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THE ORIGIN OF THE INDIAN 22-TONE SYSTEM

Mieczyslaw Kolinski

Despite several serious attempts made by both Western and Hindu musicologists to elucidate the problem of the Indian 22-tone system, no satisfactory explanation concerning the origin and meaning of that unique tonal construction has, so far, been found. While it is certainly useful, in this connection, to examine the music of present-day India, both in its practical and theoretical aspects, it is to Indian antiquity that we must turn for real clues concerning the secret of the 22-tone system.

The most revealing of the few old manuscripts that have escaped systematic destruction by insects and mankind is doubtless the chapter on music contained in a treatise on theatrical arts by the famous theorist Bharata who lived during one of the first centuries of our era. Bharata starts with the statement that the Indian gammut consists of seven svaras: shadja, rishabha, gandhara, madhyama, panchama, dhaivata and nishada; or: sa, ri, ga, ma, pa, dha, ni, if we replace the full names by the tonic-sol-fa abbreviations in common use, up to the present day.

In order to avoid basic misinterpretations it is necessary to keep in mind that the svaras, as conceived by Bharata, have been primarily intervals and not single notes. The difference between that approach and the Western one in describing the structure of a scale may best be demonstrated by applying Bharata's approach for the explanation of a Western scale. If we take, for example, the major scale do re mi fa sol la ti do, the interval do re will constitute the first svara, re mi the second one, and so on; therefore, it would be appropriate to term the Western "svaras" by contractions of two consecutive tone names, such as DoR for do re, ReM for re mi, and so on. The construction of the major scale could be demonstrated in two different ways: first by giving the order of the difference in pitch level between the "svaras," and second by giving the sizes of the "svaras" themselves. In the following table

	2	1	2	2	2	1	2	
DoR	ReM	MiF	FaS	SLa	LaT	TiD	(DoR)	
2	2	1	2	2	2	1		

the level differences between the svaras are indicated by the higher row of numbers, and the sizes of the svaras themselves by the lower one. In both cases the semitone is used as the unit of measurement: for example, the level difference between the first and second svaras DoR and ReM is 2 semitones, that between the second and third svaras ReM and MiF is 1 semitone, while the size of the first two intervals themselves, DoR and ReM, is 2 semitones each. It can be seen that the lower series is shifted by one digit in comparison with the higher one. Moreover, it is obvious that in an ascending scale the level difference between two svaras is equal to the interval between their two higher limiting notes; for example, the level difference ReM MiF is evidently equal to mi fa and not to re mi. Consequently, it is the higher limiting note which, in an ascending scale, is representative of any svara.

Bharata defines the basic old Indian scale, the so called sa-grama, in both ways mentioned above; this time, the unit of measurement is not the semitone but the shruti. Verse 25 of Bharata's didactic poem says that in the sa-grama the shrutis are arranged in the following order: 3 2 4 4 3 2 4. The next two verses enumerate the shruti values for each single svara of the sa-grama, namely: 4 3 2 4 4 3 2 for the consecutive svaras sa ri ga ma pa dha ni ("Verse 25: In the Shadj Grama the shrutis are arranged in the order following: 3 2 4 4 3 2 4. Verse 26: Sa is of 4 shrutis, ri of 3, ga of 2, ma of 4. Verse 27: Pa of 4, dha of 3, ni of 2. This is the Shadj Grama." - Reference 1; pp. 50-51). A comparison of these two series of shruti values discloses that the former concerns the level differences between the svaras, in contradistinction to the svara values of the latter. In the following table

	3	2	4	4	3	2	4	
sa	ri	ga	ma	pa	dha	ni	(sa)	
4	3	2	4	4	3	2		

the higher row indicates the level differences between the svaras, in accordance with verse 25, the lower one the sizes of the single svaras, in accordance with verses 26-27 of Bharata's treatise.

It is evident that the first level difference corresponds to the interval between the 2nd and 3rd single tone of the scale, while the first svara represents the interval between the 1st and 2nd single tone of the scale. Consequently, the structure of the basic old Indian scale, the sa-grama, is as follows (the Roman numbers designate the degrees of the scale, the Arabic ones the shruti values of the intervals between them):

I II III IV V VI VII I
4 3 2 4 4 3 2

Bharata's twofold approach caused a great deal of confusion and controversy among his interpreters; some of them, such as Hornbostel (Reference 8; p. 437), Lachmann (Ref. 9; p. 73ff.), and Popley (Ref. 10; p. 34) arrive at the conclusion outlined above, while others, such as Clements (Ref. 1; p. 48) and Danielou (Ref. 3; pp. 113-4) claim that the intervals between the tones of the scale correspond to the first of the two sets of shrutis given by Bharata for the sa-grama, thus confounding the values of the level differences with those of the svaras themselves; finally, Sachs adheres to the latter interpretation but attempts to justify his standpoint by considering authentic only verse 25 of the above analyzed part of Bharata's treatise and by assuming that the following four verses are "a later addition and an unexpected, unnecessary and contradictory restatement" (Ref. 11; p. 167). However, the above outlined considerations disclose that the two parts of Bharata's statement are not only not contradictory but thoroughly complementary and consistent. The ma-grama, the second basic scale dealt with in Bharata's treatise, will be discussed later on.

It has been necessary to clarify the connection between the seven svaras and Bharata's two series of shruti values before proceeding to the examination of the nature of the shrutis themselves. Since Bharata distinguished twenty-two shrutis within one octave, it seemed self-evident that one shruti was equal to one twenty-second of an octave; this would mean that the octave was divided into twenty-two equal parts. This was the generally accepted conception until the beginning of the 20th century. As a matter of fact, the famous English acoustician Bosanquet read in 1877 before the Royal Society in London a paper entitled "On the Hindoo Division of the Octave, with some Additions to the Theory of Systems of the Higher Orders." There Bosanquet fit the presumably equal twenty-two tone temperament of the Hindus within an involved system of various multiple temperaments. Indeed, the equal twenty-two tone scale provides fifths, fourths and major thirds the sizes of which are quite close to those of the corresponding just intervals 2:3, 3:4 and 4:5; the deviation of the fifth and, consequently, of the fourth is of seven cents, and that of the major third only of four cents (one tempered semitone equals 100 cents).

Nevertheless, the hypothesis of an equal temperament has been abandoned in favor of another concept that seemed to correspond far more to musical realities and at the same time to Bharata's text. The latter states that the intervals of 9 and 13 shrutis are samvadi, that is, consonant; it is, therefore, quite justifiable to assume that those two intervals actually represent the fourth 3:4 and the fifth 2:3. The crucial question, however, is whether the system as a whole is based on the cyclic or on the divisive principle, to use the terms suggested by Sachs. The cyclic, or quintal, principle implies the generation of all tones from continuous progressions by fourths and fifths. As a rule, the consecutive tones are obtained by a chain of alternately ascending fifths and descending fourths; it is the up-and-down principle, to use Sachs' terminology. The divisive principle derives the tones by stopping a string at simple fractions of its entire length; so the stopping of one fifth or one sixth of the string produces the major third 4:5 and the minor third 5:6.

Among Western ethnomusicologists and Indian musicians and theorists alike it now is generally assumed that India's standard scales depend on the divisive principle, just as the idea of an equal twenty-two tone temperament had been generally admitted, one or two generations ago. There is, however, strong evidence that the old Indian tone system was based not on the divisive but on the up-and-down, or quintal, principle.

