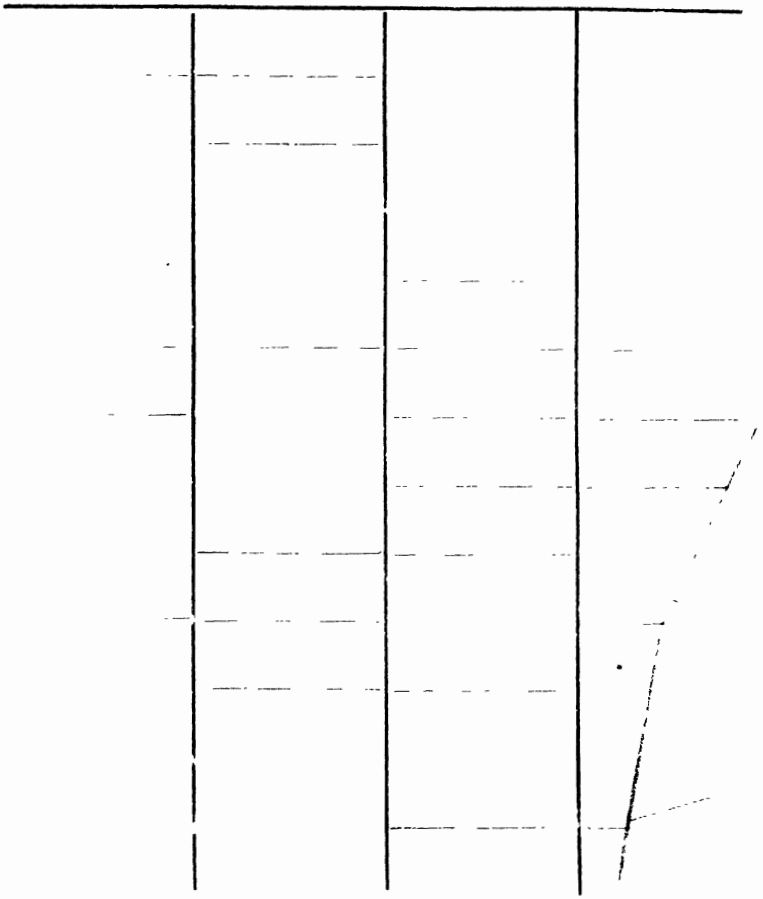

INTRODUCTION TO THE STUDY OF MUSICAL SCALES

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BY

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TO

MAX D'OLLONE

AND

TO

ŚIVENDRA NÂTH BASU

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the proofs.

FOREWORD

All music is based on the relations of sounds, and a careful study of the numbers by which these relations are ruled, brings us immediately into the almost forgotten science of numerical symbolism. Through musical experience it is easy to see that numbers correspond to abstract principles and that their application to physical reality follows absolute and inescapable laws.

It is in music only that this connection between physical reality and metaphysical principles is evident. Music was, therefore, justly considered by the ancients as the key to all sciences and arts, the link between metaphysics and physics, through which the universal laws and their multiple applications could be understood. In the present book we try to give some idea of these universal laws which the numbers represent, and to make a rapid survey of their application to music in the different traditions.

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FIRST PART

METAPHYSICAL CORRESPONDENCES

La novità del suono e il gran lume
di lor cagion mí accesero un disío
mai non sentito di cotanto acume. . . .
" Tu non séi in terra, sí come tu credi ; . . .
" Qui veggion l'alte creature l'orma
dell'eterno valore, il quale è fine,
al quale è fatta la toccata norma."

(*Dante, Paradiso, Canto I°, v. 82 e segg.*)

. . . The newness of the sound,
And that great light, inflamed me with desire,
Keener than e'er was felt, to know their cause. . . .
Thou art not on the earth as thou believest ; . . .
(Then said Beatrice) . . . . . Here
The higher creatures see the printed steps
Of that eternal power, which is the end
For which the order of things is made.

(Cary's translation, adapted).

First Part

METAPHYSICAL CORRESPONDENCES

MODERN civilisation has tended to reject the ways of thinking and the scientific conceptions which were the foundations from which it arose. Western people have largely broken away from the social and intellectual regulations by which their freedom was restricted. But in doing so they abandoned the age-long order and the traditional knowledge which had been the basis of their development. This is why sciences and arts, which were originally understood as the diverse applications of common principles, have been reduced to a condition of fragmentary experiments isolated from each other.

In the case of music, with which we are here more particularly dealing, except for a few technical and mostly arbitrary rules about the relations of sounds and chords, there remain in the West no data on the nature of music. The strange phenomenon, by which co-ordinated sounds have the power to evoke in man feelings or images, is accepted simply as a fact. Attempts are made only to define the effects of certain particular combinations of sounds without searching for their cause; and even such definitions depend entirely on the hazards of discovery. And, just as one day Newton discovered the law of gravitation, it is only through the genius of some musician that we may be able to rediscover the significance of a particular relation of sounds: it is Gluck or Chopin who may suddenly reveal to us the deep, absolute and inevitable meaning of a chord or of a melodic interval.

Unfortunately, such fragmentary experiments do not allow us to reconstruct the general laws which would give us the key of all foreseen and unforeseen combinations, and those experimental discoveries remain for us without any logical connection.

The idea that all sciences are originally experimental is so dear to Occidentals that they do not even notice that all the elements of their musical system are symbolic, as also are almost all their ways of

measuring time and space, and that, if those elements appear to us as *natural*, it is only because of the correspondence between those symbols and the perceptible world. We find in writings, which we should expect to be scientific, the poetic story, decorated with sentimental details, of the good savage who, having cut a bamboo and blown through it, discovers the diatonic scale as defined by Zarlino, which is supposed to be the "natural scale". Such stories are without any foundation and simply show the complete ignorance of those writers as to the thousands of scales which are possible, expressive, pleasant to the ear and perfectly natural and legitimate.

Besides, the real problem is not for us to know by what means men may have acquired the knowledge of musical intervals, which brings us back always to a question of myth ancient or modern, but to find out the real nature of the phenomenon by which some noises or sounds can be used in combination for the representation of ideas, images or sentiments. This we obviously cannot discover by experiments nor decide by vote. So we shall have to draw upon the data of traditional metaphysics which, under the diverse forms which they may take, according to time and place, present always the same logical and coherent theory of which we shall presently try to give an outline.

"All things", once said Dante, "are arranged in a certain order, and this order constitutes the form by which the Universe resembles God." (Paradiso, I - 103).

If sounds can evoke emotions, beings or landscapes in us, it is because there are, between the different aspects of the manifested world, some correspondences that the laws of music allow us to bring out.

In the *Li ki*, memorial of rites, edited by Confucius, we can read:—

"Music is intimately connected with the essential relations of beings"; and, according to Tong Tshung-chu (2nd century B. C.) : "The vital spirits of men, tuned to the tone of Heaven and Earth, express all the tremors of Heaven and Earth, just as several cithars, all tuned on *Kūng* (tonic), all vibrate when the note Kūng resounds. The fact of harmony between Heaven and Earth and Man does not come from a physical union, from a direct action, it comes from a tuning on the same

note producing vibrations in unison . . . In the Universe there is no hazard, there is no spontaneity ; all is influence and harmony, accord answering accord." (Cited by A. Préau, Lie Tseu, in "Voile d'Isis", No. 152-3, 1932, p. 554-5).

To be able to realize the nature of this accord between the different aspects of the Universe, we must know the principles which are common to all these aspects. This is why the theorists of Hindu music assert that though the subtle correspondences between the laws of nature and the laws of harmony, between the modes of music and the modes of our sentiments, can be experimentally discovered, they can be completely and logically explained only by traditional metaphysics whose source is in the Veda. As Mr. René Guénon explains :—

"The affirmation of the perpetuity of Veda is directly connected with the cosmological theory of the primordiality of sound among sensible qualities (sound being the particular quality of Ether, *ākāśa*, which is the first element). And this theory is, in reality nothing else than that which is expressed in other traditions when 'creation by the word' is spoken of. The primordial sound is the divine word through which, according to the first chapter of Hebrew Genesis, all things have been made. This is why it is said that the Ṛṣis or sages of the first ages 'heard' the *Veda*. Revelation, being a work of the Verb, as creation itself, is actually a hearing for him who receives it." (Etudes Traditionnelles, 1936, p. 68, Quelques aspects du symbolisme du poisson.)

According to Kṣemarāja (Commentaries on Śiva Sūtra Vimārṣiṇi, cited by André Préau, in Voile d'Isis, 1935, p. 350):

"The Bindu, desirous to manifest the thought it has of all things, vibrates, transformed into a (primordial) sound of the nature of a cry (nāda). It shouts out the Universe which is not distinct from itself, that is to say, it thinks it : hence the word *śabda* (word). Meditation is the supreme 'word' : it sounds, that is, it vibrates submitting all things to the fragmentation of life; this is why it is *nāda* (vibration). This is what is expressed in the half śloka—Sound (śabda) which is of the nature of Nāda resides in all living beings."

Swāmī Hariharānand Saraswatī explains (Siddhant, I 43, Śabda and Artha) the fundamental inter-dependence of sounds and forms :

"The *things named* and their *names* are both parallel manifestations resulting from the union of Brahman (the undifferenciated principle) and Māyā (appearances) just as waves appear in the sea. From Brahman united with Śakti (Energy = Māyā) is issued, in the order of manifestation of the world, on the one hand the *Principle of naming* : from it the monosyllable AUM, and from AUM all words (or sounds) ; and on the other hand, from Brahman united with Śakti, in the order of manifestation, is also issued the *Principle of forms* and out of it all the world, living beings, etc. .

But, between those two aspects of manifestation, the relation remains close, there is fundamental identity between the principle of names and the principle of forms, as well as between words and objects."

The Universe is called in Sanskrit *Jagat* (that which moves) because nothing exists but by the combination of forces and movements. But every movement generates a vibration and therefore a *sound* which is peculiar to it. Such a sound, of course, may not be audible for our rudimentary ears, but it does exist as pure sound. Each element of matter producing a sound, the relation of elements can be expressed by a relation of sounds, and therefore we can understand why Astrology, Alchemy, Geometry, etc., express themselves in terms of harmonic relations.

Although those pure sounds, those absolute sounds which Kabir calls "the music inaudible", cannot be perceived by our ears (they may be perceptible for more delicate instruments; and the perception of such sounds is one of the stages in the practice of Yoga), yet we may be able to produce corresponding sounds within the range of vibrations which we can perceive. Among these partial sounds we can establish relations similar to the subtle relations of Nature. These will be only gross relations, but may approach sufficiently the subtle relations of Nature to evoke images in our mind. As explained by Sir John Woodroffe, the learned commentator on Tantric metaphysics (Garland of Letters, p. 77) : "there are, it is said, closely approximate natural names, combined

according to natural laws of harmony (chhandaḥ), forming mantras which are irresistibly connected with their esoteric arthas (devatās)."

If we were able to reproduce the exact relations which constitute the natural names, we should recreate beings, things, phenomena, because this is the very process of creation, explained by the Vedas, and also indicated in Genesis or in the Gospel of John when "creative word" is spoken of. If, however, exact relations cannot be produced, approximate relations have a power, if not of creation, at least of evocating: "sound which works now in man's small magic, just as it first worked in the grand magical display of the World Creator." (Woodroffe, Garland of Letters, p. 210).

"The natural name of anything is the sound which is produced by the action of the moving forces which constitute it. He therefore, it is said, who mentally or vocally utters with creative force the natural name of anything brings into being the thing which bears that name." (Woodroffe, ibid., p. 209).

By the artificial construction of harmony we can go beyond the phenomenon of sound vibrations, and perceive not sounds but immaterial relations through which can be expressed realities of a spiritual nature. We can thus lift the veil by which matter hides from us all true realities.

By "the mutual aiding and inhibiting of the sounds in the Chhandaḥ[1], the veils of the individual sounds are removed by the order of their collocation.... The cumulative effect of the repetition of sounds and strings of sounds also may produce the aforesaid result." Woodroffe, ibid., p. 77). The effect produced by a group of sounds is practically the

1. M. René Guénon, in an article on the language of birds (Voile d'Isis, 1931, No. 143, p. 670), explains: "The (Vedic) hymns were given the name of *chhandas*, a word which properly means 'rhythm'. The same idea is contained also in the word *dhikr* which, in Islamic esotericism, applies to rhythmic formulas exactly corresponding to the Hindu *mantras*. The purpose of the repetition of such formulas is to produce an harmonisation of diverse elements of being and to determine vibrations susceptible, by their re-percussion across the series of stages in indefinite hierarchy, to open some communication with superior stages which is, as a rule, the essential and primordial purpose of every rite."

same whether their collocation is simultaneous (chords) or whether it is successive (modes); the numerical relation being in both cases identical.

Evocation through sound, as creation itself, takes place not because of the material fact of physical vibration but on account of the existence of metaphysical correspondences. Therefore all psychological explanation of musical experience has to be discarded. In reality, the personality of the hearer counts for nothing in the phenomenon of musical evocation, because evocation takes place even if there is no hearer; and if the existence of this evocation is ephemeral it is only because of the imperfection of the relation of sounds. Hearers can only be differentiated negatively by the relative acuteness of their perceptions, their greater or lesser deafness.

"Several centuries before Plato, Pythagoras, imbued with Egyptian doctrine, requested his disciples to reject the judgment of their ear as susceptible to error and variation wherever harmonic principles are concerned. He wanted them to regulate those immovable principles only on the proportional and analogical harmony of numbers." (Fabre d'Olivet, La Musique expliquée comme Science et comme Art, p. 24). The work of the musician consists therefore only in knowing, as accurately as possible, the symbolic relations of all things, so as to reproduce in us, through the magic of sounds, the feelings, the passions, the visions of an almost real world. And the history of Hindu music, as that of Chinese music, is full of the legends of marvellous musicians whose voice could make the night fall or the spring come out, or who, like the celebrated musician Naik Gopal, compelled by the Emperor Akbar to sing in the mode of fire (Dīpak rāga), made the water of the river Jumna boil, and died burnt by the flames which came out from every part of his body.

The Greeks too knew the science of connections between sounds and other aspects of manifestation, which science modern Westerners are pleased to call magic.

"Everything (pan) obeys a secret music of which the *Tetractys* is the numerical symbol, and the man who, like the initiated Pythagorean, has understood its true laws can achieve apparent miracles. It is, for

example, from the sounds of the lyra that Amphion built the walls of Thebes."[1] The mathematical laws of music are part of the laws by which the world's harmony is regulated. This is why we shall find in music the same characteristics, the same geometry, the same particular numbers which are found in other aspects of the Universe. The hermetist, the physician Michel Maier, in the beginning of the 17th century, attempted to determine those relations:

"Like all the visible things which are in Nature, celestial bodies as well as terrestrial ones have been created in terms of number, weight and measure. There is, thus, between them, an admirable and marvelous proportion in the parts, the forces, the qualities, the quantities and their effects, from which results a very harmonious music. There is also a kind of accord and musical concert between spiritual beings, among which the soul and the human intellect are counted.

In the great system of this Universe, there is a *ditone* or third from the Earth, which is the base, to the sphere of the Moon; from there up to the Sun, which is the heart, a *diapente* or fifth ; and from the Sun to the Supreme Heaven a *diapason* or octave; so that the first distance is composed of 18 commas or intervals, the second of 36 and the third of 61.[1] In the Microcosm or little world, that is to say in Man, one can see also a similar proportion between the main parts which are the liver, the heart and the brain, counting from the sole of the feet, not as mathematicians or geometers do, but as physicists do." (Cited by Paul Chacornac, Michel Maier, Voile d'Isis, 1932, p. 461).

To be able to establish the correspondence between sounds and the different aspects of the Universe, we must divide the indefinite progression of sound according to certain proportions which are determined by the cyclic character of certain intervals and the properties of fundamental numbers.

In conformity with the formula of the Tao-te King "One has given

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1. Elie Lebasquais, Tradition Hellenique et Art Grec, Voile d'Isis, 1935, p. 492.

2. Michel Maier thus divides the octave into sixty intervals, as do the Chinese, in conformity with the traditional division of the scale of fifths.

birth to two, two has given birth to three, three has given birth to all numbers,"[1] the orginal sound produces first its octave (2/1), giving the dual, then a third sound, the fifth (3/2), from which all other sounds are born. Among these sounds, in indefinite number, we must select a few whose respective ratios are adequate for the representation of the world in which we are living. In this way has been formed the scale of 5 sounds, corresponding to the material world, to the 5 directions of space (4 directions and the center), the 5 elements, etc. . This is the basis upon which develops the whole system of the harmony of fifths which, through their revolutions, form, within the octave, first a series of 12 sounds, then a series of 52 sounds, and, finally, a series of 60 sounds. As explained in an extremely ancient Chinese treatise : "the 5 degrees, born from the principles Yin and Yâng (female and male), divide themselves into the 12 lyŭ[2] which, by their revolutions, produce the 60 lyŭ." (Rules from the Hán).

To these five principal sounds are added two auxiliary ones which form the scale of seven notes, image of the celestial world, to which correspond, in the world of spheres, the seven visible planets. "The soul of the world is divided into seven parts," said Plato in his Timaeos. And this is why it was the seven stringed lyra which symbolized the beauty or the order (harmony) of the spheres. Each string of the lyra was related to a planet. The musical sounds themselves were given the names of planets. And, "because the mathematical laws observed in musical art and in cosmic spheres are related to the natural rhythms of the soul,"[3] music forms a logical and direct tie between the movements of the world and the movements of our soul.

The symbolic ladder by which Dante rose up to the supreme light had also 7 steps which are "the printed steps of the eternal power which

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1. See : R. Guénon, Remarques sur la notatation mathématique, Etudes Traditionnelles, Fevrier 1937, p. 75.

2. The Lyŭ are sound-tubes, of rigorously accurate dimensions, which are used as gauges for the measurement of sounds.

3. Paul Vulliaud, La Tradition Pythagoricienne, Voile d'Isis, 1934, No.171, p.105.

is the end for which the order of things is made." (Dante, Paradiso, I, 106). "But what are these steps ? They are precisely the different aspects assumed by this eternal power on which the order of the Universe rests; they are the seven differentiations of the one light, the seven colours of the prism and of the rainbow, the seven sounds contained in the primordial sound, the seven luminaries by which is reflected on our Earth the light of the eternal Great Luminary which shines in the centre of immensities."[1] They are the seven horses which drag the chariot of the Hindu Surya. The union of the ternary and the quaternary, the sevenfold (4+3), symbol of the soul of the world, was represented by the seven pipes of the flute of Pan, the God of the Universe.

Assimilated to the seven planets, the seven notes move across the twelve regions of the octave, corresponding to the Zodiacal signs, in which, as we shall see later, these 7 notes will occupy 22 main positions (a number which is, in certain cases, reduced to 17). We shall also see why the twelve regions of the octave cannot be assimilated to twelve fixed sounds as has been attempted in the temperate scale. They determine the space in which the notes move but can in no case be taken for the notes themselves.

"The number 12, formed by the combination of the ternary and the quaternary (3+4=12),[2] is the symbol of the Universe and the measure of sounds. . . . Pythagoras, Timaeos of Locres and Plato, when they gave the dodecahedron as the symbol of the Universe, only re-exposed the ideas of the Egyptians, the Chaldeans, the Greeks. . . . The institution of the Zodiac is the result of the application of the number 12 to the Supreme Sphere. . . . The number 12, so applied to the Universe and all its representations, was, always, the harmonic manifestation of the principles One and Two and of the way in which their elements were co-ordinated. It was, therefore, also the symbol of the co-ordination of sounds, and, as such, applied to the lyra of Hermes." (Fabre d'Olivet, La Musique expliquée comme Science et comme Art, p. 59-60).

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1. Argos, Dante et l' Hermetisme, Voile d'Isis, 1931, p. 702.
2. We can see here that the number 12 represents an area and not a sequence.

Built on such bases, music becomes a difficult science capable of a profound action. "In ancient times, music was something other than mere pleasure for the ear : it was like an algebra of metaphysical abstractions, knowledge of which was given only to initiates, but by the principles of which the masses were instinctively and unconsciously influenced. This is what made music one of the most powerful instruments of moral education, as Kong-Tsee (Confucius) had said many centuries before Plato." (G. de Mengel, Voile d'Isis, 1929, p. 494).

