronic instruments.

The first subgroup constitutes instruments where sound (i.e., sonic frequencies) is generated by varying the capacity of an electromagnetic field, created by two currents. Instruments invented and constructed by Leon Theremin are based on this principle. They include three basic models:

(1) Space-controlled Theremin (also known as Victor-Theremin, later: R.C.A. Theremin).

(2) Fingerboard-Theremin.

(3) Keyboard-Theremin.

Of these three types, the first acquired far greater popularity than the other two models. Recitals are being given by various performers on this instrument. I was the first composer to use this instrument in a solo (concertizing) part with a symphony orchestra. The composition was named: "The First Airphonic Suite" and was performed by Leon Theremin as soloist with the Cleveland Orchestra, in Cleveland and New York in 1929, with outstanding success. In

1930 a realization of my early dreams came through. I scored, rehearsed and produced together with Leon Theremin and 13 other performers, two programs presented at Carnegie Hall in New York, in which an ensemble of 14 space-controlled theremins was presented for the first time.

Space-Controlled Theremin

Each musical instrument displays some characteristics for which it is known. The chief characteristics of the space-controlled theremin is its extreme adaptability not only to pitch and volume variation, but also to the form of vibrato. In this respect it is so sensitive that the pleasantness or beauty of tone largely depends on the performer. In order to obtain a "beautiful tone" on this instrument the performer must know what physical characteristics make a tone "beautiful". These can be briefly described as a combination of the vibrato frequency with the depth of vibrato, i.e., the pitch variation between vibrato points. As this text is meant for the composer or orchestrator, there is no need to elaborate on this matter further. In 1929 I wrote "A Manual for Playing Space-Controlled Theremin", where these matters are discussed in detail. See also "The Acoustical Basis of Orchestration" described in this theory.

Pitch on the theremin is controlled by the right hand, which is moved toward and away from a vertical rod (antenna). The spatial dimensions of pitch intervals vary with respect to total space range, which is adjustable either

individually or for each performance. In other words, pitch is varied within the spatial boundaries of the electromagnetic field. Depending on the stature of the performer and the length of his arms, spatial range may be practically adjusted (tuned by a knob control) somewhere between one and three feet.

The electromagnetic field can be imagined as a three-dimensional invisible fingerboard. It is so sensitive that a slight move on the part of the performer affects the pitch. Spatially, intervals contract with the increase in frequencies, i.e., moving the hand toward the right antenna (which is a physical generality; it works the same way on the regular fingerboards, air columns etc.). Not having a fixed-length fingerboard, the thereminist faces, as it proved itself to be the case in many individual instances, a greater difficulty in pitch control than any string-bow performer. Yet some performers, who were not even professionals on any instrument, could master the pitch-control problem in about two weeks. Their reaction was that you control pitch mostly by "feeling of distances", that you play as if you were singing.

I am not offering any description of the basic timbre of this instrument, as each model had a timbre of its own. Vaguely they all resemble somewhat a combination of a stringed-bow instrument (when bowed), at its best, if not better, and of an excellent human voice singing everything on the consonant "m", which of course has its own basic

acoustical characteristics.

The left antenna of this instrument serves the purpose of controlling the volume. The left hand moves vertically toward (decrease of volume) or away from (increase of volume) the loop-shaped left antenna. The intensity range can be also spatially adjusted by turning a knob, just as in pitch-control. This permits any degree of subtlety in varying the volume, similar to the right antenna with respect to pitch.

Playing this instrument is a task in human coordination of both hands and arms, moving through two space-coordinates. It would be just to say that this instrument is much more delicate and sensitive than any human being who has played it until now.

People with good coordination and sufficient sense of relative pitch turned out to be better performers than the eminent musicians. Leon Theremin and his assistant, George Goldberg (also an engineer), proved this to be so.

The composer can have at his disposal the entire audible range, if necessary, and any volume, as sound is amplified electrically.

All forms of attacks are available.

Space-controlled theremin is a monodic (i.e., producing a single tone at a time) instrument par excellence and, therefore, particularly suitable for broad sustained cantilenas, pedal points, etc. Rapid passages of any kind

can be executed by an accomplished performer at speed comparable to that of an oboe.

One of the first models of this instrument had a knob contact for producing attacks. By pushing the knob by a finger of the left hand abruptly, one could produce the most abrupt forms of staccato, following at any desirable speed.

The Philadelphia Orchestra, through the initiative of Leopold Stokowski, its music director, used a specially built model of theremin. This instrument served the purpose of coupling and reinforcing orchestral basses of various groups. It had a pure (that is, sinusoidal) tone and an immense volume amplification.

It is best not to compare the theremin with any other standard orchestra instruments, but to look upon it as the first instrument of the coming electronic era of music, having its own characteristics and being conceived and designed along entirely new principles of sound-production and sound-control.

It is the first child of the electronic musical dynasty. Its first model dates back to 1921, when Leon Theremin demonstrated it in Moscow before a conference of electrical engineers and inventors. At that time it was in its early experimental stage.

In the U.S.A. it was manufactured by R.C.A. Manufacturing Co., Camden, New Jersey.

Fingerboard Theremin

This instrument was designed and constructed with the purpose of supplying violinists and 'cellists with an electronic instrument, which they could learn to play in a very short time. Some violinists and 'cellists played it with great success.

This instrument's main part is a cylindrical rod, about as long as 'cello's fingerboard. While being played, it is held in a position similar to 'cello. The part which is touched by the fingers of the left hand (to which procedure all the string-bow performers are accustomed) is covered by celluloid. Production of tone results from the contact of a finger with the celluloid plate. Thus pitch-control is very similar to that of a 'cello. Volume is controlled by a special lever, resilient and operated by the right hand. The higher the pressure upon the lever, the louder the tone. This form of dynamic control allows not only gradual variations of intensity but also accents and sforzando-piano. All forms of attacks are available by direct contact with the fingerboard.

Though the manner of playing this instrument more resembles 'cello than violin, violinists found it as easy to play.

The range of this instrument is adjustable, i.e., the same model can be tuned in high or low or both registers. The tone-quality of the fingerboard theremin resembles an <u>idealized</u> 'cello tone (i.e., one which is deprived of inharmonic sounds, which usually result from the friction of

horse hair over sheep's guts, while bowing) and is more of a constant than on the space-controlled model. The usual type of 'cello vibrato gives perfectly satisfactory result. The basic timbre is quite close to the double-reeds (nasal).

Of course timbre and other characteristics of this instrument could be easily modified. Some engineers in Europe, after Theremin, constructed similar instruments whose outer design resembled violin, 'cello and bass. Of course Leon Theremin thought it very funny, because the dimensions and the shape of an electronic fingerboard instrument have nothing to do with its range or registers.

The fingerboard theremin is a monodic instrument.

One of the advantages of having such instruments in the orchestra is tone-quality, which can be suggested to an engineer or a manufacturer; another, is its range which offers a great economy: a passage, starting on the 'celli and transferred to the violins, can be executed on one instrument and by the same performer.

Keyboard Theremin

Keyboard theremin is a monodic instrument, with a standard piano keyboard. It is a direct predecessor of the solovox, manufactured by the Hammond Organ Company today. Physically, though, solovox does not belong to the first sub-group, as piano strings, electromagnetically inducted, are the original sound-source. Keyboard theremin, on the other hand, physically operates on the same principle as other

theremin instruments, i.e., variation of capacity of an electromagnetic field.

This instrument was designed with the purpose of supplying the keyboard performers with an instrument which they could play without any additional training, yet to have an instrument possessing at once such features as economy of space, any pre-conceived tone-quality, well expressed forms of attack, regulated forms of tremulant, fading effects with vibrato automatically performed (like the Hawaiian guitar), automatically preset varied degrees of staccato etc.

The business end of the Theremin enterprise was not properly handled. As a result of this, there are not many space-controlled models to be found today, only a little over a decade since they were built, not speaking of the fingerboard and the keyboard theremins, of which there are very few, if any, left.

Leon Theremin built a number of other electronic instruments, among them various types of organs with micro-tuning and variable timbre-control (in the design of which I participated), but these instruments mostly served the purpose of research and have never reached the attention of the public at large.

The purpose of my directing the attention of the composer to these short-lived models is to show where lie the future stages of the field of orchestration, as there has

never been any doubt in my mind that the present standard (non-electronic) instruments will be soon outmoded and substituted by the perfected electronic models.

In this regard the composer will be confronted with new approaches and techniques of orchestration. He will have to think acoustically and not in terms of violins, clarinets, trumpets etc. So this is just a note of warning.

The second subgroup of electronic instruments uses conventional sources of sound (strings, bars, oscillating membranes etc.), but they are excited by means of electromagnetic induction and amplified through a loudspeaker system.

While Theremin's models were entirely revolutionary and constituted a decidedly radical departure from all the existing notions of designing musical instruments, the instruments which I refer to as the second subgroup are decidedly a result of compromise, lack of vision and immediate commercial considerations. It will be just to say that the theremin instruments are more refined as an idea (and for this reason the instruments of the first subgroup, eventually, will resurrect and last longer, in their future improved forms, while the instruments of the second subgroup will be considered too crude in comparison, and will die out the way the player-piano did, when the perfected radio left no room for its existence), though not sufficiently perfect in the actual operation, while the existing models of the second sub-

group are well designed and built, are reliable in operation but are based on old-fashioned and often wrong notions as to what a musical instrument should be. The instruments of the second subgroup are manufactured and sold on a mass production-consumption basis. They are widely used today, particularly in the field of radio and dance music.

The instruments of the second subgroup can be generally named by their old original names, with the addition of the definitive "electrified". Thus we can name such models as electrified piano, electrified organ, electrified guitar, etc.

The history of these instruments leads far back to Thaddeus Cahill, who constructed, in 1897, the "Sound Staves", a clumsy instrument with oscillating membranes, effected by electric current. *

As electronic instruments of all types are in an early stage of their development, and as the present models may soon become outmoded and obsolete, I shall offer only a brief description of the models which are most in use today, and only such a description from which the composer can get information and ideas valuable per se.

Electrified Piano

This instrument consists of an ordinary piano and a system of electromagnetic inductors connected with an amplified sound system. There are different designs of this

*For more historical detail see my article "Electricity, the Liberator of Music" in the April issue of Modern Music Quarterly, published by the League of Composers in 1931 (Vol. 8).

instrument, but the resulting sounds have most characteristics in common. This instrument is usually known as electronic piano. In the U.S.A. the Miessner piano is more known; in Germany, the Bechstein (famous firm, manufacturing the best pianos ever built). Some of the electronic Bechsteins are also in use in the U.S.A.