The only stringed instrument which existed in the earlier part of Indian antiquity was the arched harp. We are able to trace back its occurrence as far as five thousand years. The sensational archeological discoveries made on the western bank of the lower Indus, about 30 years ago, reveal to us an amazingly developed civilization during the fourth and third millenia B. C. (Ref. 5; p. 394 ff.). We should have discovered nothing about the music of that time had not Sachs identified a frequent ideogram of its pictographic script as "a vertical arched harp of the type common in early antiquity between the Nile and the Ganges" (Ref. 11; p. 163). After a gap of about two thousand years, we recover the tracks of the harp. We know that the vina, the classical Indian stringed instrument, was not, in antiquity, the tube zither of today but an arched harp. Particularly from the beginning of the 2nd century B. C. until the end of the Gupta dynasty, in the 6th century A. D., there are a large number of representations in which, to quote Coomaraswamy, the vina is consistently depicted as a harp. It is obviously with reference to this harp-vina that the word as it occurs in classical Sanscrit literature is used. We may safely assume that the same harp-vina is referred to in the still earlier Vedic literature; Coomaraswamy concludes that "the descriptions and actual representa-

tions are so consistent and so much in agreement that we are justified in speaking of the harp-vina here described as the old Indian vina" (Ref. 2; p. 244).

How was this instrument tuned? First of all, we can say something about the way it was not tuned: it is self-evident that the divisive principle was not applied since this presupposes stopped strings; further, we know that open-stringed instruments, such as the harpe and the lyre, follow, all over the world, the quintal principle. We have, therefore, to assume that it was the latter principle that shaped the tone system characteristic of Indian antiquity. This has been clearly recognized by Sachs who states: "India must have had the up-and-down principle, and it cannot but be hiding somewhere" (Ref. 11; p. 169). In this connection it is indicative that Yajnavalkya, a sage of the Brahmana period (between the 8th and 6th centuries B.C.) groups the seven svaras as follows: ri with dha, ga with ni, and sa with pa and ma, thus, as Fyzee-Rahamin emphasizes, pointing to the principle of progressions by fifths (Ref. 7; p. 12).

Bharata demonstrates the system of twenty-two shrutis by means of two vinas, without describing these instruments. If, as Coomaraswamy attests, Bharata meant the old harp-vinas, the possibility of a divisive interpretation is, at the very outset, to be excluded; but even if Bharata's vinas represented stringed instruments provided with fingerboards, it is inconceivable that Bharata should have replaced the up-and-down principle, consecrated by a millenial tradition, by the divisive principle without making the slightest reference to such a decisive innovation. We must, therefore, infer that the shruti system originated from the up-and-down principle.

Why, then, has the divisive hypothesis been not only suggested from many sides, but even officially adopted by the All-India Academy as the basis of the Indian tone system? The reason is obvious: the tetrachord of both the divisive and the quintal systems consists of two whole tones and one semitone; but while the quintal tetrachord includes two whole tones of equal size, the divisive tetrachord requires one major and one minor whole tone. Since Bharata indicates two different sizes, namely 4 and 3 shrutis, for the two larger intervals contained in a tetrachord, the possibility of a quintal interpretation seemed to be excluded at the very outset in favor of the divisive one. In order to give the latter hypothesis some kind of historical justification, it has been necessary to maintain the assumption that Bharata's vinas were fingerboard instruments, despite Coomaraswamy's contrary pictorial and literal evidences. The divisive hypothesis assumes that 7 shrutis represented the major third 4:5 or 8:10, and that this interval has been divided into the major whole tone 8:9 of 4 shrutis and the minor whole tone 9:10 of 3 shrutis. The former interval 8:9 belongs in both types of tetrachords while the latter 9:10 is characteristic only of that constructed according to the divisive principle. As for the 4 shruti interval, there is no doubt that it represents the major whole tone 8:9, for this interval derives from the subtraction of the 9-shruti fourth 3:4 from the 13-shruti fifth 2:3. However, the interpretation of the 3-shruti interval as a minor whole tone 9:10 is not only arbitrary but unnecessary because the 3-shruti interval fits, as we shall see, quite well into the quintal system and has to be considered a temperament of the 4-shruti interval. But before dealing with this matter, it is necessary to discuss the actual meaning of the allocation of twenty-two shrutis within one octave. For the supporters of the divisive concept it has been no easy task to arrive at the required number of shrutis. Hornbostel and Lachmann have attempted to trace the origin of the system back to a hypothetical instrument supposed to be related to the Chinese K'in. After a whole series of alterations of the actual fingerboard of the K'in the two scholars finally arrive at a hypothetical fingerboard of Bharata's vina which in fact includes twenty-two shrutis within the octave (Ref. 9; p. 81 ff.); but a similar method would allow one to establish also any other desired number of shrutis. Fox-Strangways approaches the problem in a different way: he projects all 14 murchanas, that is, the whole of the theoretically possible modal varieties, mentioned by Bharata, into the same octave, but, unfortunately, gets only twenty instead of the twenty-two expected shrutis; so he adds the lacking two shrutis "by analogy" (Ref. 6; p. 114). Danielou, on the contrary, was forced to eliminate one shruti when his calculations led him to the number of twenty-three (Ref. 3; pp. 121-2). Finally, Clements' painstaking calculations yield twenty-five shrutis within the octave. This time, however, it is Bharata himself and the other old Indian theorists who are accused of having made a mistake, and Clements insists that the real number of shrutis is not twenty-two but twenty-five (Ref. 1; p. 101). Still, the majority of the all-Indian Musical Conference has voted in favor of the consecrated number of twenty-two shrutis within the octave.

After this short survey of the divergent divisive approaches to the shruti problem it will be shown how the complex of twenty-two shrutis forms an organic part of the quintal system. First of all, however, the meaning of the shruti concept has to be discussed. Was it but a simple expedient to determine roughly the three different sizes of the svaras or did it involve an actual subdivision of the octave into twenty-two tones? The way in which Bharata utilizes the shrutis hints at the former interpretation; on the

other hand, since each of the twenty-two shrutis has its proper name, one should infer that each of these twenty-two names has its distinctive meaning. Does this, then, involve the assumption of a basic division of the octave into twenty-two tones? By no means. Both the general tonal structure of Indian music and the nature of the quintal principle from which, as we saw, the 22-shruti complex must have originated converge into the concept of a system of twelve tones within the octave, that is, a collective chromatic scale into which all heptatonic and other Indian scales and modes may be projected if differentiations in intonation of secondary structural importance are not taken into account.

Both the Northern or Hindustani school and the Southern or Carnatic school are based on the principles stated in the ancient Sanscrit treatises on music. But the South, thanks to its geographical situation, has been much less exposed to foreign influences and hardly affected by such events as the bloody Mohammedan invasion and conquest. It is, therefore, mainly the South where the musical tradition has been able to be transmitted from generation to generation, during centuries and millenia. If we compare North and South, we see first of all that the theoretical foundations of the Southern musical style are far more consistent than those of the Northern one; so far as basic principles of tonal structure are concerned, it is very indicative that, in contradistinction to the Hindustani, the Carnatic school has recognized and maintained the concept of a fundamental collective twelve tone complex as the basis for all individual scales and modes. Captain Day, in his standard book on the Music of Southern India, states: "The Hindu octave, like the European, is divided into twelve semitones," and "the employment of shrutis or intervals less than semitones is limited to grace" (Ref. 4; pp. 30 and 31). The great exponent of the theories of South Indian music, Pandit Venkatamakhin who lived in the beginning of the 17th century and whose scholastic succession is supposed to go right back to Sharngadeva, the famous theorist of the 13th century, established a sound and exhaustive classification of ragas, or melody types, which is based entirely on the twelve semitones. Did this scale depend on the divisive or on the up-and-down principle? Pandit Subrahmanya Sastri's study entitled "Venkatamakhin and his twelve notes" (Ref. 12) gives this question an indirect but unmistakable answer. Sastri presents the complete series of ratios for the intervals of Venkatamakhin's twelve tone scale. He adds that this series "will show at a glance the calculations and results arrived at by the application of Venkatamakhin's method," and he emphasizes that "after closely scrutinizing the above, one may fairly conclude that there will be no more room for any difference of opinion regarding Venkatamakhin's view" (Ref. 12; p. 23). If we examine this series of ratios,