But, on account of the imperfection which is at the very basis of the world existence, because if it were perfect it would immediately be reabsorbed into the infinite perfection, just as the heart of man is not in the centre of his chest, as the axis of the Earth is oblique, as the solar year does not coincide with the lunar year and thus are created the cycles by which all existence is conditioned and human destinies measured; so, in the same way, the development of twelve fifths (as that of the twelve months), instead of bringing back the octave, will leave a difference, the comma, with which we shall have to negociate, which will make every calculation complicated, and which will prevent us from formulating those rigid and simple laws, attractive but inaccurate, in which our vain reason delights. This comma, which the modern world tries so hard to ignore, represents, for those who can understand it, all the difference between what is finite and what is indefinite. Those fifths form a spiral of which the sounds, coiled around themselves, can never meet. For us, this limitless spiral can be the joint in the structure of the world, the narrow gate, which will allow us also to escape from the appearence of a closed Universe, to travel in other worlds and to explore their secrets.

It is only by respecting such subtle differences that the edifice of sounds can be the image of reality and can become one of the ways of spiritual realization. "It is literally by way of 'assonance', of 'accord', that 'he who understands' (evamvit) is assimilated to the source of light or—in Christian terminology—assumes a glorified body. . . . And this is possible precisely because, as Plotinus expresses it, this music is 'a terrestrial representation of the music which exists in the Kingdom of

the ideal world." (A. K. Coomaraswamy, Beauté, Lumière et Son, Etudes Traditionnelles, Fevrier 1937, Note p. 53).

Even if we leave aside the rôle of music as a means of spiritual realization, the effect of musical chords and modes (rāgas) is much more far reaching than our ears are able, at first, to allow us to perceive. Our ear can apparently be satisfied by a very approximate accuracy. But a perfectly accurate interval does not react only on our ears, it produces a transformation in all the cells of our body, a slowing down or an acceleration in the movements of every molecule in ourselves and in the surrounding matter. This effect was utilized, not only in India but in Greece, and later in Persia and Arabia, for curing certain diseases. Mohammad Hafid describes at length these musical therapeutics indicating the scale to employ for each disease. But, if we utilize habitually inaccurate intervals, on the ground that our ear does not clearly perceive the difference, the effect that those sounds will produce on our organism can well be the opposite of that which our complacent ears persist in accepting. It is with our mind only that we cognate this inaccurate music which leaves us tired, contracted by the unconscious effort of adaptation instead of being agreeably transformed by the beneficial influence of harmony. This is why to disregard small differences in intervals has very grave consequences with regard to the deeper effect of music ; consequences which can only be neglected when the real purpose of Art is totally mis-understood. Unfortunately the materialistic and highly utilitarian tendencies of our times rarely allow people to bother about anything which is not immediately tangible. We utilize daily all sorts of forces, recently domesticated, in total ignorance as yet of their effect upon the structure of our organism and upon the balance of external events. This is why we find it quite normal to change the course of sounds, if so doing brings some immediate simplification ; and this leads us to try to change into a closed circle the endless spiral of fifths, to tear up the comma and divide it between the other notes and so bring the cycle of sounds within the narrow limits of human logic. Whatever advantages may be obtaind by such an action, and there is no doubt that such advantages

do exist, we expell the heavenly element from music when we obliterate the possibilities of contacts with spiritual forces by disfiguring the intervals. The music so reformed loses its true purpose, and its magical effects, henceforth uncontrolled, can become dangerous. It is not without reason that Plato puts in the mouth of Damo, the last of the great Pythagorean teachers : "One cannot touch the musical modes without disrupting the constitution of the state." He could as well have said : without disregarding universal order. (See : Elie Lebasquais, Tradition Hellenique et Art Grec, Voile d'Isis, 1935, p. 493).

As Mr. René Guénon says : "In ancient times, as can be seen particularly clearly in the Far East, modifications could only be brought into music in accordance with some changes which had occured in the very conditions of the world, according to cyclic periods. This is because musical rhythms were intimately related at the same time to human and social order and to cosmic order and they even, in some way, expressed the relation which exists between the one and the other. The Pythagorean theory of the 'Harmony of spheres' is connected also exactly with the same sort of consideration." (R. Guénon, Les arts et leur conception traditionnelle, Voile d'Isis, No. 184, 1935, p. 134).

For the world to be in a state of equilibrium, it is necessary that its different elements be harmonized. Music being the expression of the relations between human and cosmic orders, it is essential that it should respect the data on which these relations are based, that is to say, the exact intervals of notes as determined by the traditional data which define these relations. The disregard of such an obvious law leads necessarily to a rupture of equilibrium, that is to say, to social disorder, As expressed by the Yŏ kí :

"If the Kŏng (C = tonic) (Sa) is disturbed, then there is disorganization : the Prince is arrogant.

"If the Shāng (D) (Re) is disturbed, then there is deviation : the officials are corrupted.

If the Kyŏ (E) (Ga) is disturbed, then there is anxiety : the people are unhappy.

If the Chì (G) (Pa) is disturbed, then there is complaint: public services are too heavy.

If the Yù (A+) (Dha+) is disturbed, then there is danger: resources are lacking.

If the five degrees are all disturbed, then there is danger: ranks encroach upon each other—this is what is called impudence — and, if such is the condition, the destruction of the Kingdom may come in less than a day. . . .

In periods of disorder, rites are altered and music is licentious. Then sad sounds are lacking in dignity, joyful sounds lack in calm. . . . When the spirit of opposition manifests itself, indecent music comes into being . . . when the spirit of conformity manifests itself, harmonious music appears. . . . So that, under the effect of music, the five social duties are without admixture, the eyes and the ears are clear, the blood and the vital spirits are balanced, habits are reformed, customs are improved, the Empire is in complete peace." (Cited by M. Courant, Essai sur la musique classique des Chinois, Dictionnaire du Conservatoire, p. 206-207).

SECOND PART

THE CONFLICT OF MUSICAL SYSTEMS

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The different musical systems.

WESTERN musicians have a tendency to believe that their musical theory and script are sufficient to express everything. When they hear of other intervals, they think of quarter-tones, of commas and other small units which, in their opinion, even if they may have an interest of curiosity, can have no serious importance so far as the general structure of music is concerned. It is not, however, without amazement that we observe their total inability to put into notations, without completely disfiguring them, the melodies and chords of Oriental music.

We might have a tendency to conclude that Orientals have a different theory and are using other intervals than Occidentals, as has often been suggested. But a more serious study shows us that these apparently different intervals have, for their basis, the same definitions, and refer to the same acoustic principles. Hence the difference can only come either from a musical practice in contradiction to the theory, or from the utilisation of a part only of the possibilities opened up by those common principles. We shall see that both these causes must be considered.

As noted by M. Yekta Bey (La Musique Turque, Dictionnaire du Conservatoire, note p. 2953.):

"Music is, like the other mathematical sciences, a science whose laws are fixed and invariable. Just as 2 and 2 make 4 in the East as well as in the West, the fundamental laws of music are also permanent and for all men. The differences in views which can be noted among theorists in each century and in each country can originate only from their greater or lesser lack of insight into the diverse questions whose study requires a knowledge of music at the same time theoretical and practical."

The musical system actually employed in the West is far from being a logical and absolute system based on irrefutable acoustic realities. It is the result of a mixture of traditions which has been arbitrarily simplified without taking into account, or without the knowledge of, the principles on which the component systems were based. The musical system so simplified being insufficient, musicians have attempted to develop it according to their observations or their instinct, accumulating many discoveries and observations, forming a kind of "dictionary of harmonic relations", but without any explanation of their cause or the reason for their significance.

The different musical systems do not oppose each other, but, on the contrary, they complete each other, as they all spring necessarily from the same fundamental laws of which they exploit different aspects. Like the forms in language, the musical modes are permanent marks of the tradition to which a people belongs. Everywhere, when artificial systems have not destroyed or disfigured traditional modes, it is as easy by the study of musical modes as by that of linguistics to observe the migrations and influences of races upon each other. Striking examples are the importation of Mongolian scales into China by Gengis Khan or that of Persian modes into Northern India. In the West, in spite of the havoc created by the temperate scale, it is possible quite easily to find the continuity of Celtic modes from Scotland to North Africa; while the modes of Spanish Gitanos are actually Hindu modes even in minute details of execution.

But, before we can study musical systems, it is necessary to define the exact nature of sounds and their relationship.

The Structure of Musical Sounds.

Any object made to vibrate produces a combination of sound waves which, according to its composition, is more or less pleasant to the ear, more or less "musical". This sound is formed of one, or several, fundamental notes and of other notes called harmonics. The sounds utilized in music generally have only one fundamental note. The

harmonics of this fundamental, according to their relative intensity, make the notes appear pure or nasal (the harmonics of a flute are weak; those of a violin much stronger). When, with the help of different instruments, some of these harmonic sounds are reinforced, the quality of the basic sound is enhanced and its expressive value, which is different according to the reinforced harmonics, improved. Thus is born harmony which is the art of superimposed sounds. If those sounds are successive instead of being simultaneous, -- the notion of time intervening—we have to call upon memory to establish the harmonic relationship which, alone, gives to the melody its meaning.

The group of two or three fundamental chords which displays all the notes of a melody is called a mode. The mode, being therefore a series of sounds having definite relations with a permanent tonic, can truly be said to represent the fixed harmonic basis of all melodic music, modulation[1] being almost unknown in modal music as the uncertainty it would create in the harmonic significance would last too long. The melodic figures, turning within a fixed circle and coming back frequently to certain notes, create a harmonic complex which gives its significance to the melody.

The relations between the notes which constitute a mode can be represented numerically. The mode is then, with its complete significance, represented by a group of numerical relations. Chords, also, can be represented in the same way.

In the musical systems in which the tonic is permanent and constantly present to the mind of listeners, each note has, by itself, a significance, determined by the relation which binds it to the tonic. The melody is thus composed of a succession of sounds with a perfectly definite meaning, and, therefore, its significance is absolutely clear.

But, if the tonic is not absolutely permanent, no note can have a significance unless the ratio which measures its expression is at the same time given. This is why, in every musical system where modulation is admitted, it can be asserted that no note and no

1. Change of tonic.

melody can have a significance without the harmonic context which, alone, can establish the ratios necessary to define the meaning of each note and consequently of the entire melody.

Gounod once wrote : "Sounds alone can no more constitute music than words alone can constitute a language. Words can only form a proposition, an intelligible sentence, when they are associated in a logical sequence according to the laws of intellect. This is also true of sounds which must obey certain laws of attraction and mutual response, by which is ruled their production successive or simultaneous, before they can become a musical reality a musical thought." (Menestrel of the 22 January 1882).

The Relations of Sounds.

The number of possible musical intervals is obviously unlimited. But, because of the limits of discrimination of our ears and of the consonant properties of some ratios, the number of intervals utilized in musical practice is limited. The case is different in magic where the absolute precision of a mathematical interval is necessary to produce the phenomenon. For a musical evocation, the simpler acoustic intervals are sufficient. Besides, they appear so natural that, without external help, it is vocally almost impossible to get away from them, "the sounds which form consonances being the only ones that the human ear can accurately detect and that the human vocal organ can spontaneously utter." (Gevaert, Problèmes musicaux d'Aristote, p. 177.)

If, therefore, in musical practice, there can be utilized only a small number of intervals having between themselves definite ratios, it must be possible to divide the musical scale in such a way as to allow of all the possible combinations of such ratios. To determine such a scale we must attempt to discover the laws of numbers on which such a division must necessarily be based and we must study the methods used in the application of these laws to musical practice by different peoples at different periods. Comparing then the structure

of the most important systems, we shall see whether it is possible to bring all the intervals which they utilise within the frame of a fixed division without disfiguring them as the equal temperament does.

For our investigation, musical intervals appear under two aspects: one mathematical, of numbers and logical ratios, the other symbolical and psychological, in which the relations of sounds, their harmony, awaken in us feelings, ideas and precise visions. These two aspects obviously have their origin in the same principles, but this unity is beyond the scope of experiment and, consequently, beyond the understanding of modern Occidentals. This deficiency naturally brings them to the illogical situation of leaving aside one aspect of experience whenever they study the other, as if the laws of acoustics and those of musical expression did not refer to the same sounds.

Fifth and Octave.

According to circumstances, to time and to the role attributed to music, theorists have compiled musical theories either from the point of view of expression or from that of numbers. We shall see that, in the first case, the basis is generally the interval of the octave and the relations of notes with a fixed sound, the tonic, giving birth to modal music; in the second case, emphasis is given to the properties of the interval of the fifth, and the successions of fifths, which leads to modulation and therefore to harmony.

"The conflict of the fifth and the octave, the impossibility of going from one to the other, could not escape the notice of musicians and theorists. . . . This difficulty, known to Tsyāo Yên-cheú and Kīng-Fâng, led them to the series of sixty lyŭ [division of the octave into sixty parts] which they explained by comparisons with natural philosophy." (M. Courant, Chine et Corée, Dictionnaire du Conservatoire, p. 88.)

It is obvious that in the beginning such an opposition did not exist because, as all the traditions assert, people still looked at things

from the metaphysical point of view, which explains this apparent dualism. Unfortunately, even in Hindu tradition, the definitions which have reached us on such fundamental points are often of a fragmentary character and intentionally obscure. But such definitions are implied by the very text of certain sacred books and a deeper study of such books can always give the key of it to those who possess the requisite qualifications.

Octave and Mode.

In modal music, intervals are measured by the relation of the different notes to the tonic (Sa). The numbers which symbolise those relations form, with the tonic, ratios which are generally simple and which allow comparisons to be made, for instance, between musical harmony and the proportions of sacred architecture, the proportions of the human body, the relations of colours, or the divisions of time, etc.. Further, æsthetic emotion being the mark of the synchronism of our subtle self and certain ratios, we can, with the help of those ratios, determine the fundamental numbers on which the human organism is based. These common proportions constitute the key whereby we can understand the real structure of music and utilise its power. On the utilisation of these common proportions depends the significance of chords taken individually, as well as the significance of the systems of modal music whether Hindu, Turk or Arab, including the modes used by the Greek musicians. To these must be opposed the modes defined by the Greek physicists which are based on a different principle.

That which characterizes the system of relations to a tonic is the almost continuous sounding of that tonic. This constant tonic is called "Ison" in Byzantine music, (Ṣaḍja in modern Hindu music). It seems that modern Westerners are completely unable to perceive relations with a tonic. The remarks of Bourgault-Ducoudray comparing the Ison to a spit piercing through the melody, or of Amédée Gastoué (La musique Byzantine) saying : "It is not,

as far as we know, from a need of harmony that the "Ison" was introduced (!) into the Byzantine chant but it was from the necessity of keeping the singers in tune," imply that they have not the slightest idea of those relations which are, properly speaking, the harmony of so-called monodic music and outside of which melody has not much effect or meaning. It would be just as ridiculous to speak of adding a fundamental to a chord, since a chord exists only by relation to its fundamental note.

The "Ison" or "equal" of Byzantine music was called "Chhandovatī śruti" (the measuring sound) in ancient Hindu music. It is, properly speaking, the standard by which all intervals are measured. No interval, no note, no melody has a meaning unless the "Ison" (Sa) is present. It seems that Occidentals are just as unable to "hear" those relations as Orientals are unable to perceive chords, but this is not a sufficient reason to consider either system of relations as unpleasant and useless. The "Ison" defines the meaning of each note, which can be expressed by a numerical ratio, exactly as does harmony. And melody without "Ison" is just as flavourless as is, for the modern Westerner, melody without harmony. When they disregard the importance of the "Ison", learned and respectable Occidentals only show that they understand nothing of the Eastern music they pretend to study and explain, and that they perceive nothing of its marvellous power.

The "Mesa" was, to ancient Greek music, what the "Ison" is to modern Byzantine music. "For the ancient [Greeks], the A (Mesa) is a directional string whose *permanent* use constitutes a guiding mark for the ear and a reduction to unity for the mind." (Maurice Emmanuel, Grèce, Dictionnaire du Conservatoire.) The "Mesa" is "the connecting element of successive sounds, ... the connecting agent of all the melodic forms of the octave." (Gevaert, Problèmes d'Aristote.)

Orientals often make remarks similar to this : "The Beethoven symphonies are very interesting, but why have all those chords been *introduced* spoiling the charm of the melodies ?" From

such remarks we can know for certain that they do not perceive the essential elements of the music. Their failure to understand is similar to that of the Westerner who refuses to admit that modal music has a full musical significance without the addition of harmony.

Such misunderstandings are not without serious consequences. To realize this, it is sufficient to hear the so-called Oriental melodies *arranged* by Western composers, or, still better, to hear the so-called "westernised orchestras", of which many Indian Rājās seem to be so proud, where "harmony" is understood to be the art of playing together as many disconnected sounds as possible.

In modal music, the pedal point of the tonic is indispensable for the melody to have its expression, because other notes, when they are accentuated, would have a tendency successively to substitute themselves for the tonic, and so render the expression of the mode completely indeterminate.

Suppose, for example, in the diatonic scale (white keys of the piano or organ) we choose the mode of A (Dha)[1] (Yavanpurī Toḍī) whose 3rd, 6th and 7th are minor. If we do not maintain the pedal point of tonic (A) (Dha), C (Sa) will have a tendency to become tonic instead of being a minor 3rd, the meaning of every note will be changed, and, modes destroying each other, melodies will be without expression, as is the case of Western melody if not harmonised.

It is the loss of this pedal point of the tonic, somewhere in the course of ages, which renders the modes of plain-chant so vague and so weak. They lack a basis, and their classification becomes a rather abstract game, like the system of the Greek *Dorisli* in the unreal form generally attributed to it. It is by an artificial conception that a mode can be assimilated to the plagal[2] form of

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1. For the convenience of readers, we shall be giving everywhere a double notation in the Western and the Indian systems.

2. In a given mode, when, without changing anything in the notes, we start the scale from a note other than the original tonic, the scale so obtained is called a plagal form of the original mode.

another mode. It is not sufficient to declare that D (Re), E (Ga), or G (Pa) has been chosen as a tonic to obtain the corresponding mode in any melody. The melody remains unaffected and in the tone of C (Sa), because, to determine a tone, a permanent element is required, and habit can, up to a certain point, create this permanence in favour of C (Sa) : that is, in favour of the western major mode, supposing that we are still using only the white keys of the piano. Another mode can be determined only by constantly imposing its tonic. Percussion instruments, such as drums, cymbals, etc., can be sufficient to determine this tonic. This is why, in ancient music, the problem did not arise, as such instruments were always present in a musical performance. The accurate tuning of the different notes of the scale should, of course, be sufficient to define the tonic, but, as the differences in intervals are very small, rare indeed are the musicians who can maintain this accuracy without referring constantly to the tonic.

Fifth and Modulation

In modal music, as soon as the tonic moves, the modal structure crumbles and every note loses its former significance. But, in connection with the changing cycle of fifths, some new permanent relations can be established, and those relations will evoke other aspects in the Universal structure. In the cycle of fifths we can perceive the reflection of the world of spheres in which we dwell. We shall find in it the laws which regulate the movements of planets, those of seasons and of days, and all those cycles which, within this universe, measure our destinies[1].

1. A striking difference between the structure of the cyclic system and that of the modal system is that the one normally forms an ascending scale and the other normally a descending one. This allows us to distinguish at first sight to which family a system originally belongs By its very structure the cycle of fifths forms an ascending series. Therefore, within each tetrachord, the intermediary notes between the tones will be considered as sharpened (tivra). On the contrary, modes normally form descending scales and, consequently,

Starting from a given point, the general tonic, the fifth will form ratios, at first simple, but becoming more and more complicated. These will allow us, considering as the basis the note adapted to the cosmic period, the year, the month and the day, to find out auspicious days, events past and future. This is the traditional system of the Chinese, the utilization of which in official ceremonies, as we noted already in the Yŏ kí, helps to maintain order, political harmony and security within the empire, but which can also contribute to their over-throw because it is the inescapable instrument of magical realisations.

Still, every system exclusively based on the properties of fifths remains incomplete from certain points of view. Fabre d'Olivet[1] says that such a system "will always be lacking in descending chromatic and enharmonic. Rameau, who, more than eight thousand years after Lyng-Lun, wanted to make it the basis of his musical system, starting from the same experiment, was forced to resort to an insipid temperament which mutilates every sound and which, twenty times proposed in China, was twenty times rejected because the scholars of the nation, although they had known for a long time the hollowness of their system, preferred to maintain it pure, if incomplete, rather than to spoil it in one of its parts in order to make up for that which was missing."

Harmony and temperament.

Following the mistake of the Greeks, the European classical system is divided between the two antagonistic tendencies, between mode and modulation. And, although built without any "scientific"

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within each tetrachord, the intermediary notes will be considered as flattened (komal), as is the case respectively in Chinese and Hindu music.