The main feature of all such instruments is the conversion of a regular piano into several different instruments. This is accomplished by a system of various preset forms of induction. The two characteristic extreme forms are: one, which prolongs the duration of a tone indefinitely and can even increase the volume of it after the respective key has been released and another, which has a preset form of quick fading, the sound of which resembles harpsichord. There are usually various intermediate effects between these two extremes. At the same time this instrument can be used as before it was electrified, which is of a great practical advantage. Any accomplished pianist or organist can master this instrument in a very short time.

Solovox (manufactured by the Hammond Organ Co.)

Solovox is a monodic instrument, devised in a form of piano-attachment. In fact, it is a monodic version of an electrified piano. The purpose of this instrument is to execute melody of a durable and, if desirable, tremulant tone directly from the piano (with the right hand playing the solovox) and have the accompaniment played by the same performer, on the same piano (with the left hand). Whether such a combination is desirable, is a different matter. But this will be discussed in "Acoustical Basis of Orchestration".

Lesson CCLXXI.

The Hammond Organ

This instrument (manufactured by the same company; designed by Lawrence Hammond) is the most universally accepted of all the larger types of electronic musical instruments. Hammond organ is a fairly complex piece of electrical engineering, without being bulky.

The name "organ" is applicable to this instrument only insofar as the production of durable simultaneous sounds is concerned. Otherwise, every organist or any experienced musician can tell without seeing the instrument, whether he hears a pipe-organ or a Hammond "organ". There is undoubtedly a general difference of all tone-qualities and particularly of the pedal, when this instrument is compared with a "real" organ. The term "organ" and the insistence of the Hammond Co. on the fact that this instrument substitutes the real church pipe-organ, without taking up as much space and sold for less money, was influenced by the sales policy. This company simply expected to sell most of these instruments to cathedrals, churches and chapels. It turned out to be somewhat of a joke, as this instrument approaches closer to theatrical organs than to church organs (particularly with a special tremulant speaker which, by the way, is not manufactured by the Hammond Co.) *

Today dance music and "swing" is universally played on this instrument and the company, obviously, does not object, so long as it sells.

*Vibratone, manufactured by Brittain Sound Equipment Co., Los Angeles

There are certain basic principles upon which this instrument is designed and built and they are important for the composer to know.

The following information is not available elsewhere, as it would be detrimental to Hammond Co. to disclose such facts.

The first problem is concerned with the fact that this instrument does not sound like a pipe-organ, in its tone-qualities. There are two reasons for this. One, that it is due to the type of speaker and the whole sound system, which do not permit the high frequencies (the real partials of a tone) to come through. I verified this fact by connecting the Hammond speaker with a turntable. Good high fidelity recordings sound completely "muffled". The second reason is that the Hammond instrument is not designed to include certain inharmonic sounds, which are the constants of many organ pipes. Whether such inharmonic sounds are desirable per se, is another matter.

The second problem, which in its causes is inseparable from the first, is concerned with the fact that this instrument does not sound like a pipe-organ, in its emission of sound. While in the case of a pipe-organ, the emission of sound is not instantaneous (particularly speaking of the old church organs), due to the necessary time interval required by transmission from the keyboard of the console to the pipes and then to the ear of the listener, in the case of Hammond organ the transmission of sound is instantaneous, due

to the speed of electric contacts. This particular characteristic adds one advantage to the Hammond organ, namely, the hard staccato of extreme abruptness. Organists complain that on the Hammond instrument "the sound appears before you touch the key".

The two problems are closely interrelated. The lack of real high partials on this instrument is due to the fact that the mechanical design of the Hammond organ does not permit the use of better speakers and of a better sound system, as the high-frequency response would make the key-contacts audible (they would click loudly). Hence, the "muffled" tone, as the better of the two evils.

The speed of sound transmission could be easily modified by a special mechanism of delayed action. The inharmonic tones could be introduced electronically (such devices were met with success in the electronic instruments of the first subgroup type built by Dr. Trautwein in Berlin, in 1928).

The necessity of bringing about such a discussion is caused by the fact that there is too close a resemblance between the Hammond and the pipe-organ and not in favor of the first. While the space-controlled theremin has a superior tone-quality, when compared with any violin or 'cello, the Hammond organ is an inferior organ, as compared to a good quality pipe-organ.

A valuable factor in applying electromagnetic

induction to oscillating membranes or revolving discs (as it is in the case of the instrument under discussion) is the stability of frequencies. So long as the electric current is relatively stable, i.e., of a constant voltage, the instrument, no matter how long in continuous use, remains in tune. This is not true of the instruments of the first sub-group, where warming up of the tubes eventually affects the pitch.

The Hammond organ, being evaluated per se and not in comparison with other musical instruments, must be considered a valuable self-sufficient or auxiliary instrument. The chief asset of this instrument is an acoustical system of quality variation.

Hammond organ produces pitches of a twelve-unit equal temperament in simple (sinusoidal) waves. These simple components can be mixed at random at different intensities, which results in different tone qualities. The simple components are called by the names of the nearest tones of the natural scale. Each component is controlled individually and has eight graduated degrees of intensity. The actual control is executed by pulling out the respective levers. There are nine levers corresponding to the nine components of each tone-quality.

Figure XLIX.

The numbers in the circles indicate the enumeration of levers, as they appear from left to right.

(1) corresponds to the subfundamental, i.e., one octave below the fundamental;

(2) the subthird harmonic, i.e., one octave below the third harmonic;

(3) the fundamental;

(4) the second harmonic;

(5) the third harmonic;

(6) the fourth harmonic;

(7) the fifth harmonic;

(8) the sixth harmonic;

(9) the eighth harmonic.

We shall consider such a set to be an acoustical system of components for production of one tone-quality at a time. All present models have two such systems for each of the two manuals. A special two-lever (two-component) system (the fundamental and the subthird) controls the pedal.

Once the levers of one system are pulled out into a certain prearranged position, such a position mechanically corresponds to a certain push-button. That is, the prearranged combination, producing a certain tone-quality, can be obtained instantaneously, by pushing the corresponding button. On the model E of Hammond organ the two systems correspond to push-buttons 11 and 12. The enumeration of push-buttons is the same for both manuals.

All other push-buttons, enumerated from 1 to 10 control pre-set combinations. The pre-set combinations are the most common stops of a church pipe-organ. However, these too can be rearranged, by changing some of the wire connections within the console.

The total number of tone-qualities for each manual individually (which would also absorb any of the pre-set combinations) equals the sum of all combinations by 2, by 3, ... by 9 out of nine elements (corresponding to nine levers). Each combination can be modified according to the different positions of intensity for each lever (of which there are eight). Thus if it is originally one-lever setting, each of such settings has to be multiplied by 8. There are thus $9 \cdot 8 = 72$ one-lever settings. For a combination of two levers, the value 8 must be squared; for a combination of three levers, the value 8 must be cubed etc.

There is no need in making a complete computation of all tone-qualities thus obtainable, as it would take several centuries to play them through. However, from a musical standpoint (i.e., from the standpoint of imperfect auditory tone-quality discrimination) there are not so many really distinctly different combinations, as many modifications of the same combination sound quite similar to the ear.

Though components of tone-qualities on the Hammond organ are not real harmonics, but the tones which approximate them in the twelve-unit equal temperament, the very principle

of composing tone-qualities from elements and not from complexes (like the timbres of standard instruments) has a great educational value for any student of music in general and for the orchestrator in particular.

Hammond organ is supplied with some controls adopted from the pipe-organs. Among these are the various couplers, the dynamic control swell-pedal, the tremulant-control, the "chorus" etc. The range of model E is from c of contra-octave to f# of the fourth octave (it has the frequency of approximately 6000 cycles and corresponds to lever (9) for f# of the first octave on the keyboard, which pitch is half-an-octave higher than the highest piano c).

Besides being a very diversified self-sufficient instrument, Hammond organ is frequently used in small instrumental combinations to supply the missing timbres.

The composer will make the best use of this instrument by acquiring the viewpoint upon Hammond organ as an instrument whose specialty is production of controllable and highly diversified tone-qualities, combined with sufficiently versatile forms of attacks and an enormous dynamic range, without sacrifice of dynamic versatility.

The Hammond organ keyboard has a very light action, which permits the production of rapidly repeating tones.

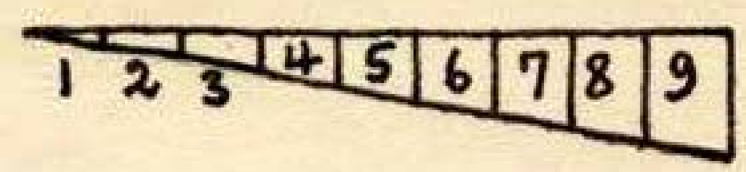
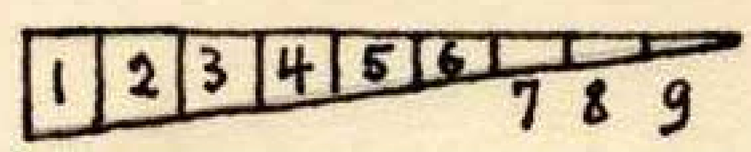
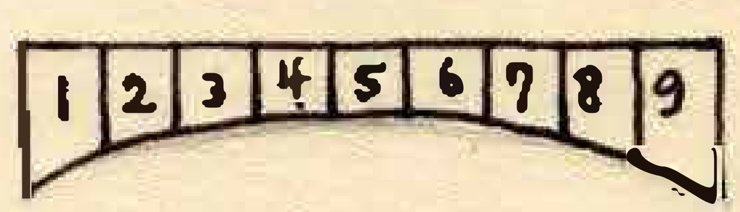
In order to help out the orchestrator with a method by which he could find the basic timbral families out of the enormous number of possible combinations, I have devised

a simple system by which such families can be instantaneously arranged and easily memorized. This system is based on the patterns of intensity of the different components in relation to their lever-scale position (which approximately corresponds to the frequency position).

The Scale of Basic Timbral Families

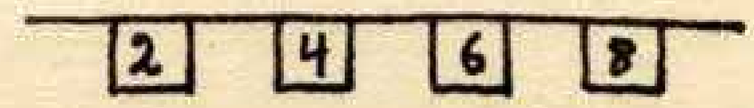
on the Hammond Organ

Figure L.