$$1 \quad \frac{256}{243} \quad \frac{9}{8} \quad \frac{32}{27} \quad \frac{81}{64} \quad \frac{4}{3} \quad \frac{1024}{729} \quad \frac{3}{2} \quad \frac{128}{81} \quad \frac{27}{16} \quad \frac{16}{9} \quad \frac{243}{128} \quad 2$$

we recognize that they are exclusively built upon two geometrical progressions, one of ratio 2, that is, 1:2:4:8:16:32:64:128:256:(512:)1024, and the other one of ratio 3, that is 1:3:9:27:81:243:729. This means that Venkatamakhin's twelve-tone scale depended entirely on the up-and-down principle. A strict application of this principle yields a very unsatisfactory octave since a twelvefold up-and-down progression by fifths and fourths results in an interval which exceeds the just octave by the Pythagorean comma, that is, by 24 cents or nearly one quarter of a tempered semitone. Sastri's series of ratios reveals to us the way in which Venkatamakhin has met the problem (see Fig. 1). Starting from the lowest tone, say, D, he progresses five times by alternately ascending fifths and descending fourths, and gets the tones A (3:2), E (9:8), B (27:16), F# (81:64) and C# (243:128); then he starts from the higher octave of D and progresses six times by alternately descending fifths and ascending fourths, and gets the tones G (4:3), C (16:9), F (32:27), B-flat (128:81), E-flat (256:243) and A-flat (1024:729). In this way he obtains a twelve tone scale within the octave 1:2 in which all fifths and fourths are just, except the interval A-flat C# (see Fig. 2).

Strange enough, Venkatamakhin's approach is identical with that applied in the Western Pythagorean system of the Middle Ages. In describing the Indian system the basic tone has been named D in order to make a consistent comparison with the Western approach possible. In fact, if one considers D, which has been the tonic of the first church tone, as starting point of the Western Pythagorean system, one arrives, East and West, at exactly the same "wolf," that is, at the same false fourth or fifth A-flat C#.

The up-and-down principle and the 12-tone scale are closely related to each other; in fact a quintal chromatic scale could be defined as the projection of a cycle of fifths or fourths into one octave. The Pythagorean scale is usually considered as an untempered one because all fourths and fifths included in it are pure except one. But it is just that one exception which constitutes a temperament of utmost importance, since the narrowing, or tempering, by one Pythagorean comma, of the last step of a twelvefold up-and-down progression transforms the false octave of 1224 cents into a pure one.

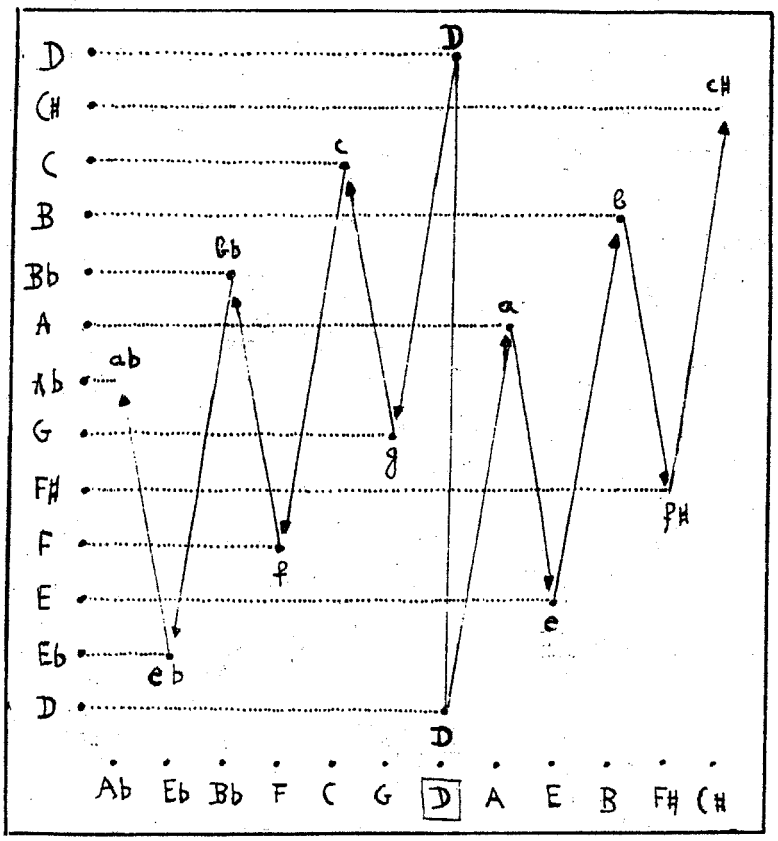

D
C#
C
B
Bb
A
Ab
G
F#
F
E
Eb
D
ab
eb
Bb
f
c
g
D
a
e
b
f#
c#
Ab Eb Bb F C G D A E B F# C#

Fig.1

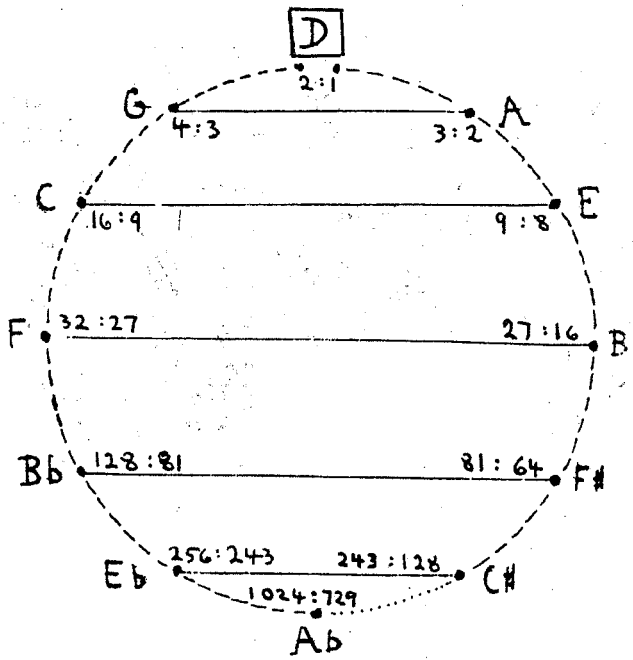
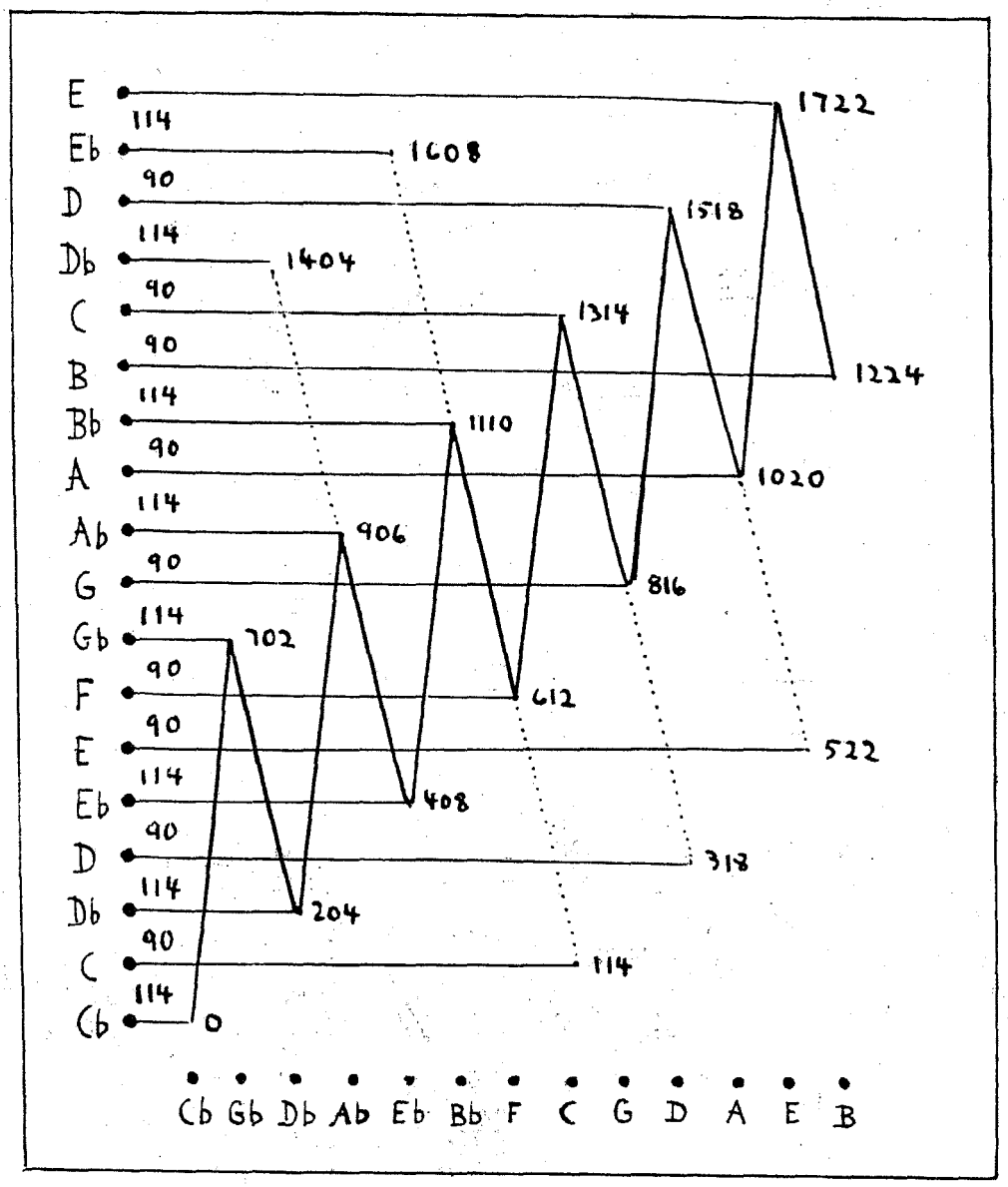