The sharpened fourth (F sharp = Ma tivra) follows the opposite rule, being considered as a flattened fifth in the ascending scale and as sharpened fourth in the modal or descending scale.

1. La Musique expliquée comme Science et comme Art, p. 80.

method, with pieces from every system, it has been able, taking advantage of this lack of a rational theory, to give rise to unexpected developments, the importance of which, in the general history of music, should, however, not be overestimated. But this lack of a proper theory, by allowing such aberrations as equal temperament, will, in all probability, quickly drive the European classical system to complete decadence. The success of Negro music with its brass instruments so alien to equal temperament, and, therefore, so expressive, is not a simple fashion. It shows the need for an understandable musical system, for logical and true intervals which may remove the veil of inexpressive insipidity which temperament spreads over the most pathetic movements of the greatest symphonies.

Melodic expression or Harmonic expression.

The development of harmony corresponds in modern Western music to an equivalent destruction of modes, so that, from the strict point of view of musical expression, that is, from the amount of sentiments and images which music is able to suggest, it is very difficult to assert that the harmonic system gives greater possibilities of expression than any modal system. Means of expression differ, possibilities seem equal.

Many imagine that the best would be to combine both systems, as has been often attempted, but this is not possible because there is an almost complete opposition between them. Except for a few fundamental chords, which are also utilised in modal music as ornaments, all changes in chords and modulations are possible only by violating the small distinctions in the structure of intervals which are the very root of modal expression.

"It is, therefore, the introduction of harmony in musical art which has caused the disappearance of the distinction between the ancient modes. It is due to this introduction . . . . . that our musical system is limited to the only two modes which possess a distinctive harmony and completely different chords, the

major and minor mode which are . . . . . those in which the greatest simplicity is united to the greatest number of differences." (H. Dubrochet, Mémoires sur une nouvelle théorie de l'Harmonie, Paris, 1840.)

All those who have been in contact with ancient Western modal music or with the music of the middle and the far East have deplored the ruin of the melodies and rhythms corollary to the development of harmony, a phenomenon which could be observed all through the 19th century and which is still perceptible in Northern countries, Russia and even Scotland and Ireland.

Willard[1] has even said this, which, on consideration, is not without foundation :

"The modern melody has not the merit of the ancient and . . . . . harmony is used with the view of compensating for its poorness and diverting the attention of the audience from perceiving the barrenness of genius."

No better description could be given of a great number of modern works.

Jean Jacques Rousseau once observed :

"If we bear in mind that of all the people of the Earth, who all possess music and songs, Europeans are the only ones who use harmony, chords, and who find this mixture pleasant ; if we bear in mind that, of all the nations who cultivated fine arts, not one knew this harmony ;[2] that no animal, no bird, no being in Nature produces any other sound than unison, any other music than melody ; that Oriental languages, so sonorous, so musical,

1. Of Harmony and Melody, Hindu music, p. 55.

2. J. J. Rousseau was mistaken when he asserted that Europeans are the only people who possess harmony and chords, because polyphony was practised in many countries a very long time before it was heard of in Europe. Chinese and especially classical Javanese music are essentially polyphonic. But it is interesting to note that, among the Eastern systems, they are very much among the less refined and, delicate and it has even been said that Chinese music is a pleasure rather for the mind than for the ear.

that Greek ears, so delicate, so sensitive, trained with so much art, have never guided those voluptuous and passionate peoples towards our harmony ; that, without it, their music had such extraordinary effects ; that, with it, ours has such feeble ones ; that, finally, it was to be the privilege of Northern races, whose organs hard and rough are more impressed by the shrillness and the noise of voices than by the softness of accents and the melody of inflexions, to make this great discovery and to put it as the principle of all the rules of Art ; if, I say, we bear all this in mind, it is very difficult not to suspect that all our harmony is only a gothic and barbarous invention, to which we would never have taken had we been more sensitive to the real beauty of Art and of truly natural music." (J. J. Rousseau, Dictionnaire de la musique, at the word : Harmonie.)

Of course, modern people, who accept so seriously many another theory of Rousseau's much more difficult to demonstrate, smile at such Genevan sallies, but they would have much difficulty in contradicting them. As Fabre d'Olivet has very justly remarked[1] : "It is true that our modern symphonists, who can understand nothing of the marvels described by the ancients, prefer to deny them ; but a denial is not an answer, and it is not sufficient to say that something is untrue for it to be so."

Famous Western scholars have spoken with irony of such irrational conceptions. Sir William Jones once wrote[2] : "The astonishing effects ascribed to music by the old *Greeks* and, in our days, by the *Chinese*, *Persians* and *Indians*, have probably been exaggerated and embellished ; nor, if such effects had been really produced, could they be imputed, I think, to the mere influence of sounds, however combined and modified." Happily, Sir William Jones allows us to know what sort of effects he attributes to music in terms which show quite clearly the understanding he has of the subject[3] :

1. La musique expliquée, p. 16.
2. On the musical modes of the Hindus, Hindu Music, p. 128.
3. ibid, p 127.

" . . . . . After food, when the operations of digestion and absorption give so much employment to the vessels that a temporary state of mental repose must be found, especially in hot climates, essential to health, it seems reasonable to believe that a few agreeable airs, either heard or played without effort, must have all the good effect of sleep and none of its disadvantages; *putting* the soul in tune, as Milton, says."

It is only natural that the followers of a particular musical system, as those of a particular religion, should consider the adepts of another school with contempt. This only proves that they have that absolute faith in the path they follow without which no realization is possible. But, if we want to rise above mere practice, and search for the principles which allow of such realizations, we have to give up the outlook of faith and accept only the logic of reason. We shall then observe that, although we are at first utterly unable to discern in a strange form of music anything comparable to that which we experience directly and without effort in a form familiar to us, an impartial scrutiny will show that all the essential elements or relations which are found in the one are also present in the other. There is, consequently, no theoretical reason why the same expressions, the same realizations, should not be equally possible through these different forms.

For judging, therefore, the possibilities and the value of musical systems, we should not trust the prejudiced judgment of our ears, but envisage, in their most abstract form, their theoretical possibilities. We may then discover the equivalence of systems which, at first, seem to have nothing in common; we may also discover a profound difference between systems whose forms are outwardly very similar. By so doing we shall, in any case, judge the musical systems soundly and on safe grounds. To be able to realize their beauty or directly to perceive their meaning is another matter and generally requires very long practice.

THIRD PART

MEASURE OF INTERVALS AND HARMONIC SOUNDS

"There are two effects one seen and one unseen. Svaras (notes) when thrown here and there without order cannot produce any results. Therefore, to realize all results, seen and unseen, we shall define grāma (scale) first."

(Saṅgīta Ratnākara.)

Third Part

MEASURE OF INTERVALS AND HARMONIC SOUNDS

The Measure of Intervals.

TO be in a position to study the different musical systems, we must first see what are the methods of measuring musical intervals and decide which method we shall use.

On any stringed instrument, to realize equal intervals at different pitches, we shall have to use smaller differences in string length the higher we go in the scale. This is because sound vibrations increase according to a geometrical progression : the number of vibrations is inversely proportional to the length of the string.

To note musical intervals, the simplest system is, of course, either to note the respective string lengths or pipe lengths of the notes, which is the ancient system, or to note the respective numbers of vibrations, which are only the inverted string length ratios, as is the general practice to-day.

For example : suppose the open string gives the C_4 (Sa) = 512 vibrations. To obtain the D (Re), which is one major tone (9/8) above, we shall have to shorten the string by 1/9th of its length. The 8/9th remaining giving the sound D (Re).

To calculate the vibrations, we have, D_4 (Re) = 9/8 of C_4 (Sa), that is to say, the inverted string length proportion.

Thus, D_4 (Re) = 512 × 9/8 = 576 vibrations per second. This simple and accurate system has one defect which comes from the difficulty of knowing the relative value of ratios without making calculations.

For example : the major half-tone corresponds to 16/15 and the minor half-tone to 25/24. We can easily know that the minor half-tone is smaller. But, is the Greek limma (256/243) bigger or smaller, and in what proportions ? We cannot, without calculation, know that it is half way between the two.

If we represent the notes by their vibrations, it will not make things easier, because the numbers of vibrations, varying proportionally, do not allow, without great labour, the analysis of intervals. This is why, for easier reading and comparisons, it is necessary to replace length ratios and vibrations by additionable numbers, which are no other than the logarithms of the geometrical ones.

If, then, we take the ordinary logarithms (base 10) and, for facility, we multiply them by one thousand, we shall have the frequencies expressed in terms of SAVARTS[1], whose symbol is σ (sigma).

The Chinese use a similar but less convenient system based on the decreasing powers of 3.

The interval of the octave (Sa to upper Sa) is equal to 2, as it corresponds to a double number of vibrations (half string length).

The logarithm of 2 being 0.30103, the interval of the octave is equal to 301.03 savarts or, with an accuracy generally sufficient, 301 savarts. This division makes the comparison of intervals very easy.

For example :

the minor half-tone (25/24) is equal approximately to 18 savarts,

the major half-tone (16/15) to 28 savarts,

the Greek limma (256/243) to 23 savarts.

We can see immediately that the limma is situated between the minor and major half-tones, at one comma ($81/80 = 5\sigma$) from either.

In America, according to a method which has a tendency to spread, the temperate half-tone has been divided into one hundred parts ; the octave is thus divided into 1200 cents. This method has three main defects : 1° — it starts from the temperate scale, which always brings errors and does not permit the nature of intervals to be understood ; 2° — it requires a multiplication by 4 if one wants to utilize logarithm tables, which are necessary to find out the correspondence between this sort of division and the proportional ratios ; and 3° — it gives only inaccurate numbers, as the octave is divided into 300 instead of 301.

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1. The French physicist Savart (1791 — 1841) advocated this system to which his name was given.

The Scale of Sounds.

Suppose that we collect all the intervals which, in ordinary practice, are used in modes (rāgas), as well as in chords, in relation to a note considered as the tonic. When comparing these intervals, we shall find a certain number of points within the octave, each of which corresponds to a perfect relation with the basic note, though they may not have harmonious relations between themselves. When we apply the same process to each of the notes of the diatonic scale (Sa or Ma grāma), in relation to each note we shall obtain a certain number of points, some of which will coincide with those of other notes, and some of which will not. We shall thus have a number of distinct points within the octave, and we can then see whether they bring out a simple division of the octave and whether the points which form an harmonic interval with one note are also in harmonic relation with other notes.

By trying all the possible combinations of the minor tone, the major tone, the major half-tone, and all the intervals resulting from their sum or their differences (the minor half-tone is the difference between the minor tone and the major half-tone ; the limma is the difference between the major tone and the major half-tone ; the maximum tone (8/7) is the difference between the ditone (2 major tones) and the minor tone, etc.), we get a division of the scale which is of nine intervals for the major tone, eight for the minor tone and five for the diatonic (major) half-tone. These intervals are separated from each other by one comma (81/80 = 5 savarts), except for a discontinuity of 8 savarts between the notes of different name (C and C sharp (Sa and Komal Re), E and F (Ga and Ma), etc.). If we compare this scale to the key-board of the piano or organ, for each key, black or white, we shall have several notes separated from each other by one comma (5 savarts). But, between the highest note corresponding to a certain key, A (Ḍha) for example, and the lowest one corresponding to the next key, flat B (Ni Komal), there remains an interval of 8 savarts.

We can divide that interval (8 savarts) into two. We then obtain, according to Western interpretation, the enharmonic sharp (or quarter-tone) and the major enharmonic sharp (three-quarter-tone) distant from the neighbouring sounds in the scale by four savarts, slightly less than a comma.

Notations.

To note these different intervals, the following convenient symbols, placed after or above the notes, have been adopted here :

The sign + indicates that the note is raised by one comma (81/80 = 5 savarts).

Ex : D+ (Re+)

The sign ++ indicates that the note is raised by 2 commas (10 savarts).

Ex : D++ (Re++)

The sign ♯ (sharp) indicates that the note is raised by a minor half-tone (25/24 = 18 savarts).

Ex : $\overset{\sharp}{D}\sharp = \overset{\sharp}{E}\flat$ (Ga♯) (ati-komal)

The sign L− indicates that the lower note is raised by one limma (256/243 = 23 savarts), or the upper note lowered by one major half-tone (16/15 = 28 savarts).

Ex : $\overset{L}{C}\sharp, = \overset{L}{D}\flat$ (ReL−) (komal)

The sign L+ indicates that the lower note is raised by one major half-tone (16/15 = 28 savarts) or the upper note lowered by one limma (256/243 = 23 savarts).

Ex : $\overset{L}{C}\sharp = \overset{L}{D}\flat$ (ReL+) (komal)

In the minor tone (which is equal to two limmas, that is, 46 savarts), both L− and L+ become one and are indicated by a plain L.

Ex : $\overset{L}{D}\sharp = \overset{L}{E}\flat$ (GaL) (komal)

The sign ♭ indicates that the upper note is lowered by one minor half-tone (25/24 = 18 savarts) or that the lower note is raised by a major half-tone in the minor tone, or by a large half-tone (27/25 = 33 savarts) in the major tone.

Ex : $\overset{\flat}{D}\sharp = \overset{\flat}{E}\flat$ (Gab) (komal)

The sign -- indicates that the note is lowered by two commas.

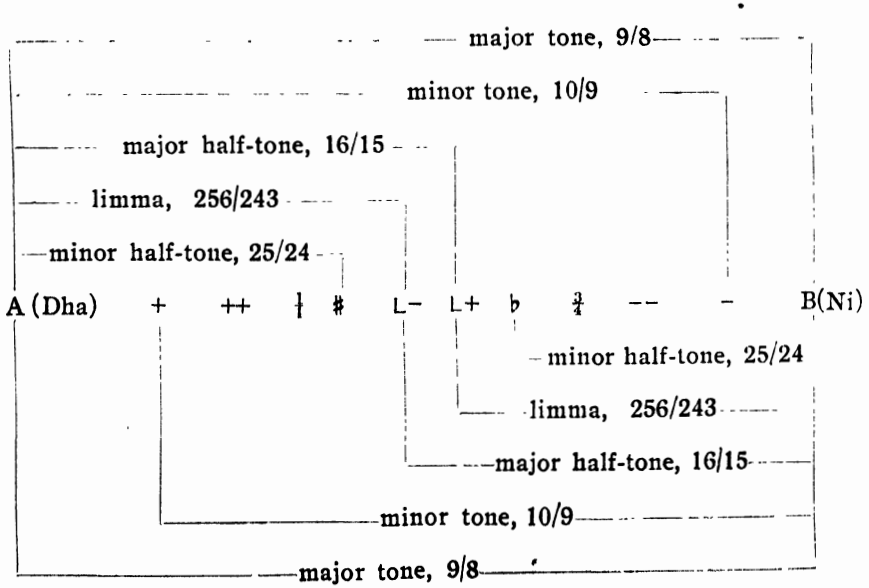
Ex : D--(Re--)

The sign - indicates that the note is lowered by one comma (81/80 =5 savarts).

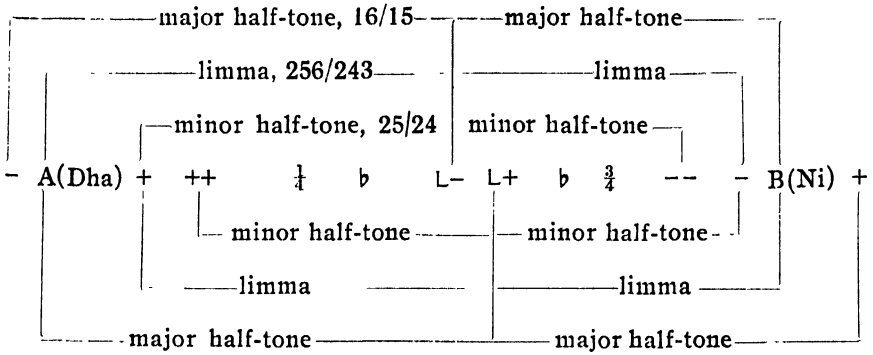
Ex : E-(Ga-)

To these signs are added, as previously explained, between ++ and ♯, the sign $\frac{1}{4}$ and, between ♭ and --, the sign $\frac{3}{4}$. The major tone, the minor tone and the diatonic half-tone are thus divided in the following way :

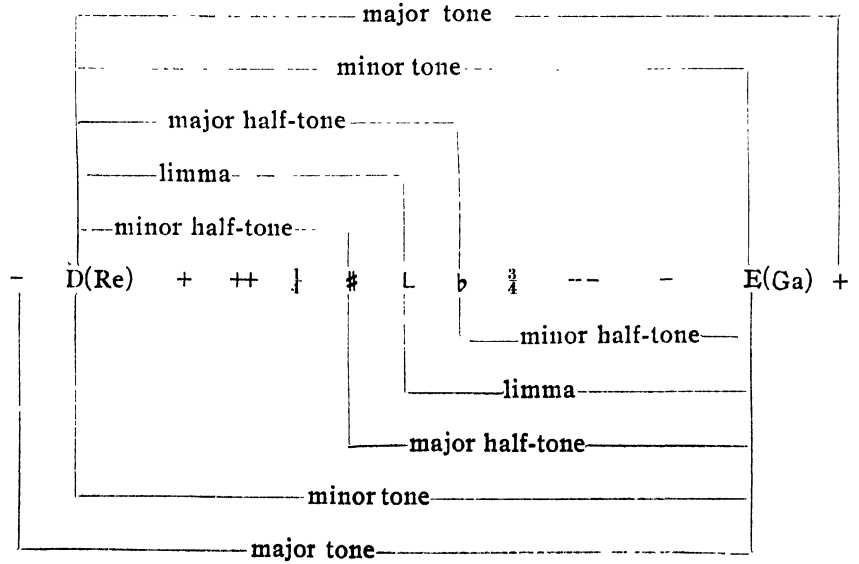
In the major tone :

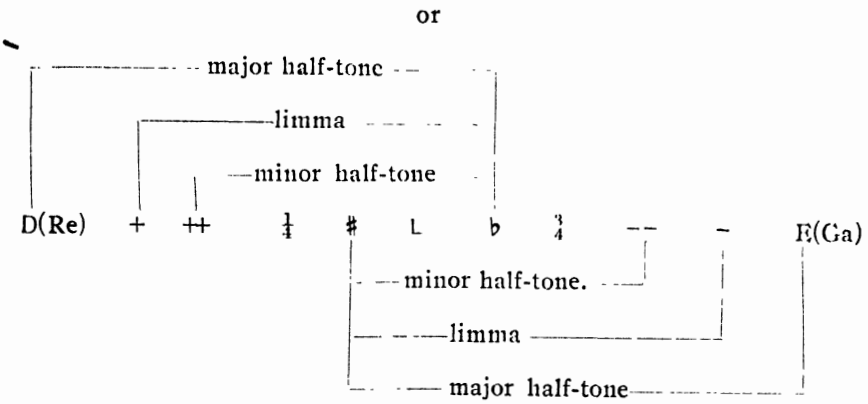


or

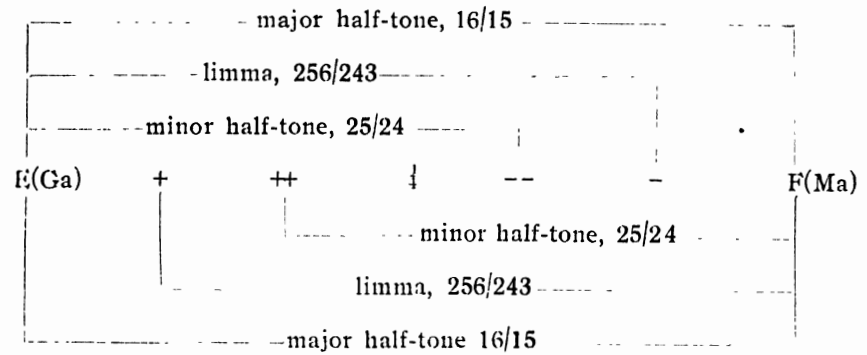


In the minor tone :





In the diatonic half-tone :



In practice, we shall indicate the exact tuning sign above the note, and the general indication sharp (♯) or flat (♭) (tivra (Γ) or komal (K)) beside the note as customary. But, in the Indian notation, as the doubt cannot arise, we shall, generally, indicate the exact tuning sign only. We then shall have $\overset{\#}{B}\flat$, $\overset{L}{B}\flat$, $\overset{\natural}{B}\flat$. $\overset{\flat}{B}\flat$, etc., (komal Ni♯, NiL−, NiL+, Ni♭, etc.). $\overset{\#}{A}\#$ would be identical to $\overset{\#}{B}\flat$, $\overset{\natural}{A}\#$ identical to $\overset{\natural}{B}\flat$, $\overset{\flat}{A}\#$ identical to $\overset{\flat}{B}\flat$, etc..