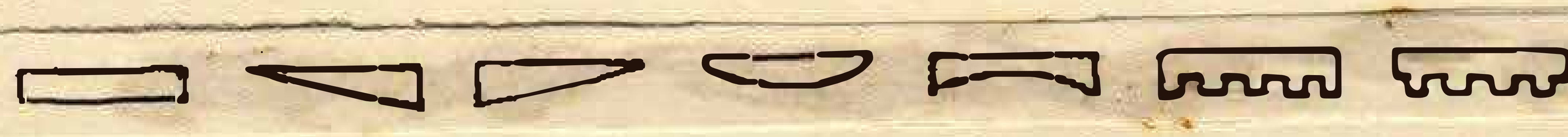
Families:	Patterns:
1. Uniform intensity of all participating components	
2. Scalewise increase of intensity of all participating components	
3. Scalewise decrease of intensity of all participating components	
4. Convex arrangement of intensities of all participating components	
5. Concave arrangement of intensities of all participating components	

6. Selective pattern of partials of uniform intensity based on odd-numbered levers.

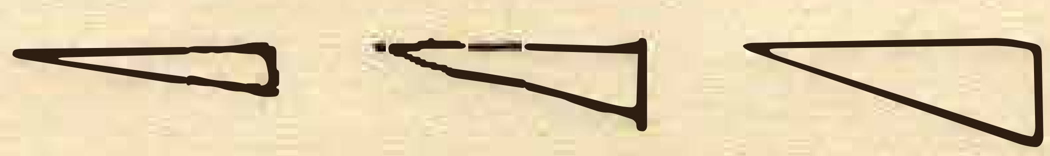
7. Selective pattern of partials of uniform intensity based on even-numbered levers.



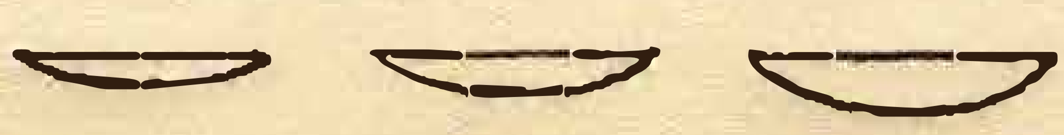
This system helps the orchestrator to associate timbral families with the corresponding scale of visual patterns:



The description of these basic qualities in verbal adjectives is highly inaccurate. For this reason I shall eliminate it altogether. The best way to get acquainted with these timbral families is by practical study of this system of timbral selection at the instrument. This practical study should be accompanied by further investigation of the dynamic variations within each timbral pattern. For instance, the second family may vary the angle representing intensities:



etc., or the fourth family may modify the form of its convexity:



etc.

This study will be of extreme practical benefit to any composer or orchestrator, and particularly in view of his study of this Theory of Orchestration.

The Novachord

The Novachord, another Hammond development, is a keyboard electronic instrument, on which simultaneous sounds can be produced. The name again is misleading, as "chorda" means "string", and of course there are no strings on this instrument. Here again probably purely commercial considerations brought about the implication that this instrument is a new version of harpsichord or clavichord. Even its body looks quite antiquated; though, of course, the design of the body has no effect upon the sound, as it is an electronic instrument.

Novachord has the range of a combined stringed-bow group. It has one keyboard of the piano type. It is supplied with numerous timbre-controls and attack-controls. This instrument can be justly considered an improved and developed version of the keyboard theremin. One of the specialties of Novachord are the attack-forms, where the period of fading can be automatically pre-set. The forms of vibrato can be also automatically controlled. Dynamic variation is controlled by pedal.

The timbres of Novachord resemble more closely (due to the selective system of attack-forms) many of the standard orchestra instruments, some of them being of such a high quality, that only the very best performers on the

original instruments can rival it.

Novachord is a very valuable instrument for substitution of the missing standard instruments in an ensemble or orchestra. As a self-sufficient instrument, which it is meant to be, it is not quite satisfactory. The reason for this is that it is a simultaneously monotimbral instrument: only one tone-quality can be produced at a time. As the result of this characteristic, melody and accompaniment sound in the same tone-quality and, in addition to this, at the same volume. Thus, when melody is played with an accompaniment, it can be singled out only by one means: by playing the accompaniment staccato.

Lesson CCLXXII.

PERCUSSIVE INSTRUMENTS

We shall adhere to the following definition of percussive instruments: all instruments, where the source of sound is a string, a membrane or a bar (often built of different materials and used by direct attack and not by electromagnetic induction), belong to the percussive group. As a consequence of this characteristic, all percussive instruments have a naturally (and automatically, unless extended by some special devices) fading sound. Therefore the period of fading is in direct proportion to the intensity of sound, i.e., to the amplitude of its attack.

As all the inharmonic (i.e., noise producing) instruments will be described as percussive instruments, though some of these really are not percussive, one distinction must be made clear: while basically sound on the percussive and inharmonic instruments is produced by attack, it is also produced by friction. For example, any drum can be played not only by a stick or a hand attack, but also by rotary motion of the palm of the hand over the skin of the drum. The same concerns the rubbing of surfaces of the two emery boards, etc.

Some of the instruments known as self-sufficient, will be described here specifically as orchestral and, therefore, coloristic instruments. Particular attention will be paid to their percussive possibilities, which are so often neglected.

Percussive sounds of the instruments, which originally are not meant to be percussive (such as stringed-bow instruments, when played pizzicato, col legno etc.), will be discussed in the Technique of Orchestration, in the chapter devoted to the Forms of Attacks.

We shall classify all percussive instruments into four groups:

Group one, where the source of sound is a string or a bar (in metal or wood);

Group two, where the source of sound is a metal disc;

Group three, " " " " " is a skin membrane;

Group four, " " " " " are various other materials.

Group One

Piano

Piano (grand and upright) is a self-sufficient instrument, most universally used in our musical civilization. The range of a piano varies from concert grand manufactured by Bluethner in Germany (whose range extends itself from g of the subcontraoctave to c of the fourth octave) to American made five-octave miniature uprights. The standard range, however, can be considered 7 1/4 of an octave, which emphasizes 88 keys (it extends itself from a of the subcontra-octave to c of the fourth octave).

Timbre of the piano, strictly speaking, cannot be uniform, as its strings are made of different materials,

differently shaped and attacked by somewhat differently designed hammers. The upper register and the middle register consist of straight steel strings used for each tone in groups of three. The middle-low and the low registers have coiled copper strings coupled in pairs. The lowest register has single copper strings for each tone.

It is to be remembered that piano is a strictly percussive instrument, as strings are excited by the stroke of a hammer. The tone of the piano fades out very quickly, as the oscillograph shows. It is our cultivated auditory imagination that extends the duration of a piano tone. Physically, a piano tone has a sharp attack and quick fading. The right pedal being pressed extends the duration of a tone, as this releases the string, permitting it to vibrate. This, however, does not exclude the fading of a tone, merely extending the time period of the fading. In musical terms this can be stated as: the diminuendo is a constant of a piano tone.

Piano gets very quickly out of tune because its system of double and triple strings for each tone makes it physically difficult to maintain perfect unisons.

We had the description of piano possibilities in the Theory of Instrumental Forms. Here we are primarily concerned with the unconventional uses of piano, as percussive and coloristic orchestra instrument.

Igor Stravinsky made an interesting use of four

pianos combined with an ensemble of percussive instruments in his "Les Noces".

The real use of piano as a percussive instrument comes mainly through the explorations of Henry Cowell, an American composer, who himself is an excellent exponent of his own techniques. Cowell has developed an exact and thoroughly developed system of playing piano with the forearms and fists. Harmonically this device necessitates the use of "tone-clusters" (Cowell's term). Under such conditions piano is capable of producing an amazing volume, uncommon to this instrument. My record library includes my own recordings of various Cowell devices, as they appear in his own compositions performed by himself. Unfortunately these are not on the market at present. There is, however, one Victor record of Ravel's "Bolero" arranged and played by Morton Gould. In this arrangement Cowell's forearm technique was employed. For more details on this subject see: Henry Cowell: "New Musical Resources", published by Norton.

Outside of this specialized field of piano execution, rapid alternating tremolos of both hands and using three or more fingers in each hand can be used very effectively as a percussive device.

Another device, which Henry Cowell uses, and which is generally not unknown, consists of plucking the strings or sliding over them (with the right hand) while pressing the keys silently (with the left). Sliding over a

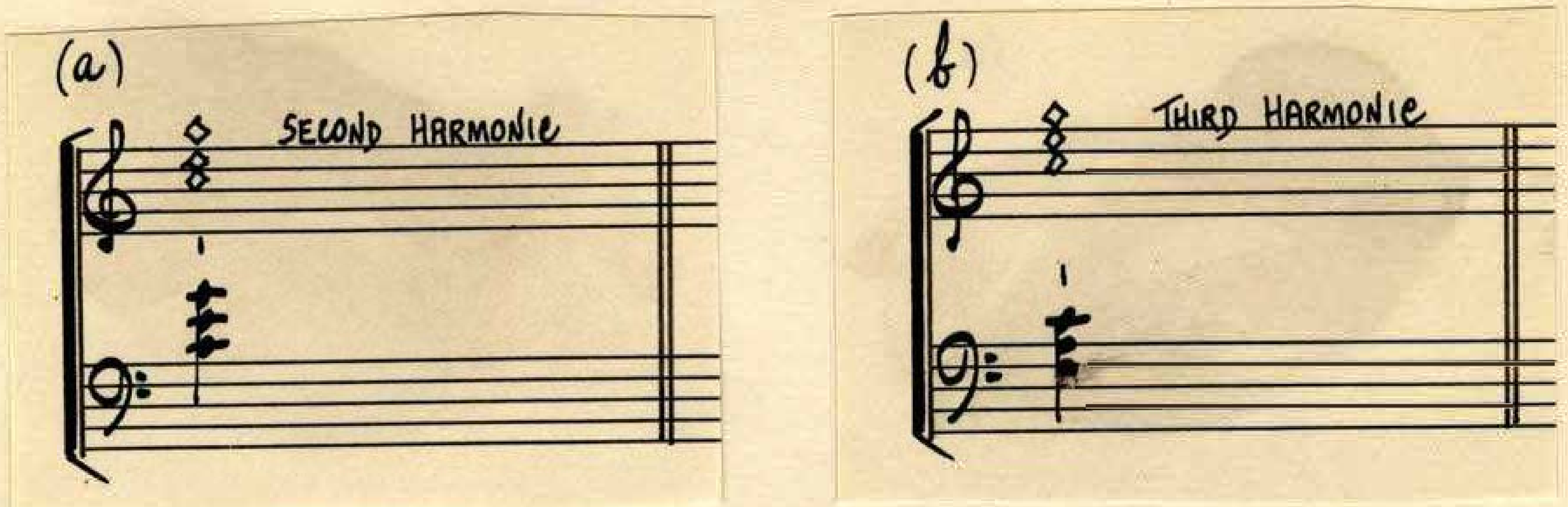
group of strings permits the sound to come only from such strings whose keys are pressed. This produces a delightful harp-like tone.