D
2:1
G
A
4:3
3:2
C
E
16:9
9:8
F
B
32:27
27:16
Bb
F#
128:81
81:64
Eb
C#
256:243
243:128
1024:729
Ab

Fig.2

This twelve-tone scale must have been preceeded by an entirely untempered one which was strictly based on the up-and-down principle and which, therefore, might be termed an untempered quintal chromatic scale, in contradistinction to the Pythagorean one. Starting, say, from C-flat, a twelvefold up-and-down progression yields the scale C-flat, D-flat, E-flat, F, G-flat, G, A-flat, A, B-flat, B, C, D, E; a fourth down from F, G and A, and a fifth up from G-flat and A-flat complete that scale to the following untempered quintal chromatic scale: C-flat, C, D-flat, D, E-flat, E, F, G-flat, G, A-flat, A, B-flat, B, C, D-flat, D, E-flat, E (see Fig. 3).



The Untempered Quintal Chromatic Scale

Fig. 3

A similar result may be, evidently, obtained if the up-and-down progression starts with an ascending fourth or a descending fourth or fifth, instead of an ascending fifth.

The modern Western tone system includes not more than 12 different varieties of intervals within one octave; this is, however, by no means the case with any other twelvefold division of the octave. The twelve-tone scale just mentioned is shaped by two sizes of semitones: the diatonic one of 90 cents, and the chromatic one of 114 cents, the difference being of one Pythagorean comma. This, obviously, involves similar differentiations between the larger intervals, too. When counting the various kinds of intervals contained in that scale, one finds that there are exactly twenty-two different

sizes which do not exceed one octave. As the following table reveals (see Fig. 4), each interval of the modern Western twelve-tone scale (column 2) is represented by two sizes differing from each other by one Pythagorean comma. However, there are two exceptions: the interval of seven and that of twelve semitones are each represented by one size only. As far as the latter is concerned, the scale contains, it is true, a second variety, the augmented seventh (or false octave) C-flat B of 1224 cents; however, since its size exceeds that of an octave by one comma, it has to be excluded from a classification of intervals within the octave. The former interval, that of seven semitones, occurs only as a perfect fifth of 702 cents while the second variety, that of the diminished sixth of 678 cents, is lacking. At first sight, this might seem surprising since the inversion of that interval, the augmented third of 522 cents is represented by the intervals

INTERVALS NOT EXCEEDING ONE OCTAVE

CONTAINED IN THE UNTEMPERED QUINTAL CHROMATIC SCALE

Serial Numbers	Numbers of Semitones	Kind of Interval	Example	Ratio	Size in Cents
1	1	Diat. Semitone	C D-flat	$(\frac{3}{2})^5 : 2^3$	90
2		Chrom. Semitone	C-flat C	$(\frac{3}{2})^7 : 2^4$	114
3	2	Dim. Third	E G-flat	$(\frac{3}{2})^{10} : 2^6$	180
4		Maj. Second	C D	$(\frac{3}{2})^2 : 2$	204
5	3	Min. Third	E G	$(\frac{3}{2})^3 : 2^2$	294
6		Augm. Second	D-flat E	$(\frac{3}{2})^9 : 2^5$	318
7	4	Dim. Fourth	E A-flat	$(\frac{3}{2})^8 : 2^5$	384
8		Maj. Third	C E	$(\frac{3}{2})^4 : 2^2$	408
9	5	Perf. Fourth	C F	$\frac{3}{2} : 2$	498
10		Augm. Third	C-flat E	$(\frac{3}{2})^{11} : 2^6$	522
11	6	Dim. Fifth	D A-flat	$(\frac{3}{2})^6 : 2^4$	588
12		Tritone	D-flat G	$(\frac{3}{2})^6 : 2^3$	612
13	7	Perf. Fifth	C G	3 : 2	702
14	8	Min. Sixth	C A-flat	$(\frac{3}{2})^4 : 2^3$	792
15		Augm. Fifth	D-flat A	$(\frac{3}{2})^8 : 2^4$	816
16	9	Dim. Seventh	E D-flat	$(\frac{3}{2})^9 : 2^6$	882
17		Maj. Sixth	C A	$(\frac{3}{2})^3 : 2$	906
18	10	Min. Seventh	D C	$(\frac{3}{2})^2 : 2^2$	996
19		Augm. Sixth	C-flat A	$(\frac{3}{2})^{10} : 2^5$	1020
20	11	Dim. Octave	D D-flat	$(\frac{3}{2})^7 : 2^5$	1086
21		Maj. Seventh	D-flat C	$(\frac{3}{2})^5 : 2^2$	1110
22	12	Perf. Octave	C C	2 : 1	1200

Fig. 4

C-flat E and G-flat B. However, we have to keep in mind that we are here faced with the untempered quintal chromatic scale; therefore, the inversion of the augmented third C-flat E will yield not the diminished sixth E C-flat but the perfect fifth E B, and the inversion of the augmented third G-flat B will yield not the diminished sixth B G-flat but the perfect fifth C-flat G-flat (see Fig. 5). So we see that the untempered quintal chromatic scale contains a variety of twenty-two intervals within the octave.