In this way is realized a division of the octave into fifty-three intervals, allowing us to play accurately, i.e. without beats, all the

usual harmonic intervals. And we can, with the help of this scale, note accurately all the modes (rāgas) of all the musical systems. By *musical* systems, are meant such systems as are used by musicians everywhere, and not the constructions of a childish arithmetic, such as the temperate quarter-tone, etc..

We can here note that the fifty-three intervals of the scale of fifths, if we want to utilize them musically, — that is, sing them or play them by ear on a non-keyed instrument, — are automatically transformed into the simpler harmonic intervals which are much easier to appreciate, much more natural. We might here add that to sing without accompaniment the temperate scale is an undertaking above human capacities, because we cannot, without strong external help, escape from harmonic intervals which, alone, are in accordance with the physical nature of sounds and, consequently, with the shapes and the possibilities of the organs by which we can emit and perceive sounds.

"The tone or musical interval", the Arab theorist Al-Fārābī once said, "can be agreeable, composed or imagined." Which may mean that there are intervals which are in conformity with harmonic laws (agreeable), intervals resulting from the relation of other intervals (composed) and intervals which may appear possible in theory but which cannot be utilized in practice. Such intervals can be conceived but cannot, by ear, be executed, and, for this reason, do not belong to the musical field proper in which alone we are interested here.

Limited to simple ratios, the acoustic intervals in use among the different human or animal races are, therefore, by the very nature of things, limited in number. But the modern "scientific" outlook, opposed to all hierarchy, consists, it appears, of considering the "agreeable" interval, that which is in conformity with physical laws, and any other interval, imagined or calculated, as on an equal footing. Such an outlook is highly astonishing to one who is not used to such equalitarian conceptions. M. Yekta-Bey remarks[1] :

1. La musique Turque, Dictionnaire du Conservatoire, p. 2959.

"The views and ideas of Western musicians about the scale appear to Orientals highly surprising and impossible to understand. For example, we hear of several scales under the names of Pythagoras, of Ptolemeus, of Aristoxenes, of Zarlino, of the physicists. This may be all right. But is it the right of every one to constitute a scale according to his own wishes and to ask people to sing according to the proportions of that scale ? If nobody can do it, from where do all these different scales come ? . . . . . The work of a theorist is to *measure* the song of man, to find out its laws, and not to write, on *a priori* grounds alone, an artificial scale composed with any ratios he is pleased to adopt."

This was also what Aristides Quintilian thought : (De Musica, Meibom, p. 3) "The work of the musician consists not so much in comparing sounds as in assembling and bringing in tune all that Nature contains in her bosom."

The Harmonics.

As is taught in primary school, we can subtract or add only things of like nature. In the same way, in the field of sounds, we can establish logical relations only between sounds of like nature. Before we can study the relations between sounds, it is essential for us to know their nature. And, for this, we must first examine what are the accessory sounds which form the natural superstructure of every individual sound, because their properties will necessarily be the basis of the practical construction of musical relations.

It is very difficult to realize a pure sound because, together with any sound, we hear always a group of harmonics. The numbers of vibrations of these harmonic sounds are the exact multiples of the fundamental. The first harmonics form a chord which is the logical basis of all music, and their intervals are the easiest to sing, the most natural. Certain wind instruments, horns in particular, can play only the harmonics of their fundamental sound.

Generally, the further these harmonics are from the fundamental sound, the fainter they are. But, according to the material used and the means employed to cause the vibration, certain harmonics may resound more strongly than others.

All possible relations of sounds are included in the unlimited series of the harmonics. There is no harmonic or melodic combination which is not implied in the very structure of a single sound. This is, of course, a logical necessity, because there cannot be an effect whose potentiality is not in the cause, and, therefore, an effect of sounds the principle of which is not in every element of sound. Incidentally, this allows us to note the comparative unimportance of arts whose developments are necessary only because of our inability to perceive principles.

All possible ratios of sounds, being included in the series of the harmonics, can, quite naturally, be represented by a relation of harmonics. We thus find that the major tone (CD (Sa Re)=9/8) is the interval from the 8th to the 9th harmonic, the minor tone (DE (Re Ga)=10/9) the interval from the 9th to the 10th harmonic, the minor half-tone (25/24) the interval from the 24th to the 25th harmonic, etc.. The temperate half-tone is said to be the interval from the 1,000,000,000 to the 1,059,463,094th harmonic.

The harmonics which are very near to the fundamental sound are the only ones that the human ear readily perceives and appreciates. They are those whose relations appear to us more pleasing and which, normally, form the elements of musical systems because their correspondence with cosmic laws (macrocosm) and with the physiological data peculiar to man (microcosm) enable them to evoke, for us, ideas and images, of which these ratios are the simplified representation. The more the harmonics are distant from the fundamental sound, the more they appear to us complicated and dissonant. This is because the numbers by which are formed the first harmonics are. in conformity with the Universe as our senses can perceive it, and form the legitimate field of man in the magic world of sounds, the field which is open to him by reason of the physical

laws on which he depends and the organs which he possesses and which are in conformity with these laws. But to those ideas, those images which man can evoke through sounds, he cannot give a tangible existence. Without the knowledge of the transcendental laws of numbers, of which the perceptible laws of our illusory world give only an imperfect and approximate image, he cannot materialize them. But this knowledge, normally, is not accessible to him. The whole of these laws constitutes the tree of science, which it may be illegitimate and dangerous to approach.

The Scale of Harmonics.

If, for the establishment of a harmonic series, we take as a basis C (Sa), we first notice the appearance of the octave (upper Sa) 2/1, then of the fifth (Pa) 3/2, then the third (Ga) 5/4, then the harmonic flat B (komal Ni) 7/4, lower than the usual flat B (komal Ni), which forms, with the upper C (Sa), the maximum tone 8/7. After this appears the major second CD (Sa Re) 9/8 and its complement the minor second DE (Re Ga) 10/9, then the harmonic F$\frac{1}{4}$ (Ma$\frac{1}{4}$) and A--(Dha--), (F$\frac{1}{4}$ = 11/8 and A-- = 13/8), and, finally, the seventh B (Ni) 15/8.

Considering only the sixteen first harmonics, of which eight are different notes and the others upper octaves, we obtain a scale of eight tones formed of the following intervals :—

	C	D	E	F$\frac{1}{4}$#	G	A--	B$\frac{1}{4}$b	B	C
	(Sa)	(Re)	(Ga)	(Ma$\frac{1}{4}$)	(Pa)	(Dha--)	(Ni--)	(Ni)	(Sa)
Ratios:		2/8	5/4	11/8	3/2	13/8	7/4	15/8	2/1
Savarts:	51	46	41	38	35	32	30	28	

The ratios are given in relation with C (Sa), and the intervals in savarts are those between one note and the next.

Although the series of harmonics contains implicitly all the possible intervals utilized in music, the order in which those intervals appear does not constitute properly a musical scale. And this is theoretically obvious, because it has only one dimension, and is, therefore, unfit for even the simplified representation of the world of forms.

The series of the harmonics has been proposed often by physicists and acousticians as a basic scale, but, in practice, its inadequacy becomes at once obvious ; the main difficulty being that all its intervals differ from one another and become smaller as the scale rises. Consequently, the fixed structure of the tetrachords, the Aristotelian "body of harmony", indispensable for the establishment of musical scales, cannot be established. In any event, the harmonic series would be contrary to any form of modulation because of the variety of its intervals.

Nevertheless, the series of the sixteen first harmonics can be considered as forming a peculiar mode. When we deal with the signification of musical modes we shall explain its remarkable significance.

The harmonic series is not limited to the first cycle. It proceeds indefinitely, though theoretically, beyond the limits of perception. We give here, starting from the C (Sa) of the physicists (powers of 2) (i. e., C_0 (Sa) = 32), a chart of the first thirty-two harmonics in the order in which they appear.

FOURTH PART

THE CYCLE OF FIFTHS

The musical theory of the Chinese.

"What we hear is either
auspicious or inauspicious;
music must not be
inconsiderately executed."

Seū-mà T'shyēn.

Preliminary Note – In this short account of Chinese music we have abundantly drawn on the admirable work of M. Maurice Courant, published under the title "Chine et Corée" in the "Encyclopédie de la Musique et Dictionnaire du Conservatoire" (Fondé par Albert Lavignac), Paris 1924, Section : Histoire de la Musique, Vol. I, p. 77 to 241. All the translations from Chinese authors are those of M. Maurice Courant except where otherwise specified. The sentences borrowed from M. Maurice Courant's work are indicated by the letters (M.C.) whenever they occur.

FOURTH PART.

THE CYCLE OF FIFTHS

Chinese Music.

CHINESE musical tradition has certainly a common origin with Hindu tradition. The two systems are only the different applications of universal principles which not only are necessarily common to them but whose first enunciation seems also to have been one. Traces of this common origin can be found in all their respective essential theories as well as in many technical expressions. Further, since the dawn of its history, China has had constant cultural exchanges with India, of which there are many "historical" proofs, even if one does not accept as historical the conquest of China by the hero Rāma, or the marriage of Nakula, (the brother of Yudhiṣṭhira) with the daughter of the King of China (Mahābhārata). But it seems that, in the periods which are more accessible to modern means of investigation, contacts between the two countries became very rare and that the two cultures took very different directions. While India's theorists were restricting themselves to the system of relations to a tonic, almost completely ignoring polyphony, the Chinese, on the contrary, were pursuing only the cyclic system which necessarily leads to transposition. Thus, the two countries became musically isolated and unintelligible to each other. This was certainly not the case fifteen or twenty centuries ago when exchanges of orchestras were quite common between the two, as many documents, mostly Chinese, prove.

The Nature and the Purpose of Music.

Like the Hindus and the Greeks, the Chinese recognize in music a perceptible representation of the relations by which the different elements of manifestation are connected ; this representation,

when sufficiently accurate, can, in turn, react upon the original relations and modify the course of events. "Music acts on the Universe, Heaven and Earth, and on all the beings contained therein." "The expression of natural harmonies, music is thus a translation of the moral forces which are also a part of the Universe ; it comes out from it but regulates it in turn. This aspect of the world's system has been profoundly analysed and minutely exposed first by the classical books, then, later, by philosophers and historians. The Yŏ kí, [the book of music compiled in the time of Wù tí (147-87 B. C.) with extracts of the Cheū kwān],[1] studies these questions from every point of view, it points out similarities, essential relations between psychological, social or political facts on the one hand and, on the other, notes, instruments, melodies, songs, etc.." (M. C.). "The ancient Kings . . . . . have established in the lyŭ the proportions of what is small and what is big and classified the beginning and the end so as to represent the duties to be performed." (Yŏ kí). In spite of its far reaching possibilities, the knowledge of those subtle relations has not generally as its aim the transgression of cosmic limits, the escape from the endless cycle of life and death. The Chinese have not this passionate desire of union with the Absolute which haunts the Hindus To them it appears the first essential to maintain order and harmony in our material world, to realize the perfect proportions of individual and social life that only the knowledge of those subtle correspondences between things, and their harmonization with the help of appropriate sounds, can allow us to realize. "Music expresses the accord of Heaven and Earth" and "produces the harmony between men and spirits." (Tsù Hyáo-swēn)

"The physical laws of sound represent the social laws of hierarchy and union ; they symbolize, prepare and support good government. We might be tempted to see in these formulas a series of metaphors ; the Chinese have seen in them, since the very beginning, ... the expression of real, tangible relations." (M.C.). "He

1, The words in brackets are ours.

who sings becomes straight and displays his moral influence, and, when he himself comes into motion, Heaven and Earth respond, the four seasons are in harmony, stars and planets are orderly, life is sustained in all beings." (Yŏ kí). This is why the mastery and ordinance of music are the first duties of statesmen because, "if it is given to the dukes and ministers to hear the lyŭ of each month in the court's assemblies, they will become able to move Heaven and to accord themselves to the Earth influx." (Pào Yĕ, about 77 A. D.)

The Yîn and the Yâng.

Since the Chinese musical system has as its only aim the establishment of contacts and mutual reactions between apparently unconnected aspects of manifestation, it is essential for us, in order to understand its applications, to have an idea of the knowledge that the Chinese had of metaphysical reality, and an idea of the book which sums up that knowledge, the Yĭ kīng. Though it may seem a disgression, it appears necessary to give here a very short account of it.

Composed by the mythical Emperor Fŏ-hī in the fourth millenium before the Christian era[1], the Yĭ kīng has been and still remains the inexhaustible source whose form conditions all Chinese metaphysical thinking.

All manifestation issues from two principles supplementary and concordant, one positive, spiritual, active, male and warm, the Yâng, the other negative, material, passive, female and cold, the Yīn. These two terms correspond to the Sanskrit *Liṅga* and *Yoni* which symbolize *Śiva* and *Śakti*, that is, *Puruṣa* and *Prakṛti*, Being and Matter.

1. cf. "Orient et Occident", by René Guénon, note p. 70.

"The exact date [of the existence of Fo-hi] is 3468 before the Christian era according to a chronology based upon the exact description of the condition of the sky at that time ; let us add that the name of Fo-hi is used, in reality, as a designation for a whole period of Chinese history."

Those two principles are the basis of all existence. Any science must, therefore, begin with the definition of their respective position and proportion in the object of its study.

It is with the study of this proportion that the scientist or the artist should begin any enterprise. And this is particularly true of music which is the most direct representation of the process of the World's creation.

"Kīng Fâng [about 45 B. C.] [1] . . . . . had deeply studied with Tsyāo Yên-cheú the Yĭ kīng, the book of cosmogony and predictions; he was also learned in astrology and acoustics, since natural sciences are connected with the study of this canonical book. Following the steps of his teacher, he explained the theory of the progression of the lyŭ (fifths) [1], not stopping after the twelfth tube, as is customary, but proceeding up to the sixtieth. He based his system on the analogy of the eight Kwá or mystical trigrams of the Yĭ kīng, which, united two by two, form sixty-four distinct combinations; similarly the twelve original lyŭ multiplied by five, the number of the elements, form, in all, sixty lyŭ." (M. C.)

The Yĭ kīng represents the Yâng and the Yīn symbolically by a full line — and a broken line - -; these two lines can be combined in four different ways, forming the four Syáng or diagrams: (See: Notes sur le Yĭ kīng, by Avitus, Voile d'Isis, 1931, p. 599.)

extreme positivity (light, heat),

small negativity (stars),

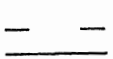
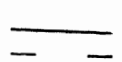
small positivity (planets),

extreme negativity (moon, cold, etc.).

1. Our brackets.

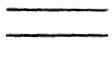
These four diagrams, in their application to manifested forms, can be compared to the three fundamental qualities (Hindu 'guṇa') by which is conditioned all existence. That is :

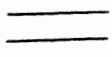
 Sattva : ascending tendency, conformity to the pure essence of being,

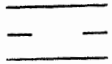
 and  Rajas : expanding tendency, development,

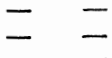
 Tamas : descending tendency, obscurity, degradation.

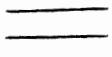
From these four diagrams are issued the 8 trigrams, which are :

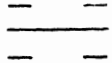
 Khiên (Heaven)

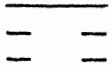
 Twéi (the marsh)

 Lî (the fire)

 Tshèn (the thunder)

 Swèn (the wind)

 Khan (the water)

 Kèn (the mountain)

 Khwèn (Earth)

The principles represented by these eight trigrams find their application in the diverse aspects of manifestation. In the sixth chapter of "The ten strokes of the wings", Kong Tse (Confucius) gives the following correspondences for the eight trigrams : (quoted by Matgioi, La voie métaphysique, Paris 1905; new edition, Paris 1936, p. 168.)

Khyên (Heaven) is : activity, the horse, the head, the father, all that is round, the sun, the prince, gold, cold, ice, red, the swift horse, the white horse, the dry tree, what is straight, the dress, speech.

Khwèn (Earth) is : passivity, the mare, the womb, the mother, the cloth, the axe, economy, equality, the mother of the bull, the cart, appearance, the crowd, the handle, black, what is square, the bag, the pipe, the fly.

Twéi (the marsh) is : the he-goat, the mouth, the girl, the child, the diviner, the tongue, the rupture, hardness, the concubine, duration.

Lî (the fire) is : vibration, the pheasant, the eye, the wife, the sun, the thunderbolt, the girl, posterity, the weapon, the tortoise, the stomach, the reptile, the fruit, the stem, the cow.

Tshèn (the thunder) is : movement, the feet, the male principle, the dragon, thunder, yellow, the causal influence, the highway, the elder son, haste, bamboo, the harmonious song, the mane, rebirth, repetition, the crow.

Swèn (the wind) is : the entrance, the hen, the thigh, the female principle, wood, the elder daughter, the thread, white, work, length, height, the branch, the sense of smell, the broad forehead, the profile, the tree, the search.

Khan (the water) is : the fall, the pig, the ear, the husband, the hidden secret, the roof, the string of the bow, indisposition, blood circulation, pale red, ardour, the light foot, the cover,

calamity, the moon, the thief, hardness of the heart, the den, the music, the thorny bush, the fox.

Kèn (the mountain) is : stop, the fox, the hand, the boy, the path the stone, the door, the monk, the finger, the mouse, solidity, the nose, the tiger, the wolf.

These trigrams, combined two by two, form 64 hexagrams which allow the representation of all the aspects of existence. It is through them that we can study and bring into practice the laws of correspondence between the different aspects of the world and, in the particular field of music, understand the modalities according to which the fifths, in succession, will allow us, following their hierarchical development, to reach all the planes of the visible and invisible world, to influence spirits, celestial emperors, elements and seasons, and to regulate the destinies of the Empire. This is possible because "rites and music rise up to Heaven and surround the Earth, act upon the principles Yīn and Yâng and communicate with the manes and heavenly spirits." (Yŏ kí). According to the words of the Emperor Hyáo-Wên (477-499) : "Music . . . . shakes Heaven and Earth, moves the spirits, brings into accord the two cosmogonic principles, penetrates men and manes."

The correspondence of the trigrams and the musical notes appear of a different nature according to the method used to determine this correspondence, each method being valid in its own field. The comparison, for example, can be based on their symbolism isolated or in combination, or it can be based on the analysis of the structure of the trigrams and the relative position of full lines and broken lines as comparable with the structure of tetrachords and chords.

The peculiarity of the trigrams is that, whatever may be the way in which they are manipulated, the results, which are thus obtained, endlessly various as they are, will always be in conformity with some aspect of reality.

The Seven degrees of the Pentatonic scale.

Chinese people have always been realists. This is why they so willingly conceive abstract principles but only to find for them immediate applications. The Yĭ kīng itself and its metaphysical trigrams may have survived the persecution of scholars only because of its magical applications.

The ancient Chinese certainly did not ignore the transcendancy of the heptatonic scale, assimilated by them to the "Seven Beginnings" (chĭ-shĭ). Conceiving music only as a means of harmonizing the elements of terrestrial existence and establishing a balance between Spirit (Heaven) and Matter (Earth), they did not pay much attention to the seven degrees, which form the scale of transcendental worlds, but, on the contrary, they cultivated to its utmost potentiality the science of the pentatonic which justly symbolizes the opposite forces of Heaven and Earth, of the Yâng and the Yĭn, which are in equilibrium in the dualism of Existence.

Many modern authors, carried away by the theory of evolution, want to make the heptatonic scale into a late development of a more 'primitive' pentatonic form. As there is no concrete basis upon which such a theory can be built, we do not propose to discuss it. We need only note that in the Chinese system, the only important pentatonic system of our times, although priority is evidently given to the five first fifths which correspond to the five elements and which alone can be expressed by integral numbers according to the traditional definitions, this priority in no way implies that the two auxiliary degrees are not known or utilized. The Hindu theory considers music as issued from seven sounds uttered by the seven Ṛṣis or Sages, and respectively connected with the seven Dwīpa or continents which symbolize the seven successive aspects of the world's manifestation, respectively characterized by the seven colours of the spectrum. And, unless we are ready to accept the idea that the "primitive" spectrum had only five colours, which is obviously absurd, it is difficult to see why things should be other-

wise for sounds. In reality, the laws which regulate the divisions of sounds, as those of light, are physical laws and not mere attributions, and it is only through ignorance that we may believe them to be arbitrary.