Henry Cowell has also developed a highly coloristic effect which, so far as I know, he is the only one able to execute. It consists of sliding over the strings (in the back of the piano; somebody has to press the right pedal down continuously) and sometimes plucking them. The sliding is done across an individual string and produces a most fantastic character. Cowell often touches the nodal points of a string in order to get harmonics. He holds the string at a knot with one hand and slides with another. He has some compositions, like "Banshee", entirely written for this technique. This device can be used with great success for wind and storm effects, as well as for fantastic and ghost-like effects.

The use of regular piano harmonics was made in Arnold Schoenberg's and my own compositions. Harmonics are particularly interesting as a variable timbre effects. By silently pressing a key (or a group of keys) which corresponds to the respective harmonic and by striking the fundamental (or a group of fundamentals) we obtain an actual harmonic. This is due to the sympathetic vibrations of the open string in response to the partial vibrations of the fundamental (which is executed staccato). The effect is that of an abrupt attack, followed by an extended fading harmonic. It is very interesting to note that under such conditions each harmonic has a different timbre.

Example:

Figure LI.



Cases (a) and (b) in the above Figure have different timbres. Higher harmonics (preferably the ones which are used on a trumpet) can also be used.

Piano is also capable of producing vibrato (in single tones or chords). Not the imaginary vibrato, where a pianist is vibrating his finger while pressing the key (which is physically meaningless, as after the hammer strikes the string no manipulation of the key has any effect upon the string), but a real physical vibrato by pitch.

This is my own device at which I arrived by the following way of reasoning. If we silently press the eleven lower keys (which is very easy to do with the palm of the left hand), then any keys we strike at an interval of an octave or more would stimulate the respective partials on the lower open strings. As the actual partials slightly differ in pitch with the corresponding keys we strike, those differences in frequencies produce beats, i.e., vibrato by pitch. I used this device with great success in the piano part of my Symphonic Rhapsody "October". All sounds must be

produced either portamento or staccato. They come out with special prominence on a concert grand piano, as there the strings are correspondingly longer and, for this reason, their partials -- louder. This device can be applied either in long durations or in rapid arpeggio passages. For this effect pedal shall not be used.

Piano can be turned, for some special effects, into a harpsichord and other plucked instruments. For these effects, it is necessary to use paper (particularly wax-paper), placed right on the strings. When the hammer strikes a string covered with paper, it produces a buzzing effect. For a more drastic percussiveness plywood boards may be used instead of paper. I made use of the latter in my background music to "Merry Ghost", which is a Japanese play by Kitharo Oka and where this effect was used to produce a sound resembling shamisen (a Japanese plucked instrument).

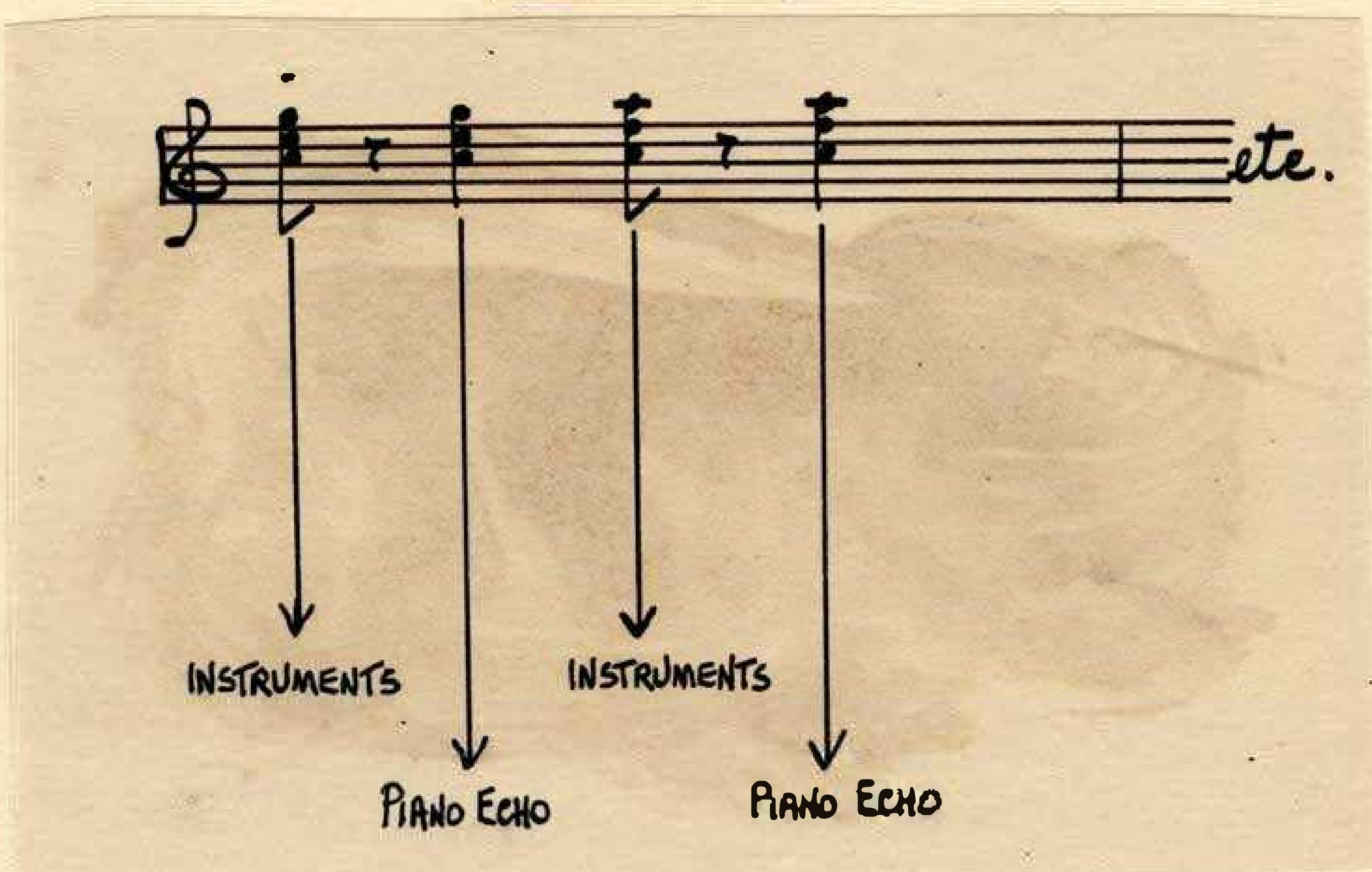
Finally, piano can be used as a sympathetic resonating (echo) system. Piano, when its right pedal is pressed, is able to reproduce sympathetically any sounds which are in its vicinity, i.e., any such sounds whose air waves can reach the strings with sufficient intensity. This concerns both the harmonic and the inharmonic (noises) sounds.

Whistle into the piano and the response is the same pitch and the same tone quality. Sing, and the same sound continues as echo. This device can be used specifically as an echo generating device. It is a natural phenomenon

based on the physical pattern-response. It existed in nature before any animals inhabited this planet. Nobody can lay any claim on discovering the echo.

I suggested this device to all my students of orchestration, and it was Nathan L. Van Cleave who effectively used it in the scores made for Kostelanetz orchestra. This device can be utilized practically, in the alternation of staccato of an instrument or a group of instruments (preferably identical ones) and its echo; both should follow in uniform durations.

Figure LII.



The alternation of such durations must not be too fast.

Many spectacular effects in orchestration can be achieved by a combined use of these piano devices.

Harp, Novachord, Harpsichord, Guitar, Hawaiian Guitar in many cases may be looked upon and utilized as

percussive instruments.

This consideration does not require any additional description.

Celeste

Celeste ("divine") is a keyboard instrument with soft hammers striking metal bars. These bars are made of precious and semi-precious metals. It renders this instrument a tone unsurpassed in delicacy and tenderness.

The most common design of this instrument includes four octaves (the small, the middle, the first and the second, usually starting from c).

Figure LIII.

The parts for this instrument are written on a two-staff system, the same as piano. The standard bass (F) and treble (G) clefs are used.

It is a miniature self-sufficient instrument, on which melody, harmony or both can be executed simultaneously. Chords in their various instrumental forms are frequently used on celeste, as it produces a very delicate accompaniment suitable to melody played on the flute, the clarinet (particularly the subtone) or in a combination with the harp.

This instrument may be looked upon as a still more delicate version of chimes. It can be employed only in transparent (low density) textures and amidst low dynamics (p, pp).

Debussy and Ravel used this instrument extensively in their scores. Chaikovsky made some effective use of it in his "Nutcracker Suite".

Glockenspiel (Orchestra Bells; Campanelli)

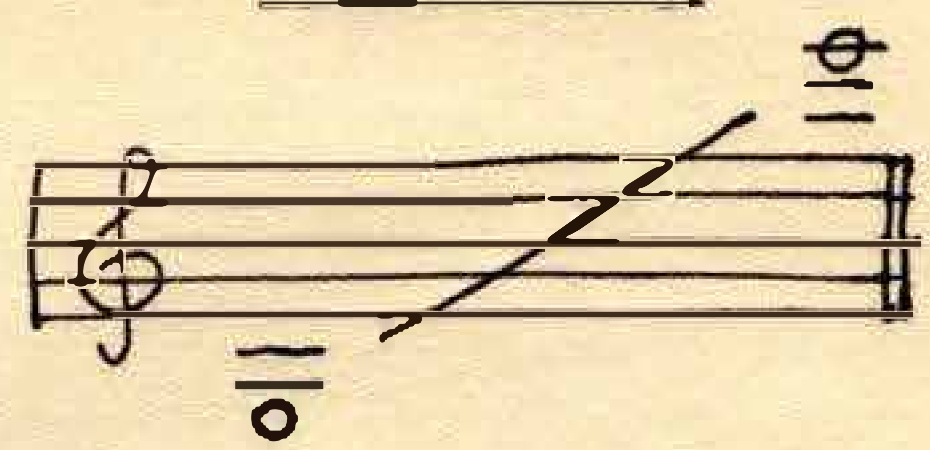
This instrument is known in two basic models: the hammer and the keyboard types.

The hammer orchestra bells are played somewhat like the xylophone, i.e., by striking the bars with two hammers (usually made of wood) held in both hands. The bars, of semi-precious and common metals, are built-in into a portable closing box. The bars are arranged in two rows, similar to the arrangement of black and white keys on the piano. Often even the musical names of the individual pitches are engraved on each bar. This makes it very easy for the performer to strike the right bar. Glockenspiel of both types is a chromatic instrument. The keyboard model is of the piano design.