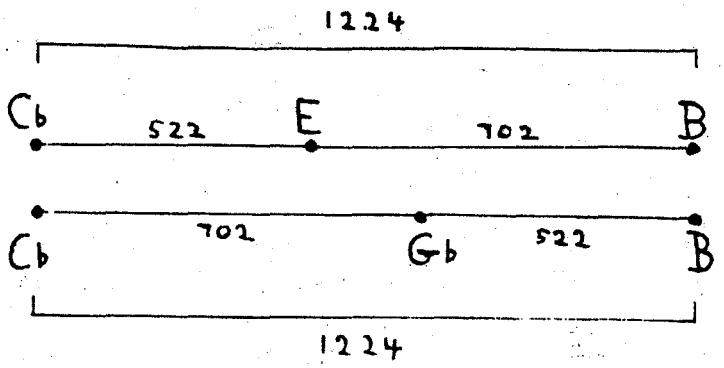


Fig. 5

An examination of the available historical facts shows that the old Indian twenty-two shruti system is nothing else than a classification of those twenty-two sizes of intervals contained within one octave of the untempered quintal chromatic scale. The intervals have simply been arranged according to their sizes (as in Fig. 4) and named by their serial numbers; for example, when Bharata speaks of the consonance of the nine and thirteen shruti interval, he means the ninth and thirteenth interval of that series, which, indeed, is the perfect fourth and the perfect fifth. This approach is reminiscent of the basic Western serial classification of intervals into seconds, thirds, fourths and so on, according to the distance of their two tones within a diatonic scale. The classification, by the old Indian theorists, of all interval varieties conceivable within the tone system is by no means surprising; it represents a quite modest example of the general trend characteristic of all Oriental civilizations to exhaust the theoretical possibilities of any musical system. So an Indian theorist states that the number of possible prastaras, that is, changes, within the series of the seven svaras is exactly 13678 (Ref. 6; p. 155).

It has already been shown why the shruti system must have originated during the pre-Bharatean harp-vina period where the up-and-down principle was the only conceivable one. However, the application of the latter implies in itself, neither the knowledge of the twelve tones contained in the cycle of fifths nor that of the Pythagorean comma since on the seven-stringed harp-vina but six up-and-down progressions were needed in order to produce the seven tones of the gramas. On the other hand, the shruti system, such as applied by Bharata, reveals to us that both the nature of the Pythagorean comma and the whole complex of tone relations included within the cycle of fifths must have been known to the theorists of the pre-Bharatean period: shruti, from root shru, "hear," means the (smallest) "audible sound" (Ref. 6; p. 108). This characterizes in the first place that sort of shruti which Bharata terms pramana or "distinctive" shruti and which, later on, has been called kaishik or "of a hair's breadth," thus, a very small interval, comparable to a Western "comma." Since the shruti system has grown out of the Pythagorean principle, the pramana shruti is necessarily to be identified with the Pythagorean comma; on the other hand, the knowledge of that comma presupposes the application of a twelvefold up-and-down progression, and thus the awareness by Bharata and his precursors of the whole twelve-tone complex derived from the cycle of fifths.

Should we infer from these facts that the old Indian theorists obtained their knowledge of the cycle of fifths and of the inherent problem of the Pythagorean comma by a merely theoretical extension of the actual sixfold up-and-down progression or, perhaps, through Chinese or Greek sources? Although the possibility of foreign influences is not quite excluded, an unprejudiced study of Bharata's text discloses that, in fact, the complete quintal chromatic scale and, consequently, the phenomenon of the Pythagorean comma has been derived practically from the old Indian harp-vinas.

Bharata's text culminates in a demonstration of the twenty-two shruti system by means of two vinas. This essential part of Bharata's treatise has proved a stumbling-

block to the supporters of the divisive hypothesis who are bound to misinterpret completely Bharata's words or to find them senseless or unintelligible. For example, Clements, to whom we owe a translation into English of fourteen verses of Bharata's treatise, simply skips that part and adds that "nothing would be gained by transcribing further passages from Bharata" (Ref. 1; p. 53). Hornbostel and Lachmann deem it necessary to insert after each phrase of Bharata one more of their own which completely changes the sense of Bharata's statements (Ref. 9; p. 75). Finally, Fox-Strangways, after a similar misinterpretation of Bharata's text, suggests that one should not take the words literally, since otherwise one might get quite a wrong idea of the old Indian scales (Ref. 6; p. 112).

However, just the contrary is true, and we shall see that if we but follow Bharata's indications strictly to the last comma without any attempt to amend his statements, we shall get a quite correct idea of the old Indian tone system.

According to the divisive hypothesis, Bharata's seven stringed vinas were zithers or lutes provided with fingerboards and numerous stops so that one single instrument would certainly have sufficed to demonstrate the peculiarities of the tone system. Hornbostel's and Lachmann's hypothetical vina fingerboard, for example, contains not less than 50 stops distributed among five of the seven strings (Ref. 9; p. 83). It has been previously shown that for historical reasons one has to assume that Bharata's instruments were identical with the old harp vinas. But even if one takes the divisive fingerboard assumption for granted, the only explanation for the use of two such instruments by Bharata would be the maintenance of a tradition stemming from the older harp vina period. So one is, in any case, bound to connect the shruti system with an ensemble of two harp vinas. As a matter of fact, it is not unusual to find two harp vina players depicted together in early representations (Ref. 2; p. 245).

What was the nature of the accordatura of those instruments? We know that (1) the usual number of strings was seven, that (2) Indian music has been, at least since the 4th century B.C., basically heptatonic, and that (3) the harps obeyed the up-and-down principle. So we may safely assume that the scale of a harp vina was a diatonic one obtained by a sixfold up-and-down progression. Although it is possible to get any of the seven modal varieties by an appropriate combination of fourth and fifth steps, a strict application of the up-and-down principle yields but two scales: C D E F G A B, or the C-mode, and F G A B C D E, or the F-mode. According to whether the first step is a descending or ascending fourth or fifth, four kinds of regular up-and-down progressions are to be distinguished. If one takes F as common starter, one arrives at the following four types of scales:

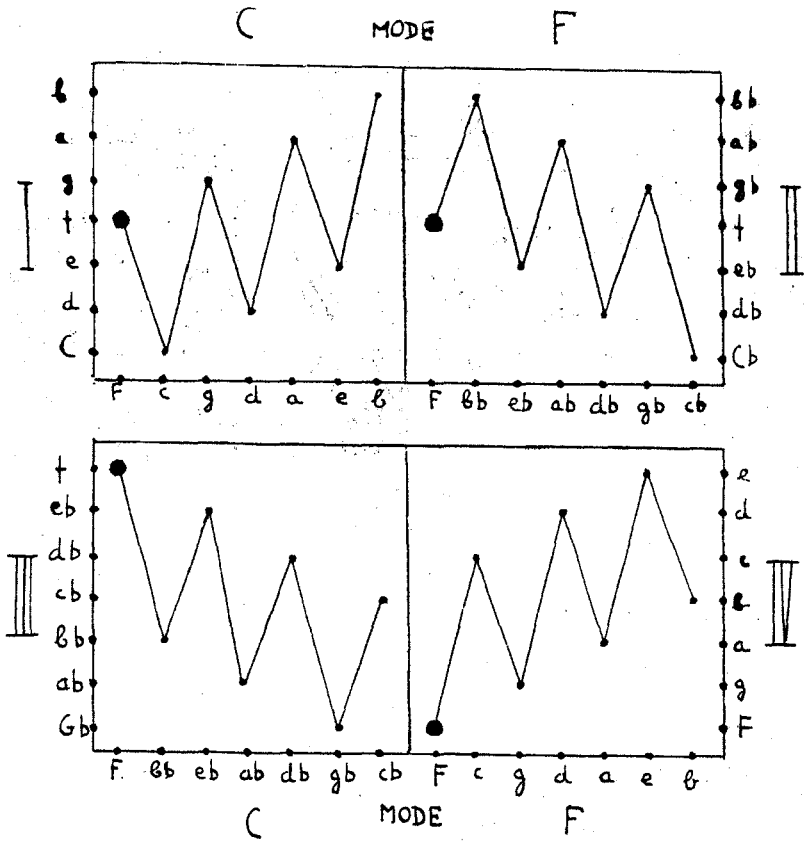


Fig. 6

We shall see that the two modes arrived at by a strict sixfold up-and-down progression are the prototypes of the two old Indian standard scales, that is, the sa-grama originated from the untempered quintal C-mode and the ma-grama from the untempered quintal F-mode; so there is no doubt that the harp vina players employed both kinds of accordaturas. It has been shown that each of the two scales can be obtained by two different kinds of up-and-down progressions: the C-mode if the progression starts with a descending fourth or fifth (I and III, see table), the F-mode if it starts with an ascending fourth or fifth (II and IV). As long as one single instrument is used, the kind of the up-and-down progression employed is of secondary importance; but since both Bharata's demonstration of the tone system and the pictorial representations of the harp vina players involve an ensemble of two instruments, the above question becomes essential. According to Bharata, the primary mode was the sa-grama from which the ma-grama had been derived; so Bharata starts his demonstration with two instruments tuned identically in the sa-grama. The demonstration consists basically in a successive lowering of all seven tones of one vina by a semitone. After the lowering of six tones of the scale the accordatura has changed from the sa-grama, or C-mode, to the ma-grama, or F-mode. A glance at the previous diagrams of the four types of sixfold up-and-down progressions shows that the change from the C-mode to the F-mode, such as described by Bharata, cannot but originate in the change from accordatura I to accordatura II where all seven tones, except the starter F, are lowered by a semitone. In this way, the ensemble of the two vinas yields a tone material consisting of thirteen different pitches. In order to clarify the problem of the twenty-two shrutis and the two gramas it is necessary to establish first the exact construction of the tone complex resulting from the combination of those two accordaturas. If one gives the common starter F the value of 0 cents, the structure of the two diatonic scales will be the following:

C-mode

C	D	E	F	G	A	B
-498	-294	-90	0	204	408	612

F-mode

Cb	Db	Eb	F	Gb	Ab	Bb
-612	-408	-204	0	90	294	498

(The cent values for the C-mode are obtained by alternately subtracting a perfect fourth of 498 cents and adding a perfect fifth of 702 cents; the values for the F-mode are obtained by alternately adding a perfect fourth of 498 cents and subtracting a perfect fifth of 702 cents.) Comparing the two scales, one states that the latter constitutes an exact mirror of the former; the importance of that fact will be discussed later on. In order to obtain the combined scale, it is convenient to give the lowest tone, that is C-flat, the value of 0 cents. Since in the above series C-flat equals -612 cents, all remaining tones will have to be raised by that amount; this yields the following scale:

	114		318		522	612		816		1020		1224
	C		D		E	F		G		A		B
Cb		Db		Eb		F	Gb		Ab		Bb	
0		204		408		612	702		906		1110	

An examination of this tone complex reveals that we are here faced with exactly the same untempered quintal chromatic scale that includes the twenty-two shruti varieties within one octave (see Fig. 3). So we see that the twenty-two shruti system actually derives from an ensemble of two harp vinas such as demonstrated by Bharata and frequently depicted in old sources.

The coexistence of these two quintal diatonic scales involves the problem of temperament since the highest tone B of one vina forms a false octave with the lowest tone C-flat of the other vina. So we may safely assume that at a certain moment of old Indian history the false octave C-flat B of 1224 cents has been reduced by one pramana shruti, that is, by one Pythagorean comma, to a just octave of 1200 cents. Theoretically, this temperament could be effectuated either by raising the C-flat or by lowering the B; practically, however, only the latter solution can be conceived since the C-flat constitutes the fundamental note of the F-mode. The lowering of the B involves a similar adjustment of its lower fifth E in order to maintain the just intonation of that interval.

Which are the exact interval values for this tempered C-mode? If one assigns to C the value of 0 cents, the values for the untempered C-mode are:

0	204	408	498	702	906	1110
C	D	E	F	G	A	B
	204	204	90	204	204	204

The lowering of E and B by one pramana shruti yields the following tempered C-mode:

0	204	384	498	702	906	1086	1200
C	D	E	F	G	A	B	C
	204	180	114	204	204	180	114

Each of these interval values is represented in the previously established twenty-two shruti system (see Fig. 4). If one replaces the cent values of the above scheme of the tempered C-mode by the corresponding shruti values, one obtains the following series:

0	4	7	9	13	17	20	22
C	D	E	F	G	A	B	C
	4	3	2	4	4	3	2

This shruti series is identical with that indicated by Bharata for the sa-grama; so we see that Bharata's sa-grama is a Pythagorean C-mode with the 3rd and 7th degree lowered by a Pythagorean comma. The following scheme shows the exact construction of that basic old Indian scale:

	180	114	204	204	180	114	204	
	3	2	4	4	3	2	4	
CD	DE	EF	FG	GA	AB	BC		(CD)
sa	ri	ga	ma	pa	dha	ni		sa
4	3	2	4	4	3	2		
204	180	114	204	204	180	114		

The upper two rows give the values in cents and shrutis of the level differences between the svaras, in accordance with Bharata, Verse 25, while the lower two rows indicate the values in shrutis and cents of each single shruti, in accordance with Bharata, Verses 26-27.

Let us now proceed to a detailed description of that essential part of Bharata's demonstration of the twenty-two shruti system which, hitherto, has been considered unintelligible or senseless. Bharata uses for his demonstration two vinas both identically tuned in the sa-grama. All seven svaras are to be lowered so as to become the next lower ones. This operation is to be effectuated in three stages: first ni and ga become dha and ri, then dha and ri become pa and sa, and finally, pa, sa and ma become ma, ni and ga (Ref. 6; p. 112). Since, according to Bharata, each svara constitutes an interval and not a single note, the question raises whether the higher or the lower tone of the svaras has to be lowered. We saw that in an ascending scale the level differences between the svaras are equal to the differences between their higher tones. Does this mean that Bharata's demonstration consists in a continuous lowering of the higher note of the svaras? The contrary is true: the Indian approach expresses the lowering of the higher tone of a svara by saying that the svara gives a part of its shrutis to its next higher svara; e.g., ni would give away a part of its shrutis to sa; on the other hand, the lowering of the lower tone of a svara is expressed by saying that the svara takes a part of the shrutis of its next lower svara; so ni would take a part of the shrutis of dha. Since Bharata circumscribes the lowering of ni by saying that it becomes dha, the lowering of ga by saying that it becomes ri, and so forth, it is evident that Bharata's demonstration consists in a continuous lowering of the lower and not of the higher tones of the svaras of one of the two vinas. So the successive lowering of ni, ga, dha, ri, pa, sa and ma means the successive lowering of B, E, A, D, G, C and F, that is, of the seven tones of the sa-grama in an order which obeys the up-and-down principle. This principle admits but one way of tuning, namely, by fourths and fifths. The only interval which in a C-mode could possibly be transformed into a perfect fourth or fifth is the augmented fourth F B by changing the B into B-flat. This creates the diminished fifth E B-flat which, in turn, has to be transformed into a perfect fifth by lowering the E into E-flat. So it is understandable why Bharata starts the series of the tones to be lowered by B and E.

Which is the exact construction of Bharata's scale at the end of this first stage of his demonstration? It has been shown that the sa-grama, expressed in cents, reads as follows:

0	204	384	498	702	906	1086	(1200)
C	D	E	F	G	A	B	(C)
	204	180	114	204	204	180	114

One has to add a perfect fourth, or 498 cents, to the value of F in order to obtain B-flat; so the seventh tone of the scale gets 996 cents instead of 1086. From these 996 one has to subtract a perfect fifth, or 702 cents, in order to obtain E-flat; so the third tone of the scale gets 294 cents instead of 384. This yields the following series:

0	204	294	498	702	906	996	1200
C	D	Eb	F	G	A	Bb	C
	204	90	204	204	204	90	204

The series represents a strictly Pythagorean D-mode since the tempered E and B of the sa-grama have been eliminated; therefore, the subsequent series obtained during Bharata's demonstration will also be strictly Pythagorean.