Furthermore, the Shū kīng and the Hán shū admit of the seven notes from the earliest times. "At the date 522 (B. C.), the Tsò chwán relates a conversation between the prince of Chî and Yén tseù who enumerates the 5 degrees, the 6 lyŭ and the 7 sounds, and commentators see in the seven sounds the 5 principal degrees and the two supplementary ones. The Kwĕ yù, in a quotation from the musician Cheū Kyeū, [contemporary of the king *Kìnǫ* (544-520 B. C.)], explain by the seven degrees, which they call the seven lyŭ, the date of the battle which the king Wù won against the Yīns ; whatever might be the value of such astrological considerations, they clearly indicate that, four or five centuries before the Christian era, the existence of the seven-note scale was acknowledged as having existed since the beginning of the Cheū" (M. C.), which by no means precludes an earlier existence. Again, the crown prince Chéng . . . . . declares that the seven-note scale has been known since the time of the Emperor Shwén (23rd or 21st century B. C.). The seven notes were then called the seven beginnings, Chĭ-shì. This expression is found in a passage of the Shū kīng, quoted by the Hán shū : "The Shū kīng says, I wish to hear the harmony of the six lyŭ, the five degrees, the eight sorts of instruments, the 'seven beginnings'." (M. C.).

These seven Chĭ-shì might well correspond to the seven Ṛṣis of Hindu tradition. The deformation of the word followed by the attribution of a somewhat different signification being not unusual for the passage of Vedic or Sanskrit words into Chinese. [1]

1. Among the musical terms which met with some change of meaning in their passage from Sanskrit into Chinese can be noted :

The Sanskrit Pañchama (fifth note) which becomes in Chinese (ancient reading) Pan-Jam, (modern reading) Pān-chéan (fifth note) but is used for the sixth note ;

Symbolic representation of the Pentatonic scale.

The Earth, or visible world, is symbolized by the number four which can be visually represented by the square. The Earth is effectively made of 4 perceptible elements and all its characteristics are regulated by the number 4 (4 seasons, 4 directions of space, 4 castes, etc.). But these 4 elements are issued from one unique and celestial element, Ether (Ākāśa) of which they are only the modalities. And, in a similar way, all matter only exists in relation to one single principle of manifestation.

This projection of the single into the multiple is symbolically represented in Egypt, as well as in America and China, by the pyramid whose square base seems to be issued from the summit, the summit which can also be represented by its projection at the centre of the square.

Music, being the representation of the relations between Heaven and Earth must, quite naturally, have this configuration of a centre or tonic (Kūng) surrounded by four notes assimilated to the 4 directions of space, the 4 perceptible elements, the 4 seasons, etc..

The Sanskrit Ṛṣabha (Rikhab), meaning 'a bull' and representing the second (ascending) degree, becomes, in Chinese, (ancient reading) Dzi-li (=ri)-dzap or Hu-li (=ri)-dzap, (modern reading) Heû-lí-chă, meaning 'sound of the bull Hŭ' and represents the seventh degree (second descending degree);

The Sanskrit Ṣaḍja (born of six), which represents the first degree becomes (ancient reading) Sa-da-lik, (modern reading) Sō-thô-lĭ (equal sound), and remains the first degree.

Instruments were also imported into China from India, such as the Tumburu Vīṇā or Tanpura, which the Chinese call Tān-pú-lă, the Tablā (or Arabic drum) which becomes Tă-pú-lă, etc..

Persian instruments were also imported, such as the Sitār, which the Chinese call Sa-thō-eūl, the rabāb which they call lă-pā-pŭ, the Sārangī which becomes Să-làng-tsí, etc..

The ancient readings of Chinese words are given according to the oldest phonetic tables of the Khāng hĭ tseú tyèn (see: M. Courant, Chine et Corée, Dictionnaire du Conservatoire, p. 96, note 4.).

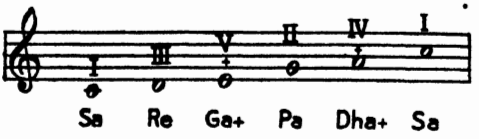
The pentatonic, thus presents a structure which allows it to be an adequate representation of the static influence of Heaven upon Earth. But, a static representation of a world in motion could not be an instrument of action upon this world. It is necessary, if we want to react upon the represented elements, to evolve from the motionless to the moving, from the angular to the circular, from the square to the circle. To express the movements of the Universe, the sounds will have to submit to the cyclic laws which, in their own field, are represented by the *cycle of fifths.*

The Spiral of Fifths.

As we have already seen, the fifth is the third sound of the series of harmonics, the first being the fundamental and the second its octave. According to the formula of the Táo-te-kīng : "One has produced two, two has produced three, three has produced all the numbers,"[1] we can understand why the third sound, the fifth, must necessarily, by its revolutions, produce all the other sounds. The first produced will be the four principal sounds which form, with the tonic, comparatively simple ratios. They are :

II. G (Pa) = 3/2 ;
III. D (Re) = 9/8 ;
IV. A+ (Dha+) = 27/16 ;
V. E+ (Ga+) = 81/64.

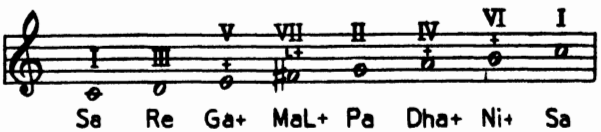
1. " ...which implies that four, immediately produced by three, is, in a certain way, equivalent to the whole of numbers ; and this because, as soon as we have the quaternary, we have also, by the addition of the four first numbers, the denary, which represents the complete numerical cycle : 1+2+3+4=10. This is the Pythagorean Tetractys . . . . . Our extension having only three dimensions, we go beyond its limits when we go beyond the third power . . . . . The elevation to the fourth power marks the very end of its limitlessness because, as soon as it is realized, we have, by this very fact, gone out of this extension. " (René Guénon, Remarques sur la notation mathématique, Etudes Traditionnelles, Février 1937, p. 75.)



To these primary five sounds, whose disposition represents the elementary structure of the perceptible world, can be added the two auxiliary sounds,

VI. B+(Ni+)=243/128 and
VII. F♯(MaL+)=729/512.

Thus is formed the seven-sound scale :



But, the two auxiliary sounds should not be used as fundamentals, because, since they belong in reality to the scale of invisible worlds, we cannot perceive their accuracy, and we could not build systems upon them without going out of tune.

"At the date 541 B. C., Tsò relates a consultation given by Hwô, physician of the land of Chîn, to the Marquess of Tsín, then ruling ; . . . . . 'Being given the central sound, if we diminish [the length], after five diminutions playing [on the instruments] is no

longer allowed'. Tshái Yuên-tíng sees in this text the law, imperative in ancient times, which allows the building of systems only on the five principal degrees . . . . . The diminution of length indicates the passage to the fifth above, and, in the series of fifths, the sixth degree obtained is a complementary degree, and, therefore, inadequate for the foundation of a system." (M. C.).

As we shall later see, the 5th successive fifth, whether in an ascending or a descending series, represents, in modal music also, the limit of consonance. Beyond this limit, no interval can appear harmonious nor can it be accurately recognized.

A rule originating from the same principle was also known in medieval Europe when the tritone was prohibited as diabolic, that is, as connected with forces which are extra-natural, and, therefore, uncontrollable.

After the seven sounds, there appear, in the series of fifths, five new sounds :

VIII. D flat (Re komal),
IX. A flat (Dha komal),
X. E flat (Ga komal),
XI. B flat (Ni komal) and
XII. F+ (Ma+),

completing the 12 sounds which divide the octave chromatically into 12 half-tones.

The 12th fifth (sound 13) brings us back to the fundamental, but with a slight difference. It is by one comma, the Pythagorean comma ($3^{12}/2^{18} = 531,441/524,288$ or 5.88 savarts), higher than the fundamental. It is, therefore, in our notation, C+ (Sa+).

If we proceed further, the twelve following fifths will place themselves one comma above the former ones, and the 24th fifth (sound 25) will again find itself one comma above C+ (Sa+), that is, in C++ (Sa++). In this way, the successive series of 12 fifths will place themselves one above another, at one comma interval, up to the

52nd fifth (sound 53).[1] But, after the 52nd fifth, the octave being filled up, the 53rd fifth (sound 54) comes out of the octave and inserts itself between the octave C (Sa) and the 12th fifth C+ (Sa+), thus forming, above C (Sa), a small interval of 0.84 savarts, which originates a new cycle, which, in its turn, with a period of 53 fifths, will divide the octave into small intervals of 0.84 savarts. The next cycle will appear after seven series of 53 when the 359th fifth (sound 360) comes out of the octave and forms, with C (Sa), an interval of 0.47 savarts. The next cycle is that of 666, whose basic interval, with C (Sa), is 0.035 savarts ; then comes the cycle of 25,524, with the basic interval of 0.0021174. This cycle is very near to that of the equinoxial precession, or Pythagorean great year, of 25,920 solar years, with a small difference, similar to that of the lunar and the solar year, of the 12th fifth and octave, etc., which leaves the door open for further cycles[2].

In practice, the Chinese, for reasons which are symbolic as well as musical, follow the series, after the 52nd fifth, only for the next six degrees which place themselves above the six perfect sounds ; and they stop the series at the sixtieth sound. The reason given is that : 12 (number of each cycle) × 5 (number of the elements) = 60.

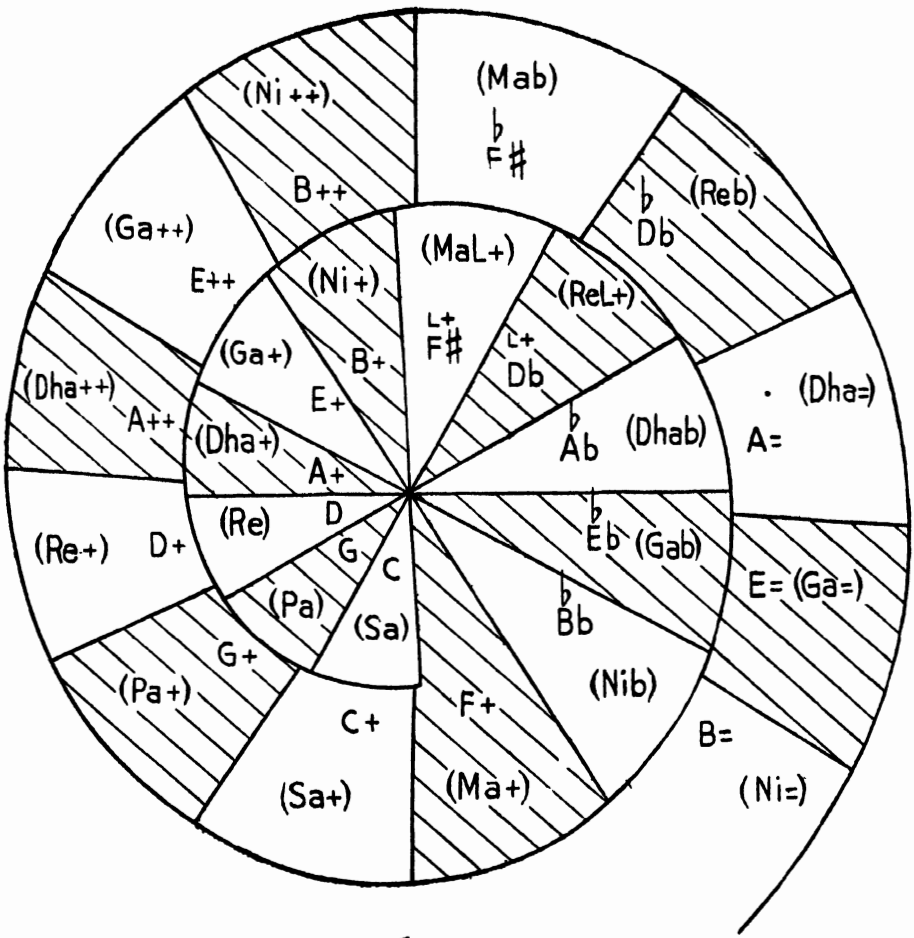
This scale of fifths, perfect for transposition because of its extreme accuracy, allows also the study of astrological correspondences and of terrestrial influx, provided one possesses the knowledge of the hierarchy of its intervals. "In the same melody, the prime, the third, the fifth, the sixth, are chosen independently because of their connection with diverse constellations and, consequently, with Heavenly spirits, Earthly spirits and Manes (pitṛ)." (Chéng Hyuên)

1. Nicolas Mercator and Holder had established a system of temperament of fifty-three degrees on the same basis.

2. The Pythagorean great year is the fifth part of the Chinese great year or Yuen, equal to $25{,}920 \times 5 = 129{,}600$, itself the double of the Hindu manvantara, $25{,}920 \times 2\frac{1}{2} = 64{,}800$, which, according to Eastern doctrine, always brings humanity back to its starting point. The duration of this complete evolution being two and a half precessions.

Taking as the tonic any one of the notes of the first cycle, a scale of five notes can be obtained which forms simple ratios (harmonic relations) with the tonic. The two auxiliary degrees already form somewhat troublesome ratios, but the others can only be used if the tonic is changed. The scale of fifths is, therefore, invariable and does not allow the study of harmonic proportions and chords.

The Spiral of Fifths.



The hatched sections represent female notes.

Equalized or Temperate divisions.

Considering the first series of fifths, we can obtain, beyond the six perfect tones,

I. C (Sa), II. G (Pa), III. D (Re),
IV. A+ (Dha+), V. E+ (Ga+), VI. B+ (Ni+),

the six imperfect tones,

VII. F♯ Ma tivra), VIII. D♭ (Re komal), IX. A♭ (Dha komal),
X. E♭ (Ga komal), XI. B♭ (Ni komal), XII. F+ (Ma+),

alternatively considered as male and female.

If we neglect the small difference between the thirteenth fifth and the octave, we obtain the equalized chromatic division into twelve half-tones on which are based all "temperaments" or equalized divisions of sound, space and time.

The six perfect tones can be represented by the sides of the inscribed hexagon. If we divide the side of the hexagon (which is equal to the radius) first into two, then into ten parts, this will lead us to the division of the circle into twelve, then 60 parts, divisions always employed for the representation of the world's movement within a closed circle. Occidentals use this division for the measurement of circles and angles ($60 \times 6 = 360$ degrees) and, consequently, for astrology and astronomy (12 Zodiacal signs, etc.).

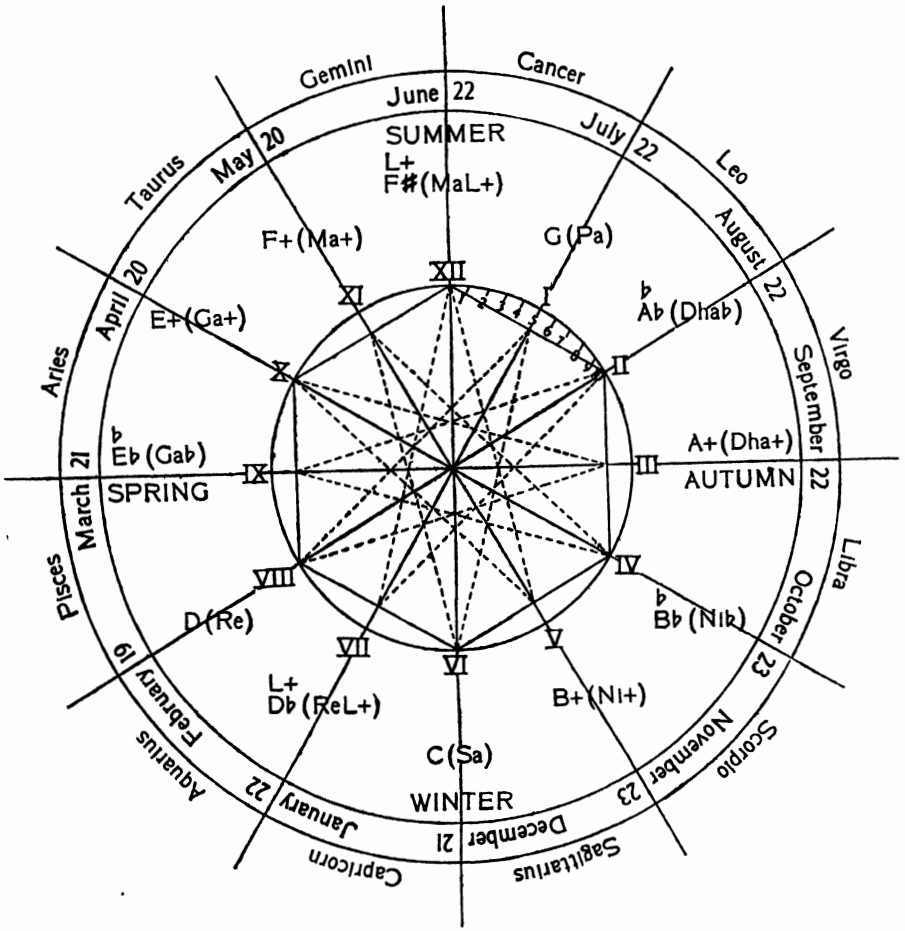
They use also a similar division for time into twice 12 hours, 60 minutes, 60 seconds, etc., all divisions which are said to have been borrowed from the Chaldeo-Assyrians. Europeans also divide the sound octave into 12, but do not proceed with the logical implications of this division as do the Chinese.

In reality, the physical laws which are applicable to sounds are not particular to them, but are those which regulate all the normal rhythms of the Universe, and those "positive" minds, which smile at such conceptions, might be very embarrassed if Saturday did not come every eighth day, if the days no longer had 24 hours (12×2), the hours 60 minutes, and if the relation of the sun and the

moon no longer formed for us a cycle of 12 months with, precisely, a slight difference comparable to that of 12 fifths and 7 octaves.

Cyclic Division into Twelve.

Showing the correspondences with the Zodiac, months, seasons, hours, minutes, octave, angles etc.



In this figure the order of succession of the fifths is given by the sides of the central star dodecagon. Each angle is connected by a dotted line to its upper fifth and its lower fifth. The notes which correspond to the angles of the hexagon are of male character ; the notes which correspond to the middle of the sides are of female character.

The Lyŭ.

The Chinese do not admit of any scale other than that formed by the first five fifths, but they observed that if, starting from one of these notes other than the fundamental, they wished to form again a similar scale, which is indispensable for transposition, four new notes were necessary. These notes are immediately given by the scale of fifths, and this is what has led the Chinese to take as the basis of their music the scale of the first sixty fifths which divide regularly the whole structure of the octave into what Occidentals call Pythagorean commas. "The scholar Chhên Chóng-jû . . . . . demonstrates the impossibility of transposition if one is limited to the original twelve lyŭ ; he also takes as argument the tuning of the Khîn, which admits of five *Tiáo*, or different systems, each one having, as its tonic, one of the notes of the original scale." (M. C.).

As standards for the sixty notes in the octave, tubes of metal of extremely accurate dimensions had been made since the remotest antiquity, giving sounds of fixed pitch which are called lyŭ and are the indispensable basis of Chinese music. Any of the lyŭ can be taken as a tonic provided that there are other lyŭ accurately tuned to form the pentatonic scale.

"The five degrees, born from the principles Yīn and Yâng, divide themselves between the twelve lyŭ which, by their revolutions, produce the sixty lyŭ : it is by those diverse agents that the influx of the "Bear" can be regulated and the relations between beings manifested. Heaven manifests itself in the seasons, Earth manifests itself in sounds, that is to say in the lyŭ. If the Yīn and the Yâng agree, then, when the seasons come, the influx of the lyŭ reacts." (Experiments during the Hán period).

The accurate measurement of the lyŭ is obviously of fundamental importance as not only the perfect relations of sounds depend on it but also the very pitch of the diapason. "If, to measure the five degrees of the scale, the foot corresponding to the fiery element is used, fire becomes important, ... with the metal foot, weapons

are important; with the water foot the lyŭ are in perfect tune, the Empire is at peace." (decree of Yâng Kyĕn, in 590 A. D.)

The Degrees of the Scale.

Issued from the principles Yīn and Yâng, the engendered fifths are successively of female and male character. Each note has a double character, one permanent as lyŭ, that is to say, as a number of vibrations, the other variable, according to its rank as degree in the scale (tonic, fifth, fourth, etc.).

A rise in the diapason, such as that which occurred in Europe during the last two centuries, must, therefore, according to the Chinese idea, considerably change the influence, if not the expression, of music. It is always to such variations that can be attributed the fortune or the fall of dynasties.