This instrument has a superior tone-quality than the keyboard model, which is clumsy and produces a less brilliant tone. Generally, the tone of this instrument is a harsher version of the tone of a celeste. The attacks, due to unsoftened hammers, are more pungent. Some musicians describe it as a "metallic" timbre.

The range commonly used for both models of orchestra bells is as follows:

Figure LIV.



Parts are usually written on one staff, in treble clef, but can be written, when necessary, on two staves.

As the sound of this instrument has a relatively long durability, it is not desirable to write rapid passages, unless such passages represent instrumental forms of one harmonic assemblage.

It is to be remembered that Glockenspiel is one of the most commonly used instruments.

Its brilliance is due to the dominance of high partials.

Chimes (Campana)

"Campana" means bells; the English term is "chimes". This instrument is used in large orchestras and has a group of cylindrical metal bars suspended from a frame. The bars are struck by a large wooden hammer (sometimes two hammers are used). This instrument has the sound of the church carillion and represents the more compact version of the latter. It is used for similar climactic or jubilant

episodes, or, in some cases, for stimulating associations with a real carillion.

The carillion, of course, is a totally different instrument, consisting of church bells and bars and played by fists, striking specially designed large keys.

Chimes usually have a set of bars covering one chromatic octave from c to c. The parts are written in the middle octave, in treble clef, but have such dominance of higher partials that, strictly speaking, their pitches do not belong to one particular octave. Chimes make a good blend with the brass instruments.

Church Bells

This instrument is actually a group of several suspended church bells, matched in their pitches for each individual score. Such a set was used in Chaikovsky's overture "1812", where the church bells represented some of the standard Russian-Orthodox carillions and conveyed the idea of jubilation over the retreat of Napoleon Bonaparte from Moscow.

Lesson CCLXXIII.

Vibraphone (also known as Vibra-Harp)

A relatively new instrument, designed and manufactured in the U.S.A. It is widely used at present in practically every dance-band. There are already several very eminent virtuosi, who appear as soloists with the dance-bands and small ensembles playing dance music (Adrian Rollini, Lionel Hampton and others).

This instrument is built on the general principle of xylophone, but its bars, of quite large size, are made of metal, have resonating tubes under them and an extension of tone. The latter is achieved by means of electromagnetic induction (which not only extends the durability of the tone, but also supplies it with an automatic vibrato by intensity) and is controlled by pressing a special pedal, built for this purpose. This device permits the execution of various dynamic effects, like sforzando-piano.

Vibraphone has a rich "golden" tone and differs from chimes in its timbral components: it has some similarity, in its basic timbre, with the "chalumeau" of the clarinet.

Vibraphones, depending on their size and price, vary in range. Large concert vibraphones usually have the following range:

Figure IV.

This instrument is played by special hammers, often even of a different design (to achieve different types of attacks). Some vibraphonists hold two, three and even four hammers in each hand. This permits to execute some self-sufficient solos in block-harmonies, following one another at a considerable speed.

Marimba and Xylophone

Marimba and xylophone are essentially the same kind of instruments. The difference between the two is chiefly in the resonating cylindrical tubes which are part of the marimba and are absent on the xylophone. Both types have the same kind of wooden bars and are played with the special hammers. Xylophone is more traditional with the symphony orchestras, while marimba is more used with the dance-bands. It is interesting to note that many truly primitive African tribes use the marimba, i.e., even they have arrived at the necessity of a resonating medium. The resonating tubes attribute to the marimba a richer and a more durable tone.

The music written for this instrument as a participant of a dance band is considerably more complex technically than the parts written for the xylophone in symphonic scoring. One of the reasons for this is that in symphony orchestras one of the percussioners plays the xylophone part but he is not expected to be a xylophone virtuoso. In the dance bands, quite to the contrary, the marimbaist is

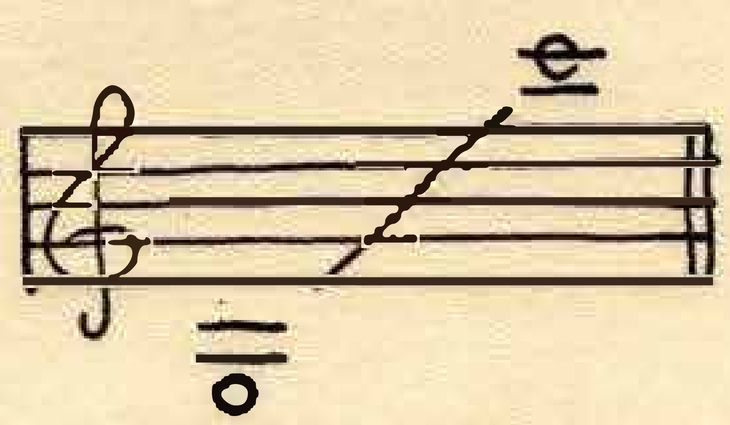
a specialized soloist (often also playing the vibraphone) and is even capable of handling two, three and even four hammers in each hand.

Some of such virtuosi handle the xylophone or the marimba as a very delicate instrument. This is accomplished by the use of special soft hammers. Some of such performers give a very refined rendition of Chopin's piano compositions.

One of the very versatile xylophonists even built a dance band around the xylophone as a leading solo instrument. His name is Red Norvo, and the recordings of his performances are available.

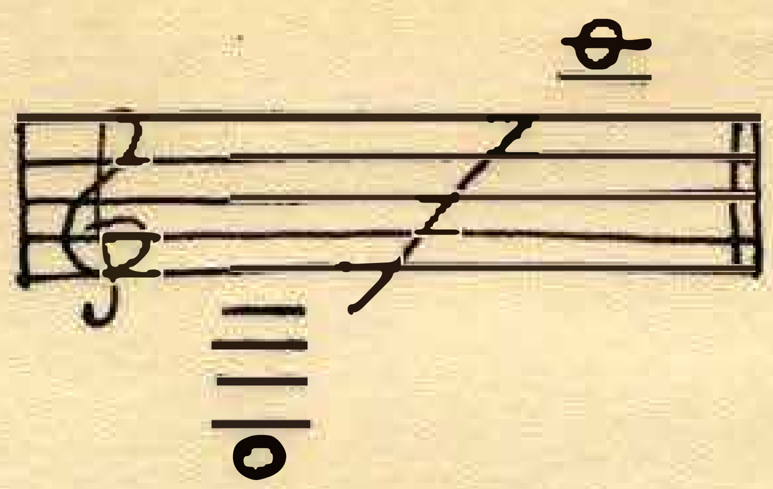
The range of the xylophone and of the marimba varies. In writing for symphony orchestra, it is best to adhere to the following range:

Figure LVI.



In writing for the xylophone or the marimba used in the present American dance-bands the range can be extended as follows:

Figure LVII.



Full chromatic scale is available in both cases.

The alternate tremolo (like the plectrum tremolo on the mandolin) of both hands on the same bar (which is equivalent to the same note) is a common way of playing long notes on this instrument. All shorter durations are bound to sound staccato. It is an excellent instrument for execution of IS2p in any form and at practically any speed.

Glissando either over the naturals (c, d, e, f, g, a, b) or the sharps (c#, d#, f#, g#, a#) are another common device on this instrument. Combinations of both glissando forms and their combinations of ascending and descending directions can also be used.

Both the xylophone and the marimba have a wide dynamic range. Xylophone blends better with the flute, marimba, either with the low register of the flute or with the "chalumeau" of the clarinet. Good combinations are also obtained by using the xylophone with the piano.

Parts for these instruments are usually written on the staff in the treble clef (G). In many French scores the xylophone parts are written one octave higher than they sound.

The reason for this is, probably, the dominance of upper harmonics which, in some cases, produces an impression that a certain tone sounds one octave higher.

Many interesting accomplishments can result when parts for this instrument are written with the full knowledge of the Theory of Instrumental Forms.

The following percussive instruments of this group can be looked upon as more primitive or more simplified versions of the instruments already described.

Triangle

This instrument consists of one long metal bar of cylindrical form and of relatively small diameter and is bent into an isoseless or an equilateral triangle (hence the name), not quite closed at its vertex. It is usually suspended on a string and is played by striking it with another straight metal bar, of about the length of each side of the triangle itself and of about the same (or smaller) diameter.

This instrument is a simplified version of a glockenspiel. Its high partials dominate to such an extent that it is considered to be an instrument "without definite pitch". Thus, triangle can be used with any harmonic assemblage whatsoever.

There are only two ways of using this instrument:

(1) individual attacks (all staccato) arranged in any desirable form of temporal rhythm;

(2) tremolo, which is accomplished by attacking alternately two adjacent sides of the triangle.

It is an instrument of a limited dynamic range (generally mf) but can be made to sound very loud in tremolo. The latter also offers crescendo-diminuendo effects.

The tone-quality of this instrument is very prominent and very "metallic".

It blends well with all high registers, as at such frequencies tone-qualities lose their timbral characteristics (due to weakness or inaudibility of the high partials).

The parts for this instrument are written on a single line. No clefs are used.

Wood-blocks

Wood-blocks are made in the form of a parallelepiped (rectangular solid) or, more frequently, in the form of a spheroid (eliptic solid). In both cases, some portion of the solid is carved out, and the hollowness thus formed contributes to the resonating quality of this instrument.

Wood-blocks are made in different sizes to secure a selection of pitches, but these pitches are not too distinct.

A wood-block may be looked upon as a simplified version of xylophone. The blocks are struck with sticks or hammers. Often (in dance combinations) an outfit consisting of three, four or five wood-blocks is added to the usual combination of traps so they can be handled by one performer.

Wood-block is a purely rhythmic instrument.

However, if a set of several is used, they may be notated on the regular five-line staff, where the pitches can be represented by the closest notes.

<u>Castagnette</u> (Castanets)

Castanets is an instrument of Spanish origin, and in most cases is used in music which is, if not truly Spanish, somehow associated with Spain. By tradition castanets is an accompanying rhythmic instrument, played by the dancer and not by an outside performer.

Castanets are two small hardwood plaques (with a shape of the sole of an infant's shoe) loosely joined by a cord. They are held within the palm of a hand, with the string put over the middle finger. The actual execution of sounds is produced by the finger attacks. Fingers strike one of the castagnets and this, in turn, strikes another. This produces a clicking and very brilliant high-pitched inharmonic sound.

In some cases, two pairs of castanets are used (one pair for each hand).

Some of the Spanish and Flamenco dancers are real virtuosi of this unpretentious instrument.

It is a highly developed (by tradition) rhythmic resource in orchestration and may be looked upon as a simplified version of xylophone. It is particularly useful for animated high-pitched figures, whereas wood-blocks are considerably lower in pitch and cannot be maneuvered at such

a high speed.