In the second stage of the demonstration the augmented fourth E-flat A is transformed into the perfect fourth E-flat A-flat, and the new diminished fifth D A-flat into the perfect fifth D-flat A-flat. This gives the following series:

0	90	294	498	702	792	996	(1200)
C	Db	Eb	F	G	Ab	Bb	(C)
	90	204	204	204	90	204	204

In the third stage of the demonstration Bharata changes the augmented fourth D-flat G into the perfect fourth D-flat G-flat and the new diminished fifth C G-flat into the perfect fifth C-flat G-flat and obtains the following scale:

-114	90	294	498	588	792	996
Cb	Db	Eb	F	Gb	Ab	Bb
	204	204	204	90	204	204

or, if one assigns the value of 0 cents to the lowest tone C-flat:

0	204	408	612	702	906	1110
Cb	Db	Eb	F	Gb	Ab	Bb
	204	204	204	90	204	204

This series represents an untempered quintal F-mode arrived at by a sixfold up-and-down progression with the ascending fourth F B-flat as starter; we are thus faced with exactly the same construction as that previously described as a result of the change of one of the two harp vinas from the C-mode into the F-mode.

In the pre-Bharatean untempered system the C-flat of the second vina formed with the B of the first one a false octave of 1224 cents; however, in Bharata's sa-grama where the E and B are lowered by one comma the C-flat of the second vina yields a just octave with the lowered B of the first one. Bharata extends his demonstration by changing the augmented fourth C-flat F into the perfect fourth C-flat F-flat. Since the E of the first vina is lowered by one comma, it coincides with the F-flat of the second vina.

At the end of Bharata's demonstration the second vina is tuned in an untempered quintal C-mode with C-flat as fundamental note; this C-flat lies one chromatic Pythagorean semitone of 114 cents below the fundamental note C of the unchanged sa-grama of the first vina. So the combined scales of the two vinas yield the following tone material:

114	318	498	612	816	1020	1200
C	D	E	F	G	A	B
Cb	Db	Eb	Fb	Gb	Ab	Bb
0	204	408	498	702	906	1110

It is a normal Pythagorean chromatic scale, similar to that described by Venkatamakhin; this time, however, with the "wolf" between F-flat and A.

Bharata's demonstration is designed to show (1) that the shruti system derives from the quintal chromatic scale and (2) that this scale can be derived from a combination of two basic diatonic scales. However, one has to keep in mind that the shruti system originated in the pre-Bharatean untempered quintal chromatic scale while Bharata's system represents a tempered, and thus later stage of the shruti and grama construction.

We have seen that the two gramas were originally obtained on two seven-stringed harp vinas by two sixfold up-and-down progressions starting from the same tone but developing in opposite directions. Strictly speaking, the ma-grama derived from the sa-grama by the lowering of all tones except the common starter of the up-and-down progression. However, there is a much simpler way of changing from the sa- into the ma-grama: instead of the above outlined retuning of six strings it suffices to leave all tones unchanged except the original starter of the up-and-down progression which has to be raised from F to F# so as to become a perfect fourth of B. Which is the exact structure of a ma-grama obtained that way?

It has been shown that Bharata's sa-grama reads as follows:

0	204	384	498	702	906	1086	1200
C	D	E	F	G	A	B	C
	204	180	114	204	204	180	114

In order to change the F into the lower fourth of B one has to replace the cents value of F = 498 by 1086-498 = 588; this yields the following ma-grama:

0	204	384	588	702	906	1086	1200
C	D	E	F#	G	A	B	C
	204	180	204	114	204	180	114

Since the original svara sa (CD) has now become ma, we arrive at the following series of svara values for the ma-grama:

	ma	pa	dha	ni	sa	ri	ga
Cents:	204	180	204	114	204	180	114
Shrutis:	4	3	4	2	4	3	2

These values are identical with those indicated by Bharata for the svaras of the ma-grama in verses 28-29 of his treatise: "Verse 28: In the Madhyam Grama ma is of 4, pa of 3, dha of 4. Verse 29: Ni of 2, sa of 4, ri of 3, ga of 2" (Ref. 1; p. 51). In the commentary to verse 25 Bharata draws attention to the fact that in the ma-grama the svara pa is lowered by one pramana shruti in comparison with the pa svara of the sa-grama; it is the next higher svara dha which benefits from this lowering of pa. So the values of pa and dha are inverted in the two gramas.

There exist various attempts to explain that slight differentiation between the two basic gramas; however, the explanation given above is by no means a merely hypothetical one. The careful reader of Bharata's treatise will discover that Bharata himself speaks of that other way to change from the sa-grama to the ma-grama; in his commentary to Verse 35 he states: "Each murchana," that is, mode, "is produced in two ways; thus in the sa-grama, when ga is raised two shrutis and made into dha" (Ref. 1; p. 51). The following table will illustrate that (1) by raising ga two shrutis and thus by changing it into dha, the sa-grama changes into the ma-grama and (2) that in the latter the values for the svaras pa and dha are inverted compared with those contained in the sa-grama, quod erat demonstrandum.

	CD	DE	EF	FG	GA	AB	BC
Sa-grama:	sa	ri	ga	ma	pa	dha	ni
	4	3	2	4	4	3	2

	FG	GA	AB	BC	CD	DE	EF
Ma-grama:	ma	pa	dha	ni	sa	ri	ga
	4	3	4	2	4	3	2

It is evident that the slight difference of one comma in the intonation of pa hardly constitutes a basic distinctive feature between the two gramas; moreover, this differentiation presupposes the tempered, thus later, form of the sa-grama; finally, both the essential part of Bharata's demonstration of the twenty-two shruti system and the previously discussed considerations concerning the origin of that system reveal that the change from the sa-grama into the ma-grama has originally been effectuated not by raising but by maintaining the common starter of the two up-and-down progressions. Some scholars interpret the distinction between the two gramas as the plagal and authentic form of a similar mode, a distinction, however, which, according to Fox-Strangways "is on the whole foreign to Indian music" (Ref. 6; p. 179).

We saw that Bharata conceived the svaras in the first place as intervals comprising two consecutive notes of the scale. When a svara was used to denominate a single note, it was, according to the generally admitted opinion, not the lower but the higher tone of the interval-svara that was meant in antiquity, contrary to the modern Indian usage where the name of an interval-svara is identified with its lower note. True, Bharata uses, as a rule, the higher limit of a svara for the designation of a single note; however, Bharata's demonstration of the twenty-two shruti system reveals that there the consecutive lowering of the seven svaras means the lowering of their lower notes, otherwise Bharata's statement that the svaras change into their next lower ones would make no sense.

So far as earlier Indian antiquity is concerned, the interpretation of a svara in the sense of the higher limiting note of an interval is still less tenable. There is no controversy about the fact that the names used to designate the scale of the pre-Buddhistic Saman chant meant single notes and not intervals. The purely vocal Saman

chant had a tetrachordic nucleus the notes of which were counted downward and named prathama, dvitiya, trtiya, and caturtha, that is, first, second, third, and fourth note (Ref. 6; p. 257). In the old Indian source Rikpratishakya which, according to Fox-Strangways (Ref. 6; p. 258) goes back as far as at least the fourth century B. C., it is stated that "the Yama is the Svara," which means that the liturgical scale corresponds to the instrumental one (Ref. 10; p. 30). From this close correlation between the Saman and the svara scale we may infer that the svaras originally meant single notes just like the notes of the Saman scale. Moreover, the fact that the seven strings of the old Indian harp-vina used to represent the seven svaras implies that the svara originally meant a single note.