The notes obtained by the ascending fifth (lower generation) in the series are of female character, and those obtained by the down-ward fourth (upper generation) are male. According to the Lyŭ-chí-chhwēn tshyeū, the most ancient text on the lyŭ (cited by M. Chavannes, Mémoires historiques, Vol. III, p. 636): "To the three parts of the generator should be added one part to form the upper generation (ratio 4/3 = fourth) [1]; from three parts of the generator should be taken off one part to form the inferior generation (ratio 3/2 = fifth)[1]." This is also in conformity with the Hindu theory on the character respectively active of the fourth and passive of the fifth.

Let us note here that the most striking difference between the system of fifths and that of proportions resides in the perfect fourth, an essential interval in the scale of proportions, while the scale of fifths has an augmented fourth as its sixth fifth, the interval of the fourth appearing only, in a slightly augmented form (F+) (Ma+), as twelfth fifth, or, almost perfect, as fifty-third fifth. But, if, instead of starting from C (Sa), we had begun one fifth below, that is to say, from

1. Our parenthesis.

the F (Ma), we might have obtained this essential note without changing anything in our scale, except that, since we begin by a male interval instead of a female interval, the character of the whole system is modified. This is not merely an attribution, but corresponds to a fundamental difference in musical expression that the Hindus express by the difference of the Sa and the Ma grāmas (tonic on the fundamental or on the fourth) and the Greeks by the difference of the modes in which the mesa (middle note) is the tonic, or the fundamental tonic ; here lies the inner difference of signification between the two Dorian modes, between the Lydian and the Hypolydian, etc. .

"The five notes, according to Seū-mà Tshiēn, correspond to the five lyŭ : hwâng-chōng, thái-cheú, kū-syèn, lîn-chōng and nân-lyù, the only ones whose measurements can be expressed by integral numbers, starting from the base 81." (M. C.)

"The numbers given by the Chinese to correspond with the relative length of the tubes in the pentatonic or five-tone scale are : 81, 54, 72, 48 and 64 . . . . . these numbers hold great cosmological significance in Chinese culture, as do the numbers 3 and 2 which symbolize Heaven and Earth respectively." (Levis, Chinese musical art, p. 67.)

The first four fifths, which form, with the tonic, ratios considered as simple, are, from the most ancient origins, the five degrees of the Chinese scale :

I.	Kūng	(C)	(Sa)	=1	=81/81,
II.	Chĭ	(G)	(Pa)	=3/2	=81/54,
III.	Shăng	(D)	(Re)	=9/8	=81/72,
IV.	Yù	(A+)	(Dha+)	=27/16	=81/48,
V.	Kyŏ	(E+)	(Ga+)		=81/64.

We see that the Chinese numbers are the denominators of these ratios and correspond, therefore, to acoustic reality, as well as to the necessities of symbolism.

To those degrees are added, by two new fifths, the two auxiliary degrees which no longer correspond to integral numbers on the basis of 81. They are :

VI. Pyén kūng (modified kūng) or hwô (auxiliary)
$= 81/64 \times 3/2 = 243/128 = B+$ (Ni+)

VII. Pyén chì (modified chì) or myeú (different)
$243/128 \times 4/3 = 729/512 = \overset{\flat}{F}\sharp$ (MaL+).

The Scale of the Lyŭ

The lyŭ hwâng-chōng being the fundamental (kūng), we shall consider it as corresponding to C (Sa), because of its traditional use as general tonic, although, according to the P. Amiot,[1] it has 708.76 vibrations and is, therefore, in the physicists' scale, an $\overset{\sharp}{F}\sharp$ (Ma♯), F natural according to the Western modern diapason.

"Kūng, source of light, the centre to which everything is attracted, corresponds to the sound we call F." (Fabre d'Olivet, La Musique expliquée, p. 73.)

To be able to represent the intervals of the first twelve fifths by integral numbers, the Chinese suppose the length of an open string (or pipe) sounding the hwâng-chōng to be equal to $177{,}147 = 3^{11}$ units. The first fifth (lyŭ II) will be 2/3 of that number, that is, $3^{10} \times 2 = 118{,}098$.

The next fifth, brought back within the octave, (lyŭ III), will be the 4/3 of this new number,

that is, $3^9 \times 2^8 = 157{,}464$.

The following fifth (IV) will be 2/3 of the preceding :

$3^8 \times 2^4 = 104{,}976$.

The following fifth (V), 4/3 of the preceding, etc..

1. P. Amiot, De la musique des Chinois tant anciens que modernes. (Mémoires concernant les Chinois, Vol. VI, p. 1 et seq.). Published in 1780.

The fifths whose numbers in the series are even, obtained by multiplying by 2/3 (fifths number II, IV, etc.), are female, and the fifths whose numbers are odd (I, III, V etc.), obtained by multiplying by 4/3, are male.

"Six lyŭ bear especially the name of lyŭ (rules), or chōng (middle, medium): they are those whose rank, in the series, is odd; they depend on the male principle Yâng. The six others, whose rank is even, depend on the female principle, Yīn, and are called lyŭ (helpers), or, in a more ancient way, thōng (companions), or kyēn (intermediaries)." (M.C.) The representative numbers of the fifths thus go on until the twelfth fifth $F+(Ma+)=2^{16}=131,072$.

After the twelfth fifth, the numbers are no longer integral, as they are no longer divisible by three, but they give an approximation similar to that of ordinary logarithms (savarts).

If we follow the endless developments of the endless series of fifths, it will lead us, octave after octave, into vibratory regions which no longer belong to the realm of sounds and where the diverse successions and groupings of the vibrations will take ever new and unexpected forms. These particular properties of the vibratory scale constitute the key by which can be understood the difference in the nature of the vibrations at the diverse vibratory stages, perceived as sound, light, touch, taste, or smell, and, finally, the structure of matter and of the atom itself, as envisaged by the Hindu grammarians.

The graphic representations of the cycle of fifths at its different stages, will give us successively all the important symbolic and geometrical constructions. Within the range of sound we already obtain, as main graphic representations, the square, the pentagon, the dodecagon, the circle, the spiral, the labyrinth, the zig-zag, etc..

We cannot enter here into a lengthy study of the properties of the powers of the ratio 3/2, and its graphic representations. Limiting ourselves to the first sixty fifths we give here only the succession of the sixty lyŭ according to the system of Kīng Fâng (about 45 B. C.).

Scale of fifths - (the 60 lyŭ)

Lyŭ	Order in the succession of fifths	Degree	Names of the lyŭ	Ratio	Chinese number	Savarts	Intervals
1	I	C(Sa) Kōng	HWÂNG-CHŌNG	1	$177{,}174 = 3^{11}$	0	tonic
2	(LIV)[1]	.....	(sĕ-yŭ)	$3^{53}/2^{84}$	$176{,}777\ldots = 2^{83}/3^{42}$	(0.84)	
3	XIII	C+ (Sa+)	chĭ-shì	$3^{12}/2^{19}$	$174{,}762\ldots = 2^{18}/3$	5.88	Pythagorean comma
4	XXV	C++ (Sa++)	pìng-shéng	$3^{24}/2^{38}$	$172{,}410\ldots = 2^{37}/3^{13}$	11.74	two commas
5	XXXVII	D♯ (Re ♯)	fēn-tóng	$3^{36}/2^{57}$	$170{,}089\ldots = 2^{56}/3^{25}$	17.61	(minor half-tone)
6	XLIX	D♭ (Re ♭−)	chĭ-mŏ	$3^{48}/2^{76}$	$169{,}800\ldots = 2^{75}/3^{37}$	23.48	(limma)
7	VIII	D♮♭ (Re♭+) sharp Kōng	TÁ-LYÙ	$2^{7}/2^{11}$	$165{,}888 = 3^{4} \times 2^{10}$ or 2/3 of VII	28.52	(major half-tone)
8	XX	D♭ (Re ♭)	fēn-phì	$3^{19}/2^{30}$	$163{,}654\ldots = 2^{29}/3^{8}$	34.38	(large half-tone)
9	XXXII	D−−(Re−−−)	.....[2]	$3^{31}/2^{49}$	$161{,}451\ldots = 2^{48}/3^{20}$	40.35	(small tone)
10	XLIV	D− (Re−)	.....	$3^{43}/2^{68}$	$159{,}278\ldots = 2^{67}/3^{32}$	46.12	(mino· tone)

1. The Roman numerals within brackets refer to fifths above the fifty-second (sound LIII) which form, with the adjoining notes, intervals smaller than a comma.
2. At the time of printing this book, we were unable to obtain any of the Chinese works in which the complete list of the lyŭ is given ; we have thus been compelled to leave the list of names of the lyŭ incomplete.

11	III	D(Re) Shāng	THÁI-TSHEÚ	$3^2/2^3$	157,464=$3^9\times2^8$ or 4/3 of II	51.14	major tone 9/8
12	(LVI)	.....	.....	$3^{55}/2^{87}$	157,136... =$2^{86}/3^{44}$	(51.99)	
13	XV	D+ (Re+)	shî-sĭ	$3^{14}/2^{22}$	155,344... =$2^{21}/3^{8}$	57.07	(large tone)
14	XXVII	D++ (Re++)	.....	$3^{26}/2^{41}$	153,253.. =$2^{40}/3^{15}$	62.89	
15	XXXIX	Eb (Ga ♯)	.....	$3^{38}/2^{60}$	151,190... =$2^{59}/3^{37}$	68.76	(small minor third)
16	LI	$\overset{L}{\text{E}}$b (Ga L)	.....	$3^{50}/2^{79}$	149,155... =$2^{78}/3^{39}$	74.63	(trihemitone)
17	X	$\overset{b}{\text{E}}$b (Gab) sharp Shāng	KYĂ-CHŌNG	$3^9/2^{14}$	147,456=$3^2\times2^{13}$ or 2/3 of IX	79.68	minor third (major tone + apotome)
18	XXII	E--(Ga--)	.....	$3^{21}/2^{33}$	145.471.... =$2^{31}/3^{10}$	85.53	
19	XXXIV	E-(Ga-)	.....	$3^{33}/2^{52}$	143,512... =$2^{51}/3^{22}$	91.40	(small major third)
20	XLVI	E (Ga)	.....	$3^{45}/2^{71}$	141,581... =$2^{70}/3^{34}$	97.37	(major third)
21	V	E+(Ga+) Kyŏ	KŪ-SYÈN	$3^4/2^6$	139,968=$3^7\times2^6$	102.31	ditone 9/8 × 9/8 = 81/64

22	(LVIII)		.....	$3^{57}/2^{90}$	139,676 ..$=2^{89}/3^{46}$	103.14	
23	XVII	E++ (Ga++)	pyén-yû	$3^{16}/2^{25}$	138,084... $=2^{24}/3^{5}$	108.17	(large major third)
24	XXXIX	F−− (Ma−−)	.....	$3^{88}/2^{44}$	136,225... $=2^{43}/3^{17}$	114.04	
25	XLI	F− (Ma−)	.....	$3^{40}/2^{63}$	134,391... $=2^{62}/3^{29}$	119.91	(small fourth)
26	LIII	F (Ma)	yī-hîng	$3^{52}/2^{82}$	132,583 ..$=2^{81}/3^{41}$	125.78	(fourth)
27	XII	F+ (Ma+) sharp Kyŏ	CHÓNG-LYÙ	$3^{11}/2^{17}$	$131,072=2^{16}$	130.81	large fourth (fourth + Pythag. comma).
28	XXIV	F++ (Ma++)	nân-chōng	$3^{23}/2^{36}$	129,307... $=2^{35}/3^{12}$	136.68	
29	XXXVI	$F^{\#}$ (Ma#)	.....	$3^{35}/2^{55}$	127,566... $=2^{54}/3^{24}$	142.55	(small augmented fourth)
30	XLVIII	$F^{\flat}$ (MaL−)	.....	$3^{47}/2^{74}$	125,849... $=2^{73}/3^{36}$	148 42	(harmonic tritone)
31	VII	$F^{\natural}$ (MaL+) pyén Chì or Myeú	JWEÏ-PÎN	$3^{6}/2^{9}$	$124,416=3^{5}\times 2^{9}$	153.46	cyclic tritone (3 major tones)

32	(LX)		.....	$3^{59}/2^{93}$	$124,156... = 2^{92}/3^{48}$	154.29	
33	XIX	$\overset{\flat}{F}\sharp$ (Mab)	chéng-pyén	$3^{18}/2^{28}$	$122,741... = 2^{27}/3^{7}$	159.42	(large augmented fourth)
34	XXXI	G−−(Pa−−)	.....	$3^{30}/2^{47}$	$121,088 .. = 2^{46}/3^{19}$	165.19	
35	XLIII	G−(Pa−)	.....	$3^{42}/2^{66}$	$119,459... = 2^{65}/3^{31}$	171.06	(small fifth)
36	II	G (Pa) Chi	LÎN-CHŌNG	3/2	$118,098 = 3^{10} \times 2^{1}$	176.09	fifth 3/2
37	(LV)			$3^{54}/2^{85}$	$117,852... = 2^{84}/3^{43}$	176.93	
38	XIV	G+(Pa+)	khyù-myĕ	$3^{13}/2^{20}$	$116,508... = 2^{19}/3^{2}$	181.96	(large fifth)
39	XXVI	G++(Pa++)	.....	$3^{25}/2^{39}$	$114,940... = 2^{38}/3^{14}$	187.83	
40	XXXVIII	$\overset{\sharp}{A}\flat$ (Dha$\sharp$)	.....	$3^{37}/2^{58}$	$113,393... = 2^{57}/3^{26}$	193.70	(small diminished sixth)
41	L	$\overset{L}{A}\flat$ (DhaL)	.....	$3^{49}/2^{77}$	$111,867... = 2^{76}/3^{38}$	199.57	(diminished sixth)
42	IX	$\overset{\flat}{A}\flat$ (Dhab) sharp Chi	YÎ-TSĔ	$3^{8}/2^{12}$	$110,592 = 3^{8} \times 2^{12}$	204.61	diminished sixth (fifth + apotome)

43	XXI	A−−(Dha−−)	kyà-hîng	$3^{20}/2^{31}$	109,103... $=2^{30}/3^{9}$	210.47	
44	XXXIII	A−(Dha−)	.....	$3^{32}/2^{50}$	107,634... $=2^{49}/3^{21}$	216.34	(small sixth)
45	XLV	A (Dha)	.....	$3^{44}/2^{69}$	106,185... $=2^{68}/3^{33}$	222 21	(harmonic sixth)
46	IV	A+(Dha+) Yú	NÂN-LYÙ	$3^{8}/2^{4}$	104,976 $=3^{8}\times 2^{4}$	227.24	cyclic sixth (fifth+ major tone = 27/16)
47	(LVII)		.....	$3^{56}/2^{88}$	104,757... $=2^{87}/3^{55}$	228.08	
48	XVI	A++(Dha++)	kyĕ-kōng	$3^{15}/2^{23}$	103,563... $=2^{22}/3^{4}$	233.11	(large sixth)
49	XXVIII	♯B♭ (Ni♯)	.....	$3^{27}/2^{42}$	102,169... $=2^{41}/3^{16}$	238.98	(small minor seventh)
50	XL	B♭ (NiL−)	.....	$3^{39}/2^{61}$	100,794... $=2^{60}/3^{38}$	244.85	(seventh harmonic)
51	LII	B♭ (NiL+)	yî-hán	$3^{51}/2^{80}$	99,437... $=2^{79}/3^{40}$	250.72	(minor seventh)
52	XI	♭B♭ (Ni♭) sharp Yú	WÛ-YĬ	$3^{10}/2^{15}$	98,304 $=3^{1}\times 2^{15}$	255.76	(minor seventh)

53	XXIII	B--(Ni--)	pí-yèn	$3^{22}/2^{34}$	96,980... $=2^{33}/3^{11}$	261.62	
54	XXXV	B- (Ni-)	.....	$3^{34}/2^{53}$	95,675... $=2^{52}/3^{23}$	267.49	(small seventh)
55	XLVII	B (Ni)	.....	$3^{46}/2^{72}$	94,387... $=2^{71}/3^{35}$	273.36	(major seventh)
56	VI	B+(Ni+) Hwô or pyén Kōng	YÍNG-CHŌNG	$3^{5}/2^{7}$	93,312 $=3^{6}\times 2^{7}$	278.4	cyclic major seventh $=243/128$
57	(LIX)		.....	$3^{58}/2^{91}$	93,117... $=2^{92}/3^{46}$	279.24	
58	XVIII	B++(Ni++)	chhî-néi	$3^{17}/2^{26}$	92,056 .. $=2^{25}/3^{6}$	284.26	(large major seventh)
59	XXX	C--(Sa--)	.....	$3^{29}/2^{45}$	90,817... $=2^{44}/3^{18}$	290.13	
60	XLII	C-(Sa-)	.....	$3^{41}/2^{64}$	89,594 .. $=2^{63}/3^{30}$	296.	(small octave)
1	I	C (Sa) Kōng	HWÂNG-CHŌNG	2	88,573... $=3^{11}/2^{1}$	301.03	octave
2	(LIV)		sĕ-yŭ	$3^{58}/2^{83}$	88,388... $=2^{82}/3^{42}$	301.87	cyclic octave

Symbolism and Correspondences of the Lyŭ.

We here wish to warn Western readers against any hasty judgment about the practical value of the correspondences attributed to musical notes by the Chinese or the Hindus. Those attributions, by no means arbitrary, are perfectly in accordance with the inevitable significance of musical intervals, although they often refer to certain kinds of correspondences which we are not accustomed to consider. Their application can be found in every music, and in particular in Western music, in a way which appears almost systematic, as in Wagner, or instinctive, as in Bheethoven, Liszt or Chopin. And it is necessary that it should be so, because the descriptive value or the emotional significance of all music depends on these correspondences.

The Chinese system of correspondences is logical and coherent ; we can unfortunately only glance at it here.

The first twelve fifths or lyŭ divide the octave into twelve half-tones corresponding to the different moons or months.

The tá-lyŭ, (VIII) (D♯b) (Re+), corresponds to the twelfth moon,

The thái-tsheŭ, (III) (D) (Re), corresponds to the first moon,

The kyă-chōng, (X) (E♭b) (Gab), corresponds to the second moon, etc. .

"The hwâng-chōng, (I) (fundamental = C (Sa)), is the lyŭ of the eleventh moon, that of the winter solstice. Of yellow colour, it corresponds to the element "Earth" because, in that season, the Yâng influx, male and hot, is hidden in the Earth." (M. C.)[1]

"The hwâng-chōng (I) is used as the fundamental in the sacrifices to Heaven because it is the lyŭ of the eleventh moon and because, in that season, the vivifying influence of Heaven begins to make itself felt ; the thái-tsheŭ, (III) (D) (Re), is adequate for the

1. "Yellow is the colour of the natural agent *Earth* (t'u), that is to say, of the base, of the fixity, of the centre, of the pole around which revolutions are accomplished." (André Préau, La Fleur d' Or, Voile d' Isis, 1931, note p 92).

Sun because it is the male form of the kyă-chōng which corresponds to the spring equinox ; it is, indeed, at the time of the equinox that the Sun is worshipped. The hwâng-chōng, (I ′C) (Sa), is assigned to the Emperor, prince among men and image of Heaven, the nân-lyù, (IV) (A) (Dha), to the Empress." (M. C.).

The Chinese scale, being invariable, constitutes, properly speaking, a single mode. Every change in expression or significance will depend thus upon modulation, that is, change of tonic, as is also true, to a certain extent, of Western music.

According to Kīng Fâng : "Each lyŭ, separately, being the perfection of a day, the others are to be transposed, according to their order, because the lyŭ corresponding to the days are, in succession, the fundamental note . . . . . .

"Because there are twelve lyŭ and twelve scales similar to the standard scale [of seven notes], there are eighty four systems, of which sixty are for the principal modes and twenty four for the complementary modes." (M. C.) "Among the twelve lyŭ, seven sounds (degrees) are taken successively which make a scale . . . . . For each scale there are seven systems : in total eighty four systems on which are based the melodies, sung or played." (From a report made by Wâng Phŏ in 959 A. D.).

"For sacrifices at the altar of Heaven, the hwâng-chōng (I) should be taken as a fundamental (Sa), for the altar of Earth the lîn-chōng (II), for the temple of ancestors the thái-tsheú (III), for the ceremonies in the five suburbs, for the assemblies of congratulations, and for the court banquets, the lyŭ of the month." (Tsù Hyáo-swēn).