The part of each hand must occupy one line. Thus for two pairs of castanets two lines must be used. The advantage of writing on two lines lies in the fact that it would accommodate many complex interference rhythms, which would still be easy to execute by the two hands. It is well worth while to make a study of the traditional Spanish castanet rhythms.

Clavis

Clavis is a Cuban instrument, consisting of two fairly thick sticks made of hardwood. The performer hits one stick with another. Both sticks are alike. This instrument is commonly used today as a rhythmic ingredient of Afro-Cuban dance forms (Rhumba, Carioca, Samba, Conga etc.) by our dance orchestras.

The sound of clavis is high-pitched, inharmonic and piercing.

In rhumbas it usually performs the $\frac{8}{8}$ series trinomial (i.e., 3+3+2, 3+2+3, 2+3+3).

The part of clavis occupies one line.

Clavis is ordinarily used with the so-called rhumba bands, but can be introduced into symphonic scoring, when Cuban character is present in the music.

Group Two

Gong

This instrument comes from Hindustan and China. It is made in two shapes: a circle or a square (sometimes,

an oblong). It is all made out of metal, some of which is semi-precious and precious. It is usually very massive and large in dimensions. At least this is the type used by the symphony orchestras. It is suspended from a frame to which it is attached at a distance by a pair of strings.

Figure LVIII.

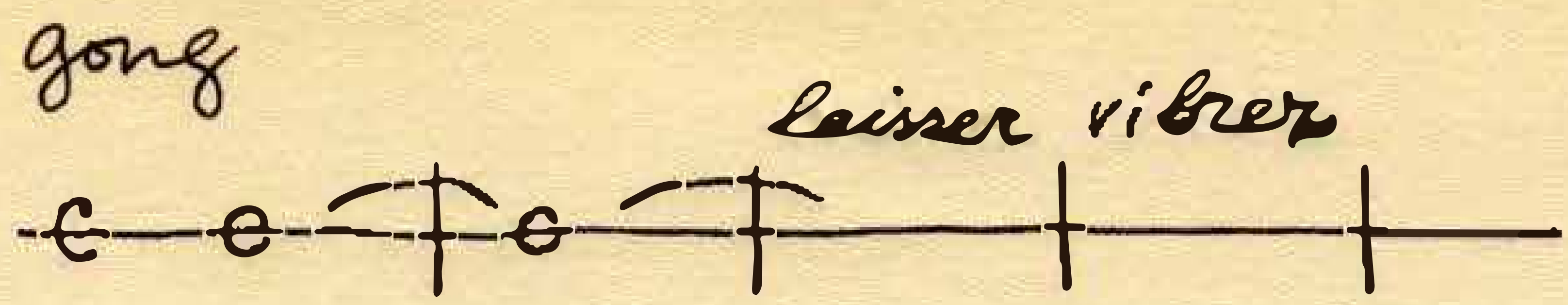
It is the lowest-pitched inharmonic percussive instrument of the metal disc group.

It is attacked by a stick with a round soft end. The sound is very rich in its quality and has a great dynamic range, combined with long durability of tone. It blends well with low register of brass instruments.

Gong must be very moderately used, as it is the last resource of main climaxes. Too frequent use of this startling tone-quality neutralizes its character in the listener's impression.

If the sound of the gong must be shorter than its natural fading period at a given intensity, it is damped out by the hand. Otherwise the term commonly used is written out above the note: "laisser vibrer" (let vibrate).

Figure LIX.



As gong has a slowly fading sound, successive attacks require a considerable time-interval between them.

Piatti (Cymbals)

Cymbals consist of a pair of discs of approximately 18" diameter. They are made of semi-precious and precious metals. Each disc has a leather handle, in the form of a short loop,,by which it is held.

Cymbals are played in two basic ways:

(1) by striking one cymbal over the other (for louder and more prolonged sounds, with a certain amount of friction);

(2) by making a tremolo of alternating attacks over one suspended cymbal (which is in horizontal position); for this purpose either hard drumsticks (which results in harsher tone-quality and higher-pitched) or kettle-drum sticks (which are soft and render lower-pitched softer tone).

The range of cymbals, the tone of which consists of rich inharmonic sound-complexes, varies depending on the form of attack. When the friction surface is small, the

sound is higher-pitched.

Cymbals cover approximately the range of trombones (excluding their pedal tones) and trumpets, with which they blend very well.

Cymbals struck by one another, i.e., cymbals held in hands usually are not indicated in any way, except by their temporal values and dynamics. A suspended cymbal is usually recognized by the performer, because its part is written as tremolo (indicated ~~~~ over the note). The use of hard sticks is marked: colla baghetta da tamburo. The use of soft sticks is marked: colla mazuola or colla baghetta da timpano.

This standard terminology is notoriously clumsy. I recommend to my students to use my own nomenclature, which is simple and economical, and permits a much more diversified use of the different types of attack:

a suspended cymbal:

(a) hard sticks: —●

(b) soft sticks: —○

two cymbals in hands: ○

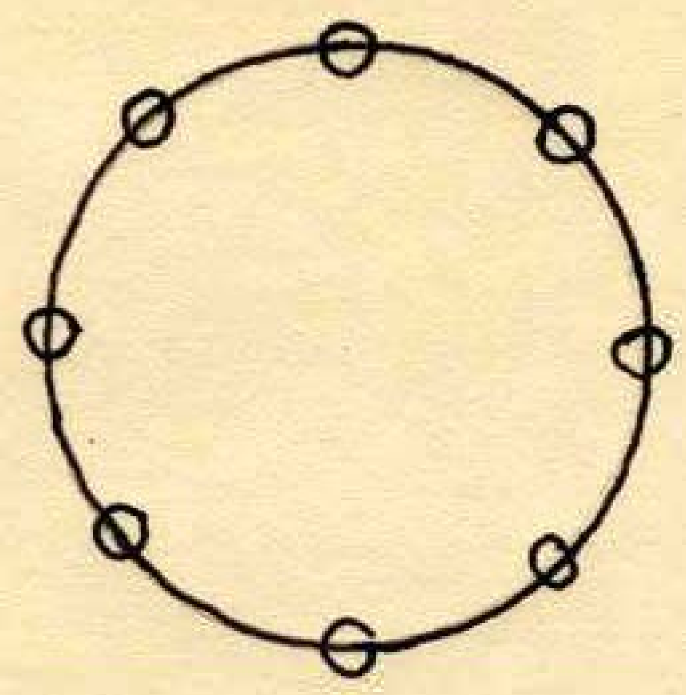
I usually make footnotes at the beginning of my scores explaining the meaning of these symbols. I made the first use of this nomenclature in 1921.

An instrument which at once belongs to Group Two (discs) and Group Three (membranes) is a well known

Tamburino (Tamburin)

This instrument consists of a circular wooden frame over which a skin membrane is stretched, covering one side of it. Thus the form of the membrane is a circle. In addition to this, there are small (about 1.5" in diameter) metal double discs, loosely attached in a perpendicular position to the frame of the tamburin. The tamburin viewed from above appears as follows:

Figure LX.



This instrument, associated with Italian and Spanish folk dancing, is played by either striking the skin with the palm, which at once produces a high pitched inharmonic drum sound and the jingling of the discs (high pitched "metallic" inharmonic sound), or by shaking the tamburin in the air (held by the left hand), which produces the jingling of discs alone, or by producing an oscillatory frictional movement over the skin, by the thumb of the right hand, which results in a scintillating type of tremolo. Often these ways of playing the tamburin are combined in effective dynamic and rhythmic sequences. A great deal of varying the attack forms is left to the initiative of the performer.

The parts are commonly written on one line, indicating the durations and the dynamics. Tremolo is marked as usual by: ∿∿∿∿ .

Group Three

Timpani (Kettle-Drums)

Kettle-drums are the first percussive instrument to occupy a lasting place in symphonic scoring. It was Josef Haydn, who introduced them (Simfonie mit Pauckenschlag [symphony with kettle-drums]). Since that time they have become a standard ingredient of symphonic and operatic scoring.

Kettle-drums are ordinarily used in groups of three and four. The original selection of three kettle-drums usually furnished the tonic, the subdominant and the dominant. Today they are used in any pitch-group combination that satisfies the harmonic need.

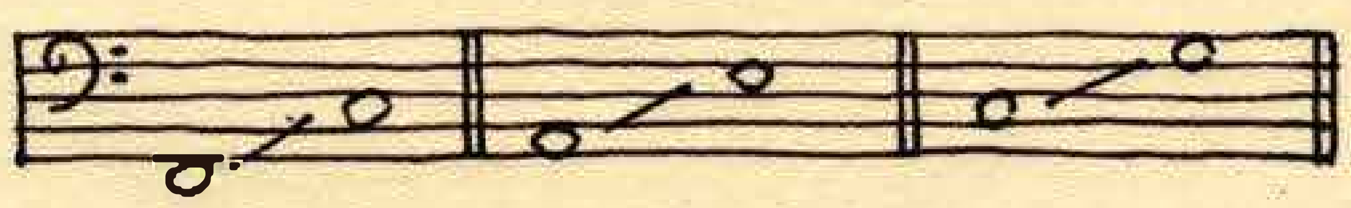
Kettle-drum consists of a hollow copper hemisphere, with a skin membrane stretched over its equatorial circumference. The tension of the membrane is adjustable, in other words, kettle drums can be tuned. This is accomplished by screwing in and out the handles (of which there are several around the skin surface) controlling the tension of the membrane. It calls for a keen sense of pitch, to tune kettle-drums, as it has to be done quietly while the orchestra is playing. Kettle-drummers (or tympanists) usually know the parts of the neighboring instruments, from which they borrow the necessary pitch. Then they tune the

membranes and try them out quietly, while the orchestra is playing loud enough before their entrance.

Each kettle-drum produces one pitch at a time. To obtain many pitches at a time would require as many kettle-drums. Berlioz used in one of his scores as many as 16 of them. Considering the usual equipment of the large symphony orchestra, it is advisable not to use more than four. In some instances two simultaneous tympanists can be used, in which case one may count on four or five instruments.

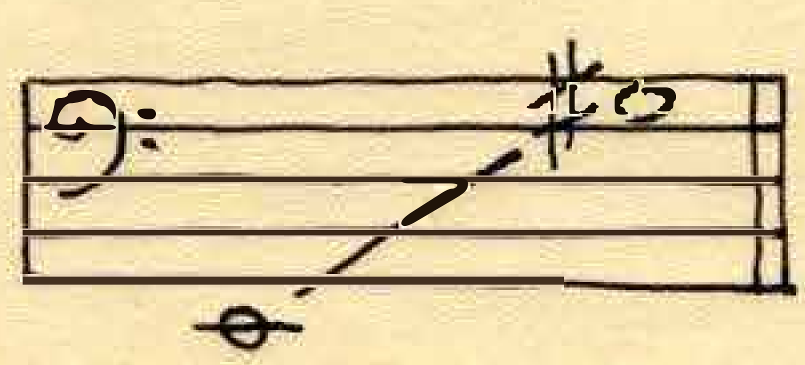
The three standardized sizes, usually allow the tuning within the following ranges:

Figure LXI.