It has been shown that the seven notes of the sa-grama constitute a C-mode; consequently the pre-Bharatean svaras will have to be identified as follows:

sa	ri	ga	ma	pa	dha	ni
C	D	E	F	G	A	B

This statement is important in view of a just evaluation both of the Saman scale and of the grama system. The ancient treatise Taittiriya-Pratishakhya contains precise indications concerning the interrelationship between the two scales (Ref. 6; p. 258); there the four notes of the tetrachordic nucleus of the Saman scale are identified with four consecutive svaras, that is, prathama with ga, dvitiya with ri, trtiya with sa and caturtha with ni. The tetrachord gradually extended towards both sides until a total range of two tetrachords was reached. The first additional note was mandra which means "low." Mandra follows caturtha in a downward trend and has, therefore, to be identified with dha. The note mandra is mentioned as early as the fourth century B. C. in the previously quoted Rikpratishakya; there, however, trtiya is omitted. So we get the scale:

prathama dvitiya caturtha mandra

which, according to Taittiriya-Pratishakhya, corresponds to the notes ga, ri, ni, and dha. These four svaras represent, following the above given table, the scale E D B A. If trtiya (or sa) is inserted, one arrives at the pentachordic construction E D C B A. This scale, if read upward, is identical with the raga Abhogi which, according to a South Indian tradition, constitutes the ancient Saman chant (Ref. 10; p. 27). If we took the svaras of Taittiriya-Pratishakhya in the sense of upper limiting notes of intervals, as it has usually been done, we should arrive at the tritone B F instead of the fifth A E as frame interval. So far as the nucleus of the Saman scale is concerned, we see that it represents the descending series E D C B which is identical with the Dorian tetrachord, the nucleus of the old Greek tone system.

The statement mentioned previously, contained in the very early Rikpratishakya, that the liturgical scale is the instrumental one justifies the assumption that originally the svaras of the two basic gramas were counted downward like the notes of the Saman chant. This would explain the name of the lowest tone of the sa-grama, Shadja, which means "born of six," that is, the svara which follows the six higher ones. Above all, however, this concept would clarify the old problem of the ga-grama. Nothing definite is known about this grama which was not mentioned by Bharata but which is supposed to be of very early origin. By analogy with the two basic gramas it is generally assumed that the ga-grama has constituted an ascending series of shrutis beginning with ga. It is inconceivable that this grama was unknown to Bharata; so why did he not deal with it? If one considers that the gramas originally were conceived downward, the starting svara of the ma-grama would be ga; so one might assume that the ga-grama was nothing else than the ma-grama named after its original starter. This hypothesis would shed some light on both an established Indian tradition that the ga-grama was abandoned because it was "too high" for the voice (Ref. 10; p. 35) and a statement by the famous theorist Sharngadeva that the ga-grama retired to heaven (Ref. 6; p. 110).

Last but not least, Bharata's comment on the svara ma, or Madhyama, calls for an explanation. Bharata says textually: "Madhyama is the eldest (pravara), the imperishable (anashin), the note fixed by the singers of the Samaveda in the Gandharvakalpa (musical treatise), and the note which would still subsist though all the other notes of the mode should disappear" (Ref. 10; pp. 142-3). Madhyama, which means "middle," has generally been approached to the Greek term mese. True, both terms have a similar literal meaning, there are, however, strong evidences against the assumption of an equivalence of the Indian madhyama and the Greek mese. Such a concept would imply that the sa-grama represents the plagal form of the ma-grama and not an independent mode. However, both musical facts and theoretical considerations reveal the untenableness of such an interpretation of the two gramas, and the reasons why the sa-grama is to be considered a C-mode and the ma-grama an F-mode, derived from the former, have been previously discussed in detail. This basic modal dualism is reflected in Venkatamakhin's classical classification of the 72 main South Indian Ragas,

or Melakartas, for these ragas are divided into two categories, according to whether the fourth above the tonic is a perfect one (shuddha ma) or an augmented one (prati ma). Popley expresses the same view by saying: "We see in this the survival of the difference between the ancient sa- and ma-gramas" (Ref. 10; p. 42).

Since an interpretation of the term madhyama in the sense of the Greek mese cannot be maintained, the question rises why not only this svara has been named madhyama but above all why Bharata confers to it the extraordinary privilege to be imperishable, to be the eldest note and the one which would still subsist though all the other notes of the mode should disappear. In fact, such language could hardly be used except to indicate that madhyama is to be considered the nucleus and starting point of the whole tone system so that the term would actually mean "central note" and not merely "middle note."

The answer to the question of the pre-eminence of madhyama is given by the theory developed above concerning the origin and meaning of the twenty-two shruti system. Dealing with this theory it is important to keep in mind that originally the seven svaras of the sa-grama were identical with the seven notes of the C-mode so that the pre-Bharatean madhyama has to be identified with F. We saw that the untempered sa-grama has been produced on one harp-vina by a sixfold up-and-down progression starting with a descending fourth so that the opening note of the progression becomes the fourth note of the scale, that is, madhyama. A second harp-vina produced the untempered ma-grama by another sixfold up-and-down progression which this time starts with an ascending fourth. The opening note of this progression is again the madhyama of the sa-grama. So we see that the combined tone material of both gramas derived from madhyama. This tone material represents the untempered quintal chromatic scale upon which the twenty-two shruti system is based. But madhyama is not only the nucleus of the whole Indian tone system, it constitutes, moreover, its actual center. Normally the untempered quintal chromatic scale derives from a twelvefold up-and-down progression moving from C-flat to B or from B to C-flat; in the old Indian tone system, however, the same scale has been obtained by two sixfold up-and-down progressions moving in opposite directions from the common center F or madhyama:

Cb Gb Db Ab Eb Bb **F** C G D A E B

So Bharata's statement concerning madhyama finds its full explanation. In this connection Vedanta's definition of madhyama is particularly indicative; there it is stated that the name of madhyama is given to "the fundamental perceptible sound from which all the differentiations of sound are issued (Ref. 3; p. 111).

It has been shown that the note madhyama may not be approached to the Greek mese; there exists, however, another note the function of which reveals a striking resemblance with that of madhyama: it is the Chinese huang chong, or "Yellow Bell." Just like madhyama, huang chong is considered the "eldest," the "imperishable" note, and Bharata's statement that madhyama would still subsist though all other notes should disappear, could just as well be made by a Chinese theorist speaking of huang chong. Like madhyama, huang chong represents a nucleus from which, through up-and-down progressions, the whole tone system has been developed. True, huang chong is regarded as a tone with a fixed pitch, and the utmost importance has been attached to have this pitch established, maintained, or corrected; but, to quote Popley, the svaras, too, "were intended no doubt to indicate in the first instance absolute pitch, and were later transferred to relative pitches" (Ref. 10; p. 33). In each case the tone material of which the total system is composed represents a quintal chromatic scale, although huang chong is the starter of a continuous elevenfold up-and-down progression, unlike madhyama from which two opposite sixfold up-and-down progressions are derived. Finally, both systems are connected with a cosmological dualism in which the celestial principle has been contrasted with the terrestrial one: In Chinese music it is yang and yin; in Indian music marga and deshi which represent the perfect and the imperfect, heaven and earth (Ref. 3; pp. 100-1). In Chinese cosmology the twelve tones obtained by a continuous up-and-down progression from huang chong are alternately attributed to the two principles yang and yin; this yields two whole tone scales, one starting with huang chong and representing the yang principle, the other one starting with the upper fifth of huang chong and representing the yin principle. So the harmony of the cosmos results from the merging of both principles and their two scales. It has been shown that the Indian tone system reveals a strictly dualistic foundation, too; but while the Chinese splitting of the tone material into two whole tone scales has a purely cosmological signification and no musical justification, the two Indian up-and-down progressions diverging from madhyama symmetrically in two opposite directions constitute the actual foundation of the two basic modes of Indian music. Since the Indian theorists and philosophers integrate every aspect of the tone system with their general cosmological conception, it would seem likely that, in a manner similar to that of the Chinese

cosmology, the Indian distinction between celestial music, or marga, and terrestrial music, or deshi, was originally applied to the distinction between the two basic gramas derived from the two opposite up-and-down progressions. This, however, is at present an assumption, relevant to this study only in that it suggests the possibility of additional agreement between the tone systems of ancient Indian and Chinese music, the latter generally known to be quintally derived, the former only now, in the present work, proved to be so.

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