According to the Tá tshīng hwéi tyèn (eighteenth century) :

"The hwâng-chōng (I) is fundamental for sacrifices to Heaven and to the Shâng tí. The lîn-chōng (II) is fundamental for the sacrifices to the Earth. The thái-tsheú is fundamental for sacrificing to the emperors or empresses of the ruling dynasty, and also to the Sun and to the Thaí-swéi, [the spirit of the year identified with the planet Jupiter]. The nân-lyù (IV) is funda-

mental for sacrifices to the Moon. The kŭ-syèn (V) is fundamental for sacrifices to the First Agriculturists. In spring the kyă-chŏng is fundamental, and in autumn the nân-lyù (VI) is fundamental, for the sacrifices to the Thái-shé, the Thái tsĭ [spirit-protectors of the state territories], to the rulers of former dynasties and to Confucius . . . . . When the Emperor appears in the great hall of the throne, for the three great yearly festivals, the fundamental is the hwâng-chŏng (I) ; when the Empress comes into the central palace, on the occasion of the three great yearly festivals, the fundamental is the nân-lyù (IV). For ordinary assemblies at the Court, the lyŭ of the month should be taken as fundamental . . . . . Generally, there are melodies of 9 repetitions (for sacrifices offered to the Sháng tí), of 8 repetitions (for sacrifices performed at the altar of Agriculture, the altar of the Sun, the altar of the First Agriculturists), of 6 repetitions (for sacrifices performed in the temple of Ancestors, at the altar of the moon, etc.).

"From the winter solstice to the summer solstice are the months born from the Yâng principle, in these months only half lyŭ (high-pitch) [1] are used and no double lyŭ (low pitch) [1]. From the summer solstice to the winter solstice are the months of the Yĭn principle, then are used double lyŭ and no half lyŭ, because the Yâng corresponds to 1 and the Yĭn to 2." (Prince Tsái-yŭ, 16th century).

"To the Emperor and the prince corresponds the hwâng-chŏng (I) (C) (Sa), that is, the element Earth. If the hwâng-chŏng is fundamental, the second (D) (Re) suits the ministers. The fundamental expresses the majesty of the Emperor." (M. C.)

"The five regions of space are under the dominion of the five celestial Emperors." (M. C.)

Yellow Emperor, hwâng-chŏng (I) (C) (Sa), Centre.
Red Emperor, hân-chŏng (II) (G) (Pa), South.

1. Our parenthesis.

White Emperor, thaí-tsheú (III) (D) (Re), West.

Black Emperor, nân-lyù (IV (A+) (Dha+), North.

Green Emperor, kū-syèn (V) (E+) (Ga+), East.

The tonic A (Dha) is called Hu-si, (western lamentation), by the Chinese, a name which is in accordance with the melancholy character of the scale of A (Dha) (minor mode).

After the winter solstice, the fundamental is the lower C (Sa).

Before the winter solstice, the fundamental is the upper C (Sa).

The odd lyŭ are male, the even lyù are female.

We can establish some of the correspondences of the lyŭ in the chart to be found on p. 87.

Signification of the Names of the First Twelve Lyŭ

(according to Tù Yeú, d. 812 A. D.)

Hwâng-chōng, C (Sa),[1] = yellow bell.

Yellow is the colour of the element Earth. In this season, (winter solstice), the Yâng influx, male and hot, is hidden in the Earth.

Tá-lyù, $\overset{\flat\flat}{C}\sharp$ (ReL+). "Tá" = large.

Thái-tsheú, D Re). Thái = great, tsheú = to arrive, multiply. During the first moon, all beings come to life under the Yâng influx.

Kyă-chōng. $\overset{\flat}{E}\flat$ (Gab). Kyă = to help (in relation with Heaven), therefore the synonymous "yuên" = round.

Kū-syèn, E+ (Ga+). Kū = dryed up, old, Syèn = washed, fresh. During the third moon all beings are renewed.

Chóng-lyù, F+ (Ma+). Chóng = middle (or syào = inferior).

Jweĭ-pīn, $\overset{\flat\flat}{F}\sharp$ (MaL+). Jweĭ = luxuriant vegetation, Pīn = to treat as a guest. The Yâng influx begins to give place to the Yīn influx.

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1. Chōng means : bell. Lyŭ means : sound-pipe, rule. Lyù means help, accessory.

Some Correspondences of the Twelve first lyu.

Notes	Name of lyŭ	7 beginnings	Fundamental for sacrifices	Annual cycle	Sex	Moon
C (Sa)	hwâng-chŏng, I	Heaven	to the *yellow* emperor, to Heaven.	winter solstice (Yâng influx)	male	11th (December)
♯C♯ (ReL+)	tá-lyù, VIII				female	12th (January)
D (Re)	thái tsheú (male form of kyă-chŏng), III	Man	to the *white* emperor, to ancestors.		male	1st (February)
♭E♭ (Gab)	kyă-chŏng or yuên-chŏng, X		to spring.	spring equinox	female	2nd (March)
E+ (Ga+)	kŭ-syèn, V	Spring	to the *green* emperor, to the First Agriculturists.		male	3rd (April)
F+ (Ma+)	chŏng-lyŭ, XII				female	4th (May)
♯F♯ (MaL+)	jwĕi-pīn, VII	Summer		summer solstice (Yīn influx)	male	5th (June)
G (Pa)	lîn-chŏng or hân-chŏng, II	Earth	to the *red* emperor, to Earth.		female	6th (July)
♭A♭ (Dhab)	yî-tsĕ, IX				male	7th (August)
A+ (Dha+)	nân-lyù, IV	Autumn	to the *black* emperor, to the Empress, to the moon.	autumn equinox	female	8th (September)
♭B♭ (Nib)	wû-yì, XI				male	9th (October)
B+ Ni+)	yīng-chŏng, VI	Winter			female	10th (November)

Lîn-chŏng or hân-chŏng, G (Pa). Lîn = forests. During the sixth moon the forests are flourishing. Hân = to envelop. It is an allusion to celestial action.

Yî-tsĕ, $\overset{\flat}{A}\flat$ (Dha♭). Yî = to wound ; tsĕ = rule, chastisement. In the seventh moon, all beings begin to feel the hardships of winter.

Nâu-lyù, A+ (Dha+). Nân = to support. Vegetals are less luxuriant and appear oppressed (eighth moon).

Wû-yì, $\overset{\flat}{B}\flat$ (Ni♭). Wû = privation ; yì = impulse, production. With the approach of winter, Nature closes itself, concentrates itself.

Yĭng-chŏng, B+ (Ni+) = the bell which answers.

Correspondences of the Degrees of the Scale.

"Notes begin to have a musical value when a certain number of them, chosen for reasons of perceived affinities, form a scale or melodic progression. The chromatic series . . . . . is, therefore, not properly musical, each sound being put into a neutral state, in a balance indifferent towards the others . . . . . The lyŭ, the material of music, acquire a meaning when some of them are chosen as degrees of a scale." (M. C.) Then, only, their signification becomes clear and their symbolism can be definitely perceived and understood. "The Yuĕ lĭng bring out the connection between months and elements, the lyŭ on one side and the five degrees on the other, and, finally, the numbers from 5 to 9." (M. C.)

Here are some of the correspondences of the notes considered as degrees. Those correspondences will be maintained in transposition whatever may be the lyŭ corresponding to the fundamental degree (kūng)." The element 'Earth', which has no corresponding season, is, anyhow, connected with a degree, a lyŭ, a number." (M. C.).

According to the Yŏ kĭ : "The five degrees of the scale are assimilated to the prince, the ministers, the people, the works, the

material resources, but, the prince being superior to the minister, it is necessary that the corresponding note be lower than that of the minister." (M. C.)

"The degree kūng (tonic) represents the prince ;
the degree shāng (second) represents the ministers ;
the degree kyŏ (third) represents the people ;
the degree chì (fifth) represents public works ;
the degree yù (sixth) represents the products.

If the five degrees are not disturbed, there will be no discordant sounds." (Yŏ kí).

The five notes correspond to the five natural agents[1] :

Kūng (tonic)	=	centre of the Earth ;
Shāng (second)	=	metal and autumn ;
Kyŏ (major third)	=	wood and spring ;
Yù (sixth)	=	water and winter ;
Chì (fifth)	=	fire and summer.

"The shāng degree is firm and rigid ; . . . . . it has the sound of metal." (M. C.).

According to the Cheū lì :

1 and 6 are the numbers of water (carapace-wearing species),
2 and 7 are the numbers of fire (feather-wearing species),
3 is the number of wood and also that of the dragon of the eastern sea,
4 is the number of metal and of the west, (hair-wearing species, the white tiger of the western hills),
5 is the number of the Earth (naked species and spirits of the Earth),
6 is the number for celestial spirits.

The colours of the five degrees are :

1. See : A. Préau. Lie-Tseu, Voile d'Isis, 1932, No. 152-3, p. 556.

Fundamental, (C) (Sa), yellow ;
Major second, (D) (Re), white ;
Ditone, (E+) (Ga+), blue ;
Fifth, (G) (Pa), red ;
Sixth, (A+) (Dha+), black.

Indeed, the dominant colour in spring (E+) (Ga+) is blue, the dominant colour in summer (G) (Pa) is red, the dominant colour in autumn (D) (Re) is white, and the dominant colour in winter (A+) (Dha+) is black.

Western commentaries.

With the prejudice of Westerners, who, so often, *a priori* deny all the scientific conceptions of other races until they are "rediscovered" by themselves and ceremoniously re-christened with a name of Latin or Germanic origin, the Chinese division of the octave, however rational it may be, is ridiculed by most Western writers. Even M. Maurice Courant allows himself to write :

"Needless to say, the sixty degrees in the octave are scarcely perceptible and are difficult to realize, a slight difference of temperature bringing an important variation in the sound as compared with the interval of two successive degrees. Such a scale can never be accurate."

We do not know on what grounds M. Maurice Courant makes such a sweeping statement, which experiments could easily have proved unfounded.[1] We suggest that M. M. Courant tune, with one comma of difference, two strings corresponding to the same note of his piano. He will then see if this interval is not perceptible ; and we refuse to believe that the piano of M. M. Courant plays such bad tricks at every change of temperature. We should

1. A difference of one comma in the lower part of the strings of a Cello is of approximately half an inch.

Correspondences of the Degrees of the Scale.

Degrees	Notes	Colours	Directions of space	Elements	Seasons	Numbers	Function	Animals and qualities.
Kūng, fundamental	C (Sa)	yellow	Centre	earth		5	Emperor and Prince	Naked species.
Shāng, major 2nd.	D (Re)	white	West	metal	Autumn	9 and 4	ministers	Hair-wearing species (the white tiger of the west), metallic sound, firm and rigid, unbearable for spirits.
Kyŏ, major third (ditone)	E+ (Ga+)	blue	East	wood	Spring	8 and 3	people	Scale-wearing or aquatic species (the blue dragon of the eastern sea).
Myeú or pyén Chì (modified Chì), augm. 4th (tritone)	F♯ (Ma⊥+)							
Chì, fifth	G (Pa)	red	South	fire	Summer	7 and 2	public services	Feather-wearing species (the red bird of the south).
Yù, sixth	A+ (Dha+)	black	North	water	Winter	6 and 1	products	Carapace-wearing species (the black turtle of the north).

not forget that the problem is not to play in succession intervals of one comma, but to play intervals with an accuracy of one comma. A difference of one comma in a fifth or an octave is not only perceptible but extremely disagreeable even to an untrained ear ; the same difference in a third or in a major second — it is then the difference of the major and minor tones — changes completely the colour of the note and its expression. And one can even say, as a rule, that such differences are the very basis of vocal and melodic expression, whether one is conscious of it or not, as can easily be verified with instruments accurate for the measuring of vibrations.

Western scholars have two obsessions, into the frame of which they wish to force all the facts ; one is the theory of Evolution applied to the short period which we call historical, and the other, sometimes called the "prejudice for classicism", which pretends that everything whatsoever comes from the Greeks. To give an instance of the first, they remain undisturbed by the fact that their musical theory is extremely nebulous and often in contradiction to elementary acoustic laws, and find it quite natural to believe that the Chinese have been using, by mere chance, for thousands of years, a perfectly scientific theory.

As an adept of the "prejudice for classicism" let us quote M. M. Courant : "it seems that an entirely new musical system has been substituted for the *rudimentary*[1] carillons in which China had hitherto *taken delight*[1]. As this system is exactly that of the Pythagoreans, and it makes its appearance in the Far East after the expedition of Alexander, one would be inclined to believe that it was a result of the influence of Greek civilization in China."

M. Courant here but repeats the words of other Orientalists who claim that Chinese music has indeed developed as a result of

1. The italics are ours.

a Greek military expedition to the Indus. It is impossible to treat seriously such poetic flights which only show a very weak knowledge of geography. There is no doubt that the Chinese system is similar to that of Pythagoras. But, if an influence is to be considered, it was certainly in the opposite direction.

The immediate sources of Greek music were undoubtedly the Near East, and the Phrygian and Lydian modes were not so called because Alexander had taught them respectively to the Phrygians and the Lydians but because the Greeks had borrowed them from those peoples. Besides, the travels of Alexander to the banks of the Indus can in no way affect Chinese culture, because, to come from Macedonia to Bactriane is a very simple journey as compared with the enormous distance and the formidable obstacles which separate the Indus from Peking. A few scholars however take a diametrically opposite view. According to David and Lussy: (Histoire de la notation musicale depuis ses origines, Paris, Imp. Nationale, p. 17—36.)

"The musical system of the Greeks had certainly not originated in their country.... One is bound to suppose that Pythagoras brought from the East the musical system which was adopted by his country-men of Hellas ..... It was foreigners coming from India, Persia, and Asia Minor, the Phrygians Hyagnis, his son Marsyas, and Olympus, the Thracians Linos, Thamyris and Orpheus, who imparted music to Greece. We therefore believe, until better information is obtained, that the Hellenic tonal system had its origin in India or perhaps in China; the Greek instruments were all of Asiatic origin, and we admit, with Fetis, that, in music, nothing belongs to them which cannot be found in the Orient in conditions of superiority which leaves them far behind ..... Let us examine their instruments .... ; compare them with the abundant variety of instruments that the Orientals once possessed and we shall be bound to recognize that the Greeks, so remarkable in other artistic fields, have been, of all the ancient people, the least proficient in those resources which are the essentials of a musical culture."

These simple observations, which every available fact corroborates, should create at least some doubt in a non-prejudiced mind, as regards the Greek origin of Eastern musical systems. But, as we have already seen this does not apparently disturb later scholars when they want to impose their prejudices. This ability to juggle with facts, and ignore all those views or proofs which contradict their opinion, has made almost all the theories of Western scholars concerning the relations of Eastern and Western civilizations of ancient times, absolutely untrustworthy. And, in certain fields, admitted theories, which are believed by most Westerners to be irrefutable truths, amount to nothing less than a deliberate falsification of history.

FIFTH PART

THE RELATIONS TO A TONIC

The modal music of the Hindus.

न सोऽस्ति प्रत्ययो लोके यः शब्दानुगमादृते ।
अनुविद्धमिव ज्ञानं सर्वं शब्देन भासते ॥

वागेव विश्वा भुवनानि जज्ञे ।
स भूरिति व्याहरत् भूमिमसृजत् ।

वेदशब्देभ्य एवादौ निर्ममे स महेश्वरः ।

"In this Universe, there is no form of knowledge which is not perceived through sound ; knowledge is pierced through by sound ; all this Universe is but the result of sound."

(Vākya Padīya 1, 124.)

"Utterance (Vāk) brought forth all the Universe. He (God) pronounced "Bhū" and the Earth was born."
"From the sound of Vedas that supreme Divinity made all things."

(Manusmṛti 1, 21.)

Fifth Part

THE RELATIONS TO A TONIC

The Hindu Musical Theory.

SINCE the remotest antiquity there has existed in India, besides a general theory of sounds, a theory of musical modes which seems to have been the source from which all systems of modal music originated. The Hindu theory is not, like other systems, limited to experimental data ; it does not consider arbitrarily as *natural* certain modes or certain chords, but it takes as its starting point the general laws common to all the aspects of the world's creation.

Starting from metaphysical principles, the Hindus have recreated the theory of sounds. They have analysed and classified all the possible ratios and relations between sounds. The result is, obviously, an astronomical number of theoretical chords, modes and combinations, of which few only are utilized in practice ; the others, however, remain accessible for the day when new conditions, or the inspiration of musicians, may require new modes or new musical forms

The Hindu classification deals once and for all with the subject of musical relations. It is the necessary basis of any serious study. All other classifications are, beside it, child's play. Unfortunately its approach is difficult, no systematic study of it has been made in any modern language, and we cannot here start this enormous enterprise[1]. But, without going beyond the limits of the classifications utilized today in Hindu music, we can find

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1. "Music, in which the Hindus excelled, has not as yet been the object of special studies. The refinements of a too scholarly theory have paralysed the researches of the Europeans." (Sylvain Lévi ; at the word 'India' in the "Grande Encyclopédie".)

therein easily understandable elements which are sufficient for the comparative study of all the existing modal systems.

The Laws of Music and their Applications.

The theory of sounds can be approached in two ways, either as the systematic application of the universal laws of creation common to sound and other aspects of manifestation, or, as the empirical utilization of physical peculiarities in the development of sounds. The first approach is called by the Hindus' Mārga' (directional) and, being based on absolute laws, is Universal and unchangeable, while the other, which is called 'Deśī' (regional), varies endlessly according to place and time.

The power of a music constructed according to the Mārga rules is extraordinary, its influence over animate and inanimate things unlimited. In the words of a grammarian: "This science of sounds is the chemistry of the Universe." There is no sort of transformation in the structure or appearance of things which cannot be achieved through the influence of organized sounds.

Ritual music must necessarily follow the rules imposed by Mārga theory. This is why most of the Mārga definitions are kept in the ritual which regulates the singing of Sāma Veda.

On the other hand, the object of Deśī music being usually only pleasure or the expression of human feelings and passions, Deśī systems vary very much according to countries and time. Their influence may be good or bad. All the modern musical systems are of this empirical and unstable kind. And their relative value can only be measured by comparing them with the permanent definitions of the Mārga theory, which, alone, is based upon absolute laws.

"The music which is called Gāndharva (Mārga) is that which has been, from time immemorial, practised by the Gandharvas (celestial singers) and which leads surely to Mokśa (liberation), while the Gāṇa (Deśī) music is that which has been invented by composers (Vaggeyakaras), in conformity with the recognized rules, and

which pleases people. Gāndharva music always follows the rules of the theory." Rāmāmātya, (Svaramelakalānidhi, II. 7, 8, 9, edit. Ramaswami Aiyar.)

"Music is of two kinds Mārga and Deśī. The kind which was sought by Brahmā and other gods, and practised by Bhārata and other sages in the presence of Śambhu (Śiva), is called Mārga. It brings everlasting prosperity. While the songs, play and dances which please the hearts of people in different countries are called Deśī (regional)." (Śārṅgadeva, Saṅgīta Ratnākara, I. 22, 23.)

Modal system and Harmonic system.

Before starting the study of Hindu music, and in order to be able to understand its meaning, we should fully realize the difference which exists between modal and harmonic music. We should also give up the prejudice which sees in the harmonic form a development, a "progress", over the modal form ; there is only a difference in the way of expression, which does not imply any superiority either in conception or in possibilities. In the words of Rājā S. M. Tagore : "There is nothing to make us regret that the principles of acoustics, as they exhibit themselves in our music, differ from the European system.[1]" We must remember that, just as Hindu musicians only see in harmony a meaningless noise, Europeans, similarly, are absolutely incapable of appreciating the significance of an isolated modal degree. They cannot realize how an isolated note can convey, because of its position in regard to the memorised tonic, and possibly another axial note, the full meaning of a chord. Still, it really does, by the work of memory, form a chord or relation of sounds. According to Vedantists, "a single sound is not capable of manifesting a meaning (Sphoṭa), otherwise to utter another sound would be useless, ... but, each sound leaving an impression (samskāra) in the mind, it is by the cumulative

1. Hindu music, p. 340.

operation of the previous sounds (dhvani) that the last sound reveals the idea." (Swāmī Hariharānand Saraswatī, Śabda and Artha, Siddhant, I 45 p. 3.)

Occidentals, although they are bound to acknowledge this process in the spoken language, are not trained to perceive it in the musical language, and they recognise the meaning only if the few sounds which represent the idea are heard simultaneously. An exception can be, however, made for the arpeggio which can, theoretically, be understood in both systems. There is, no essential difference between successive or simultaneous sounds, provided the ratios which bind them are the same. The image appears suddenly to our mind as soon as the different elements which constitute it have been perceived. It is the relation of sounds which represents the idea, and, as long as this relation remains incomplete, the idea cannot appear ; "the partial manifestation of a concept being impossible because a concept has no parts." Swāmī Hariharānand Sarasvatī, ibid. . . .)