The total range may be considered practical even if one semitone is added at each end:

Figure LXII.



Rimsky-Korsakov ordered for his opera-ballet "Mlada" a small kettle-drum, which could be tuned up to $d^{\flat}$ of the middle octave. He called it "timpano piccolo".

The contemporary American-made kettle-drums have a pedal device for automatic tuning. This device is supposed to stretch the membrane at all points at an equal tension, which is not too reliable in actual practice. The performers still have to rely on their pitch-discrimination.

The tuning of kettle-drums is marked at the beginning of the score, like this, for instance: Timpani in F, $B^{\flat}$, C. When the tuning changes, the performer is warned by the composer in advance, as a certain amount of time is necessary for tuning of this instrument (the actual time period required largely depends upon the performer's experience and skill). It is indicated like this, for example: muta in G, $B^{\flat}$, D.

Kettle-drums are played (the parts are written in the bass clef [F] on a regular five-line staff; two staves can be used if necessary) by two special sticks, having soft spheroid-like ends. The whole performance consists of individual and rolling (i.e., alternating tremolo attacks; the latter may affect one or two instruments) attacks.

This instrument has an enormous dynamic range and in ff can pierce the entire tutti of an orchestra. Big crescendi are particularly effective in tremolo (marked: ~~~~~).

Sometimes, very seldom though, very delicate sounds are obtained by muting. Flannel or other soft cloth is put over the skin of a kettle-drum. The use of such mutes is indicated by: timpani coperti (i.e., covered kettle-drums). To restore the normal effect, "modo ordinare" is used as a term.

The sound of kettle-drums does not possess too distinct a pitch. This is due to the abundance of lower inharmonic tones. This instrument has a quickly fading tone. The pitch, due to the presence of low inharmonics, seems to the ear lower than it is written.

Lesson CCLXXIV.

Gran Cassa (Bass-Drum)

This instrument has a cylindrical frame of very large diameter. The skin-membranes are stretched on both sides. It is considered to be an instrument without definite pitch, as the inharmonic tones predominate and all frequencies are very low.

Bass-drum is usually played by a special stick, made for this instrument. The parts are usually very simple, are written on one line, and consist of merely individual attacks.

Of course other sticks can be used, and the execution of tremolo is also possible.

Some of the bass-drums used by the dance-bands have a narrow frame and only one membrane.

Bass-drum blends naturally with low pitches.

Tamburo (Snare-Drum)

This is the most alert instrument in the entire third group. In shape it is the same as the bass-drum; its size is considerably smaller. While the bass-drum is played in vertical position, this drum is played in an almost horizontal position (there is a small angle to the horizon). It is played by a pair of hard sticks, known as drum-sticks.

Snare-drum derives its name from the snares which are a pair of thin gut strings, stretched across its lower head and producing a rattling sound.

Sometimes tamburo is used without snares (it is

quite customary with the dance bands), in which case this should be indicated: "no snares".

This instrument produces middle-high inharmonic sounds. It has a wide dynamic range.

The speed of rolling is the main feature of this instrument. Even the equivalent of grace-notes is often extended into rolls (marked:  , i.e., the small note is the roll and the large note is the attack).

It is suitable for any intricate rhythmic patterns which can be executed practically at any speed.

The jazz era created many outstanding drummers in America. Yet the patterns of their improvised rhythms are still very one-sided and limited, as compared to their cannibal colleagues in Belgian Congo.

Snare-drum has always been in use in all military organizations. Its martial character by now is an inherited association.

The parts are written on one line.

For the students of this system, there are many opportunities in utilizing the snare-drum as a two-part instrumental interference medium.

<u>Pango Drums</u>

This outfit usually consists of a pair of drums. The shape of the frame is a hollow inverted cone (it can be played on either side), which at its open ends has skin membranes. One of the drums is somewhat larger than the

other, but there is no fixed ratio. Pango drums are played by hands.

Though probably of African origin, it is widely used in Cuban rhumbas and congas. Rhythmic patterns executed by the Cuban performers are often extremely intricate (mostly based on splitting of the $\frac{8}{8}$ series).

Pango drums are often employed by the rhumba bands, and Cuban performers are very common.

Tom-Tom

This instrument consists of a small cylindrical frame, which is relatively wide for its size. It has one skin membrane over its frame. It is ordinarily used (one or more) in jazz bands and played with a stick. Its inharmonic sound blends with the middle register.

Group Four

No instrument can be considered standard in this group. All special sound-effect instruments belong to this group. There is neither any need nor possibility to describe all such instruments, as new types are being developed and introduced every year. Some of these instruments have a brief popularity after which most of them become obsolete.

The purpose of bringing sound-effect instruments to the composer's attention is to stimulate his resourcefulness and to suggest that he too can use some special materials for sound effects. It is also advisable for him

to study the history of instruments and to attend the music departments of museums, as this would give him a proper perspective and orientation in the subject.

One of the more commonly known instruments of this group is an ordinary sheet of iron (usually termed in French: feuille de fer). By holding such a sheet at one end and shaking it, one obtains thunder-like sounds. Single strokes and tremolo also can be executed on a suspended iron sheet, using the different types of standard sticks.

Cow bells are used sometimes as a musical instrument for descriptive music of bucolic character. The bells can be either shaken or struck with a hard stick. Their tuning is unimportant, as the use of them is supposed merely to suggest cow pastures.

Emery boards (I used them in my Symphonic Rhapsody "October" to produce a steam engine effect) are used sometimes in symphonic and dance scoring. Rubbing of the surfaces of two emery boards (i.e., sound is obtained by friction and not by attack) produces a powerful sound. It is an excellent descriptive medium for locomotive or train effects.

Musical saw was once very popular. It was used as an instrument of the melodic type. Two methods of playing were used: striking it with a stick or a small hammer, or striking it with the bow (usually a long stroke ending with staccato). It is an extremely effective instrument, whose

tone-quality resembles an idealized soprano voice and whose vibrato can be controlled by the performer. The handle is held rigidly between the knees and the end of the saw is supported by the middle finger of the left hand. While the finger presses the end of the saw, the entire saw bends: the greater the curvature, the higher the pitch. Bow or hammer produce attacks and are held in the right hand.

Today composers begin to use phonograph records with sound effects (birds, animals and other sounds of the surrounding nature); the latter are included as component parts of a score.

Program and background music in radio and cinema utilize such recordings and often simply transfer them on a sound-track.

There is a sound-effect renting record library, containing any imaginable sound (there are more than 10,000 items now) effects. The firm is located in New York, but it supplies the entire country.

Human Voices (Vocal Instruments)

Human voice is one of the original natural musical instruments. It is by no means standardized. There are too many types of voices and too many ways of using them. Each national culture has different types of voices and different methods of singing. Even different styles of music within one national culture often call for totally different manners of execution. Just to get a bold illustra-

tion, compare the bel canto style of operatic vocal art with the so popular crooning or "torch-singing" of today. The contrasts in singing of different nations are at least as great. Compare, for instance, French folk singing with Siamese folk singing or with Abkhasian (some of the Black Sea Caucasian shore; the mythical land of Golden Fleece [Jason]) choral singing which has a unique instrumental character of its own.

Even in the so-called European musical culture we find such different styles as the Italian bel canto, the Russian vocal style (like Chaliapine), the German lieder-singing etc. Then we find such contrasting styles as vocal jazz ensembles and the plain chant of the Catholic Church.

No doubt new styles will appear in the future.

Besides the necessity of considering all these stylistic and national differences in the voice as musical instrument, there are also biological differences and modifications, which take place as time goes on. One of such modifications is the appearance of greater differentiation of ranges and characters. Some time ago there were mostly tenor and bass male voices. Later it became necessary to single out the intermediate type: baritone. Now we have bass-baritones, tenor-baritones etc. Standard parts of the classical repertoire are not written for them; so they have to either sing the parts which are too high or too low for them, or else look for composers who would write for these

new vocal instruments.

Sometimes we also encounter biological aberrations producing such voices as altino, which is not only higher than the male tenor, but also has a peculiar quality of its own, not to be confused with a boy's alto or a female's contralto. Rimsky-Korsakov even wrote a part for an altino (the astrologer in "Coq d'Or"), for which Russia found only two performers.

There are also other cases of vocal travesti, like the Russian Gypsy singer Varia Panina who possessed a genuine baritone; or another Russian singer, Anna Meichick, who had such a massive and wide-ranged contralto that she sang the part of Demon, in Rubinstein's opera of the same name. Anna Meichick was the first contralto at the Metropolitan Opera House in New York for many years.

With all this in view, the problem of describing standard human voices seems to be insoluble. What the composer has to be aware of is that when writing for an oboe, he has a pretty well defined auditory image in his mind, while when writing for a tenor, he would not know what he would get in the actual performance.

There are other considerations of equal importance. One of them is the effect of language upon the style of vocal execution. And this often concerns such important facts that the very nature of the Italian language (i.e., the type and the distribution of vowels and consonants) makes

singing easy and natural and the articulation clear, as compared to the English language. A number of good singers, whose native tongue is English, <u>sing better</u> in Italian. Certain English sounds, like <u>th,</u> do not permit to get a proper air impact. On the other hand, the entire manner of singing in French, due to its phonetic and articulatory nature, acquires a nasal character (on, en, un, in etc.).

All this naturally cannot be neglected by the composer.

Thus, in order to present a somewhat practical description of human voices as orchestral instruments, I have to resort to somewhat specialized generalities.

Among these are the standard choral ranges, as they are traditionally used in our scoring for a capella or accompanied chorus. Soloists sometimes have wider ranges. But it is not always the case.

Another generalization can be drawn with respect to basic timbres of vowels, in which case I shall use the Latin pronunciation of vowels.

No other components can be generalized, as all tone-qualities are individual; their forms of vibrato are also individual. Physically, each sound produced by the same voice on the different vowels of the same pitch, or on the same vowel differently pitched, not speaking of the different vowels differently pitched, has a different character. But this we cannot take into consideration, as even

violin changes its character (and in many instances even timbre) on different strings.

Another component, which cannot be generalized, is dynamics. The volume of voice and its dynamic range varies individually. Powerful voices, if combined with pleasing quality, are considered valuable, as such voices can produce a powerful impression by their dynamic versatility. Nowadays the timbre, the character and the volume can be considerably modified either by using a microphone or by acoustical modification of the sound-track, which is constantly done in the radio and the cinema field.

Neither can individual articulating quality (which, strictly speaking, belongs to the field of vocal attacks) be generalized, even when considering one particular language. Some outstanding singers had magnificent articulation in addition to their vocal quality and general technique. I can mention two, as an example of perfect articulatory technique, though these singers belong to two different national cultures: one, Mattia Battistini (an Italian baritone); another, Theodore Chaliapine (a Russian basso).

Now, after making all these necessary warnings, I can proceed with the description of choral ranges and basic timbres of the latinized vowels.

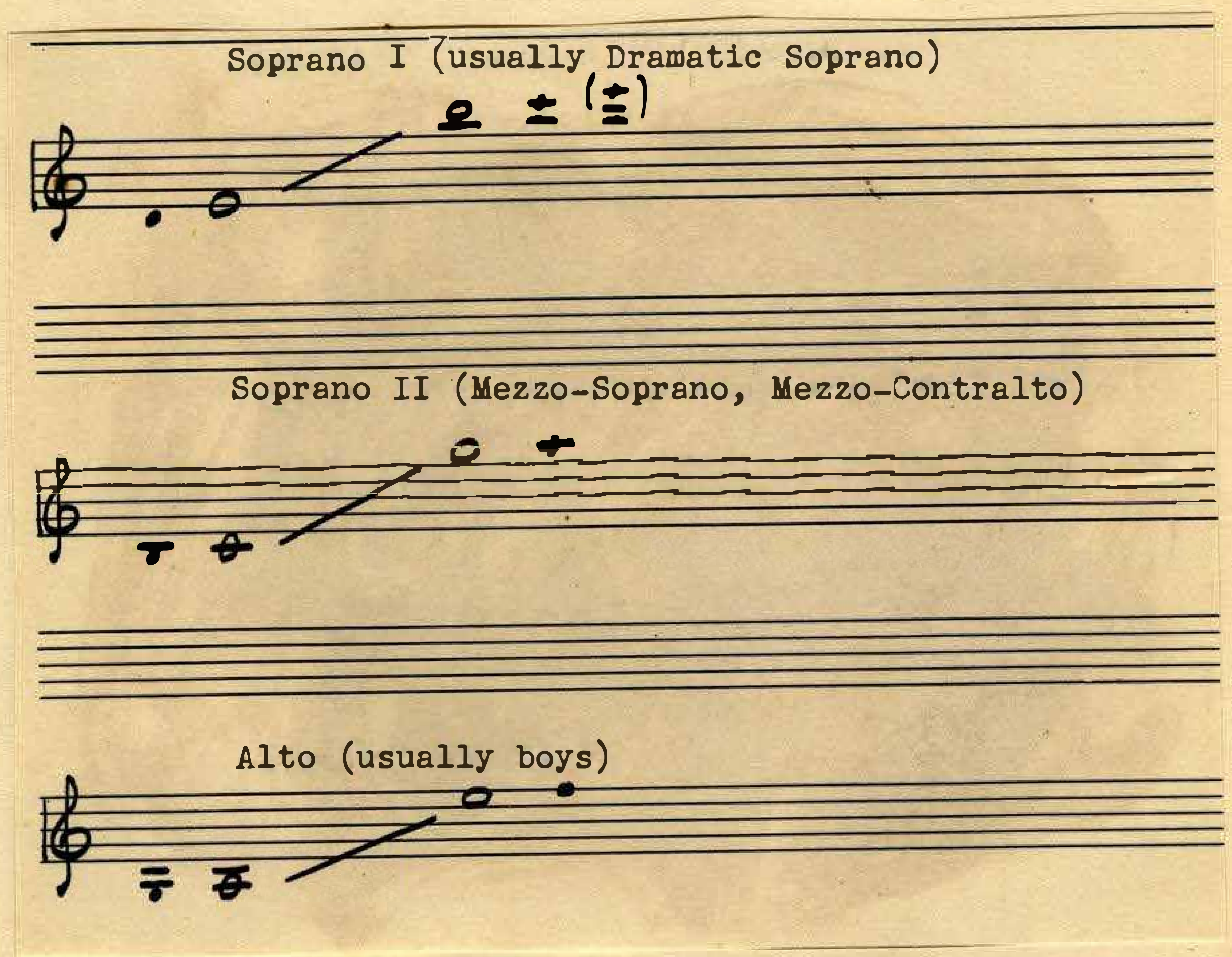
In some cases composers write certain solo, or even choral parts, for a definite performer or a definite organization of performers. In such a case, of course, he

can do a better job, as his parts would be more fitting for the individual characteristics of the soloist or the ensemble.

Figure LXIII.

Standard Choral Ranges

Female Voices:



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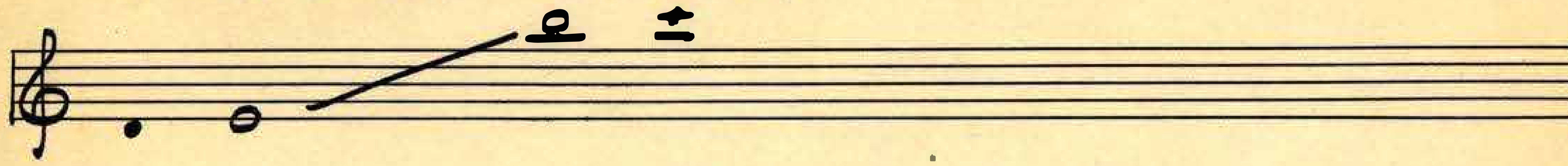
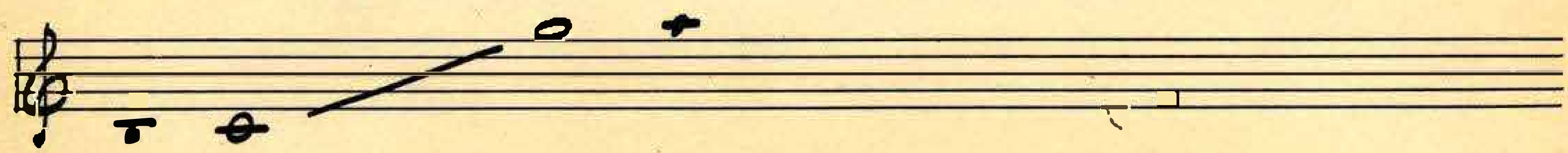
Contralto

Male Voices:

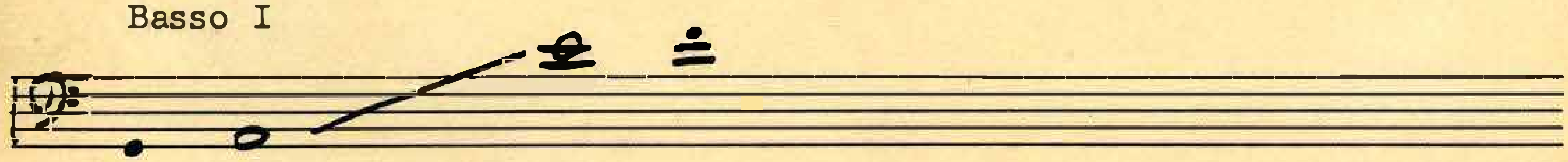
Tenor I (usually Dramatic Tenor)



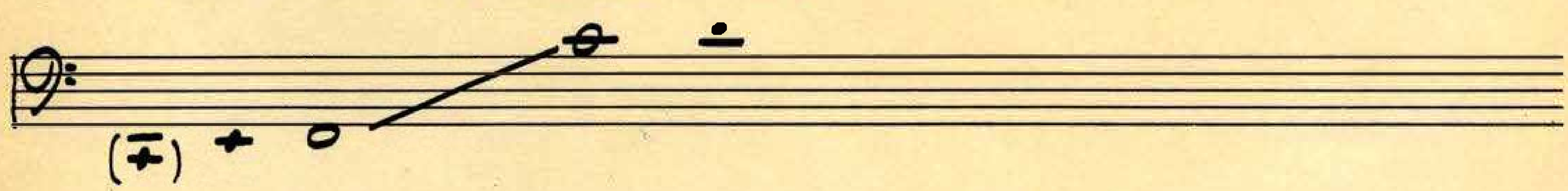
Tenor II (Baritone)



Basso I



Basso II (usually Basso Profundo)



Male voices, when written in treble clef, sound one octave lower. The so-called lyric sopranos and tenors usually have the range of ~~soprano II and tenor II respectively, but with less developed lower register.~~

Figure LXIV.

Timbral Scale of the Five Basic Latin Vowels

Latin	English Phonetic	Timbre	
u	oo	open	○
O	oh	reed	R
a	ah	stopped	⊕
e	eh	double reed	RR
i	ee	closed	●

This scale relates the vowels to five basic timbral groups, with which each vowel blends itself respectively. Thus, ○ corresponds to flutes, R to clarinets, ⊕ to horns, RR to oboes and bassoons, ● to nasal timbres and muted instruments (muted brass, celli, muted stringed instruments in general).

This scale can be extended to nine units, by means of combined vowels. The latter can be obtained by mixing of the adjacent vowels of the basic scale. A nine-unit scale may be extremely helpful in evaluating general timbral characteristics of the English, French, German and Scandinavian vowels.

Figure LXV.

Timbral Scale of the Four Combined (Intermediate) Vowels

Latin	English	Timbre
u + o	u (up)	○ + R
o + a	o (cod)	R + ⊕
a + e	a (as)	⊕ + RR
e + i	i (it)	RR + ●

Further supplements, which may still be necessary, derive from combinations of the non-adjacent vowels. The most important of these are somewhat common to Latin, English, French, German and Scandinavian.

Figure LXVI.

The Two Additional Combined Vowels

Latin	English	(Phonetic)	French	German	Timbre
œ	e (alert)	oe	eu	ö	R + RR
	i (bird)				
	u (fur)				
y			u	ü	○ + ●

All other u-vowels, as in the English word "you", or the sound of Russian character "Ю" (pronounced: you), have an attack of the attack of the English "y" (as in "yoke"), or German "j" (yot), or Russian "й" (brief "ee" [in Russian: ee kratkoye]) and the duration of the Latin "u", or English "oo".

This information is sufficient to guide the student in the field of basic vowel characteristics and help him to understand the reason for selecting one or another instrumental timbre in the accompaniment to vocal parts, which is based on coincidence (similarity) or juxtaposition (contrast) of the basic timbral characteristics, such as "u" (Latin), for flute, "o" (Latin), for clarinet, etc.

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