The harmonic system, in which the group of related sounds is given at once, is, in a way, more direct, but it is also less clear, because an accurate discrimination of the different elements which constitute a chord is not usually possible. On the contrary, the modal development allows the exact perception and immediate classification of every one of the sound-elements. The modal system permits, therefore, of a much more accurate, powerful and detailed outlining of the expression.

This is why the modal system is always to be given preference when music is envisaged, not merely as a stimulant of sensations, but as a means of education, capable of creating in the mind profound and durable impressions. This is easily explainable ; it is because an external perception can only produce a permanent impression in our mind (Sthāyi bhāva) if we concentrate on it for a sufficiently long time. Only modal music can create such permanent impressions because all its variations only tend towards the expression of one feeling or one image accurately determined. This cannot fail, after a sufficient time, to imprint that

feeling or that image in the mind of all those who hear the mode, whether they are attentive or not.

In Western music, all the notes have an approximately equivalent value because each note can be fifth or third, second or octave of a chord. The significance of the notes as modal degrees is consequently generally nil, and, in any case, extremely weak. On the contrary, in modal music, where modulation is unknown, the idea of a third will always be represented by the third degree, the idea of a fifth by the fifth degree, etc..

The result of this difference is that, in modal music, the modal degree will have the significance which in harmonic music, is attached to the corresponding interval; degree and interval being the elements which respectively, in each case, represent a permanent numerical relation. And we shall see that the Hindus attribute to the modal degree almost exactly the same emotional and suggestive characteristics that the Occidentals attribute to the corresponding harmonic interval.

The ancient Hindus were aware of the equivalence of the two systems, and treatises insist on the point that the same thing can be expressed by the succession of notes in a well-established mode or by the harmony of simultaneous sounds; the cosmic and emotional correspondences being the same in both cases.

The Problem of the Division of Sound.

While the divisions of light (blue, red, yellow, etc.) seem to us obvious, like the divisions of taste (sweet, bitter, salty, etc.), the divisions of sound are the subject of constant controversy. However, sounds, like the other phenomena by which we perceive the elements, are regulated by fixed laws and their relations evoke in our mind precise images. Whence, then, comes this difficulty in fixing the divisions of sound as we do the divisions of light? Occidentals generally deny that there is a division of sounds in perfect accord with the rules of musical expression, as well as

with the laws of acoustics, and they hide their ignorance behind the impressive word 'Psychology'. But this leads nowhere and is in flagrant contradiction with experience ; a minor chord will never have for anybody the expression of a major one. If musical expression changes, it is only because the ratios between sounds change, and it is only the extraordinary ignorance of Western musicians as to the intervals which they are actually utilizing which allows them to believe that they can give to a certain note a more or less expressive value, by some mysterious transfusion of their "personality", without changing its pitch. The case is further complicated by the use of temperate instruments of which all the intervals are wrong in regard to the logical scale of sounds ; a fact which leaves room for doubts in interpretation which every one may, to a certain extent, exploit according to his own tendencies, doubts which are *impossible* if the intervals are accurate. On temperate instruments, like the piano, to be able to give to any note a definite expression, it is necessary that the structure of the chords should compel us to interpret that note in a particular direction ; and this necessitates a useless mass of chords whose rôle is *only* to colour the notes, otherwise perfectly insipid, of the temperate scale. Modern music is overcrowded by such chords, among which those chords which have a properly harmonic expression, a meaning, a "message", seem lost.

The Theory of Elements.

Hindu metaphysics explain why it is difficult for us to perceive the natural divisions of sounds, and indicate the method by which we can realize them.

The world is composed of five elements[1], which we perceive separately by five distinct senses. The senses corresponding to each

1. Here are meant the principles of elements which must not be imagined. in the way modern science considers them, as definite chemical substances, nor

one of these elements can perceive also the lower elements but not the higher ones ; therefore Earth, whose corresponding sense is smell, can be perceived by all senses ; Water, to which corresponds the sense of taste, is perceived by all senses except smell ; Fire (identified with light) corresponds to sight and cannot be tasted or smelt ; Air, to which corresponds touch, is no longer visible ; and, finally, Ether can be perceived only through sounds. (see : Manu smṛti, 1, 20.)

Being unable to verify our hearing perceptions with the help of any other sense, it is impossible for us to justify the divisions of sound, as we perceive them, because we can have no direct element of comparison.

Sound being a quality of Ether, we can only visualize it through its reaction upon other elements, such as air, for example, of which the sensible quality is touch. We, therefore, easily represent sound as a vibration of air which, touching our ear, forces it to vibrate, a fact which actually is only a secondary phenomenon[1].

as the conditions of such substances (liquid, solid, etc.). All chemical substances are a combination of the five elements, though their relative proportion may be, among them, diversely distributed. As explained by M. René Guénon (La théorie Hindoue des cinq éléments, Voile d' Isis, 1935, No 188-89, p. 327) :

" . . . . . the cause of sound abides in Ether, but it must be understood that this cause is to be differentiated from the diverse mediums which can be used secondarily for the propagation of sound, ... The sound quality is also perceptible in the four other elements in as much as they all proceed from Ether."

1. " . . . . . the mode of production of sound by vibratory movement, ... is far from being a recent discovery, as some might believe ; Kaṇāda expressly declares that 'sound is propagated by undulations, wave after wave, or vibration after vibration, radiating in all directions from a definite centre.' . . . . . Sound . . . . is the less differentiated of all movements because of what we might call its "isotropism". And this is why it can give birth to all the other movements, which will be differentiated from it in that they no longer will be uniform nor spread in all directions . . . . . Thus, the differentiation of Ether, originally homogenous, differentiation which

theoretically simple and accurate, yet opposes to any analysis of musical relations an insurmountable barrier of complication and inaccuracy, or, as Rājā S. M. Tagore has expressed it, "mystifies the subject by enveloping it in a cloud of mathematicism." (Hindu Music, p. 340.)

The relative ratio between two sounds is, however, of a different nature ; it only incidentally represents musical vibrations. The same ratio expresses the relative rank of the sounds in the scale of harmonics ; 25/24, for example, is the interval between the 24th and 25th harmonic The same ratio, also, represents the length ratio (inverted) of pipes or strings etc. . These ratios are, therefore, the expression of general laws of sound which are applicable to the numbers of vibrations also, but not exclusively.

The nine Svaras.

The Hindus consider the scale as made of seven principal notes, or *svaras*, connected with the seven main planets, and two secondary notes, corresponding to the two planets which are not visible to the naked eye. This brings the total of the moving notes of the scale to nine sounds related to the nine groups of consonants of the Sanskrit alphabet[1]. These sounds place themselves, according to modes, into the twelve regions of the octave just as the nine groups of consonants associate themselves with the twelve vowels, or the nine planets with the twelve zodiacal signs.

The seven principal notes, or svaras, are called : Ṣaḍja (born of six), Ṛṣabha (Bull), Gāndhāra (pleasing to celestial beings), Madhyama (middle sound), Pañchama (fifth note), Dhaivata (deceitful),

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1. Simultaneously issued from the primordial creative sound, the divisions of articulate sound and of musical sound (of Śabda and Svara) are strictly parallel and inter-dependent. The very terms which express these divisions are often identical.

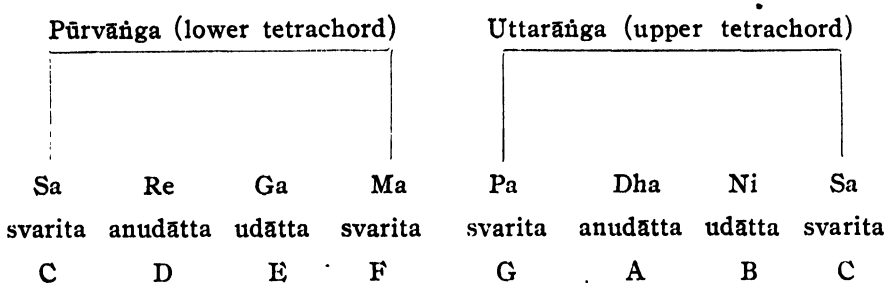
and Niṣāda (seated). In practice they are called more briefly : Sa, Re, Ga, Ma, Pa, Dha, Ni[1]. The two accessory svaras are named Antara Ga (intermediary Ga), and Kākalī Ni (pleasing Ni).

In the nomenclature of Yajur Veda the notes are called *Udātta* (raised), *Anudātta* (not raised) and *Svarita* (accented) ; Svarita notes correspond to what Aristotle, later, called the "body of harmony" ; they are the fixed notes which determine the structure of the tetrachords. Inside each tetrachord, the higher note is called Udātta (raised), and the lower one Anudātta (not raised).

According to the Nārada śikṣā, one of the most ancient texts on music :

"Niṣāda and Gāndhāra are born of Udātta,
Ṛṣabha and Dhaivata are born of Anudātta and
Ṣaḍja, Madhyama and Pañchama are born of Svarita."

The scale is, thus, divided into two tetrachords as follows :



In the classification of Sāma Veda the notes are simply numbered starting from Madhyama which is called Prathama (first).

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1. "It appears that the West owes its system of notations by the initial letters of the names of the notes to Hindu music ; they borrowed it, as they did for numbers, from the Arabs who had learnt it from the Hindus."
(Sylvain Lévi, at the article 'India' in the "Grande Encyclopedie".)

The seven notes are thus called :

Prathama	(first)	Ma	F
Dvitīya	(second)	Ga	E
Tritīya	(third)	Re	D
Chaturtha	(fourth)	Sa	C
Pañchama	(fifth)	Dha	A
Atisvāra	(extreme note)	Ni	B
Kṛṣṭa	(pulled, dragged)	Pa	G

According to the Nārada śikṣā :

"The svara (note) which is prathama (first) in the singing of Sāma (Veda) is the Madhyama of the flute, Dvitīya is Gāndhāra, Tritīya is Ṛṣabha, Chaturtha is Ṣaḍja, Pañchama is Dhaivata, Atisvāra is Niṣāda, Kṛṣṭa is Pañchama."

We can see, therefore, that the scale of Sāma Veda is a descending scale with five principal notes and two secondary ones, while the later scale of profane music, given here as that of the flute, is a full seven note ascending scale. We shall again meet with the peculiar inversion of the Dhaivata and Pañchama of the Vedic scale when we study the Pythagorean theory.

The Tonic and the Grāmas (basic scales).

The lowest note of the scale, which should be considered only as the auxiliary tonic, is the only tonic used in modern times. But, in ancient books, the general tonic is always given as the fourth note, Madhyama (middle sound), which corresponds to the *Mesa* of the Greeks.

The tonic is the only note which cannot be modified or suppressed, therefore "the destruction of Madhyama should never be performed, Madhyama is the best of all svaras and everlasting in the opinion of the sages who sing Sāma Veda". (Nāṭya Śāstra, 28th chapter, 69.)

Madhyama is the appropriate name for the general tonic, as, according to the definitions of Vedānta, this name is given to "the fundamental perceptible sound from which all the differentiations of sound are issued." (Śabda and Artha, Sidhānt, No. 43.)

In reality, the note taken as starting point in the sequence of svaras varies according to the plan of approach. If we deal only with terrestrial (ādhibhautika) music, the scale should begin from Sa (C), the first note. This is called *Ṣaḍja grāma* (scale of C).

"All the Deśī rāgas are those of Ṣaḍja grāma."

(Rāmāmātya, op. cit., p. 61)

But, if we deal with celestial (ādhidaivika) music, the scale begins from Ga. This is called *Gāndhāra grāma* (scale of E). From the metaphysical (ādhyātmika) point of view, the scale begins from *Ma*. This is the *Madhyama grāma* (scale of F). To understand this differentiation, we may remember that, in a similar way, the sequences of seasons "correspond to Spring, Summer, Autumn, Winter in *pratyakṣa, adhyātma* sequence, or Autumn, Winter, (*ut supra*) Spring, and Summer in *parokṣa, adhidaivata* [angelic] sequence : similarly, to Infancy, Youth, Maturity, and Age in our corporeal parlance, that is, to Maturity, Age, Youth, and Infancy, spiritually, . . . ". (A. K. Coomaraswamy, A new approach to the Vedas, appendix, p. 111.)

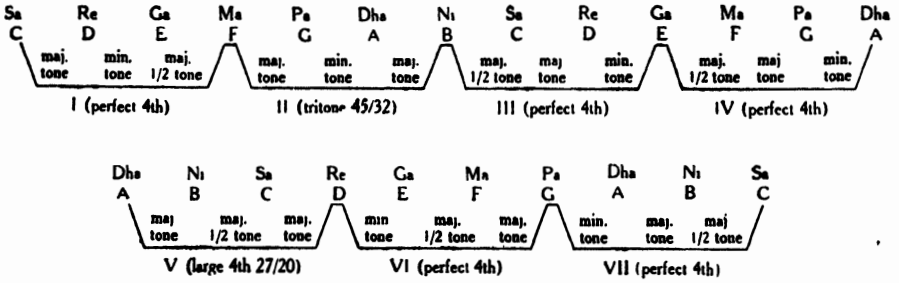
The difference of the Sa and the Ma grāmas is similar to the difference, in Greek music, between the two forms of the Dorian mode. In the first Dorian (Sa grāma) the fundamental is at the same time tonic and final, but, in the second Dorian (Ma grāma), the modal fifth has for its fundamental the mesa (Madhyama), which thus becomes pseudo-tonic and fundamental, but without completely ousting the "Sa" which remains final and becomes pseudo-dominant.

The diatonic Series and the Comma diesis.

The shifting of the tonic from Ma (F) to Sa (C) is not an arbitrary operation, but corresponds to a peculiarity in the structure

of the harmonic scale of sounds, similar to the Pythagorean comma in the cycle of fifths.

The diatonic scale is composed of intervals of three different kinds (major tone, minor tone and major half-tone), which can be considered as forming an indefinite periodical series of seven joint tetrachords of diverse composition.



Keeping apart the tetrachord II, which contains three full tones (tritone), all the other tetrachords form a perfect fourth (major tone + minor tone + major half-tone = 4/3), except one, the tetrachord V, which is too big by one comma (2 major tones + major half-tone = 27/20 = 4/3 × 81/80)

If we raise the A (Dha) by one comma into A+ (Dha+), in order to have from A+ (Dha+) to D(Re) (tetrachord V) a perfect fourth, it is the fourth E A+ (Ga Dha+) (tetrachord IV) which becomes too big. It is this particularity which is utilized by the Nāṭya Śāstra to define the śruti equal to one comma diesis (81/80), which is the difference of the major and the minor tones, of A and A+ (Dha and Dha+) ancient Pa- and Pa.[1] No greater accuracy in definition could be found because the perfect fourth (or its inversion the perfect fifth) is an interval which cannot stand inaccuracy. If we tune two instruments according to the detailed instructions of Bharata, without any difficult measuring we obtain an

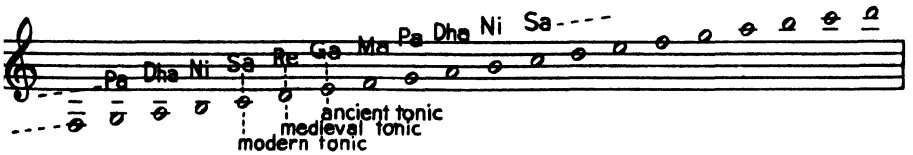
1. See : Nāṭya śāstra, XXVII, 22.

interval of one comma extremely accurately. We shall, later on, see this method in detail. This shows, by the way, that the modern authors, who pretend that the microtonal intervals (Śrutis) are not clearly defined in Sanskrit treatises, and interpret them according to the fancies of their imagination, either have not read, or have not understood, the Nāṭya Śāstra, or are nct aware of the most elementary particularities of the diatonic scale. Many, therefore, repeat tirelessly with N. A. Willard: (the Science of Music — Hindu Music) "Several Sanskrit treatises are in existence, but they are so obscure that little benefit is to be expected from them to the *science*." Willard, however, did not know Sanskrit.

The Tonic and the Cosmic Cycles.

Quite independantly of the differentiation of the grāmas, that is, of the fact whether the first or the fourth note is taken as the fundamental of each scale, the very note considered as the first note in the indefinite diatonic series varies according to the development of the cycle. Thus all the notes of the diatonic scale are successively considered as the first note, that is as the C (Sa).

The scale given by the Nāṭya Śāstra, in its present form, is, according to modern conception, the scale of D (Re) in the diatonic series ; it belongs, therefore, necessarily to a later period than the Greek scale because the note which appears to be the logical fundamental goes lower and lower following the development of the cycle.

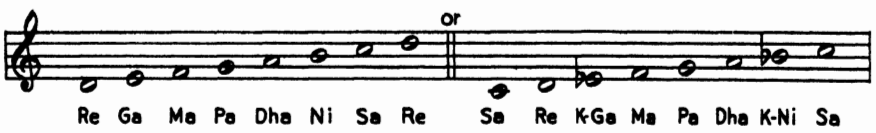


When we speak here of tonic, it is not a question of diapason, although this also is far from being unimportant, but it is a question of the note chosen as general tonic in the unlimited diatonic scale,

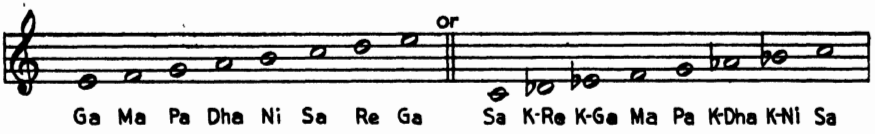
This note happens to be called, in modern times, successively, D, E and C (Ga, Re, and Sa) because the scale considered as without alteration (śuddha) is the scale of C (Sa), the tonic of this particular time. In this modern scale, the Greeks would have called E (Ga) the fundamental. The ancient Egyptians would have given this name to the F (Ma), while future generations will give it to the B (Ni).

But, this does not in any way affect the modes, as every note of the scale can be taken as modal tonic ; it indicates only the predominance of certain modes in certain times, such as the major mode (Bilāval) today, the Kāfī mode (mode of D) mode of Re) in the middle ages and the Dorian mode (mode of E) (Bhairavī) in Greco-Roman times.

Kāfī, or mode of Re (D)



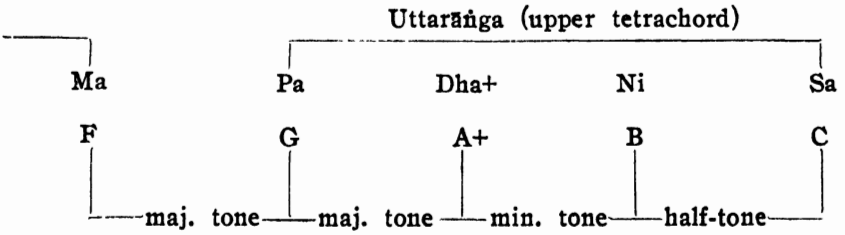
Bhairavī, or mode of Ga (E)



If, therefore, we consider the diatonic scale, as given by the white keys only of the piano or organ, the note which the ancient authors would have called C (Sa) is the note which we to-day call D (Re), because they considered as unaltered (śuddha) the scale which has a minor third and a minor seventh (Kāfī ṭhāṭ) while we, to-day, recognize only the major mode (Bilāval ṭhāṭ) as the unaltered scale.

The two Diatonic Scales

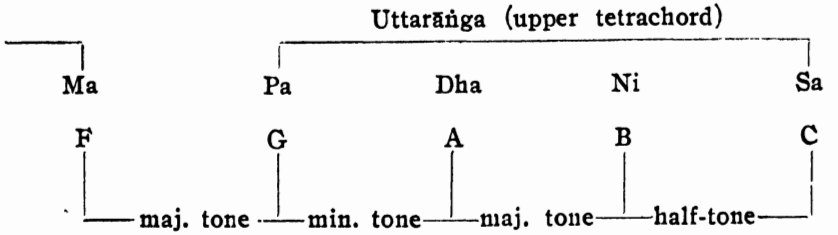
As we have seen, it is the adjustment of A (Dha) which differentiates the two forms of the diatonic scale; the one, in the second tetrachord, has the intervals as follows:



śrutis[1] : . . . . 4 . . . . . 4 . . . . . 3 2

This is called Sa grāma, the scale of the tonic, it is, in modern notations, the mode of D (Re), because the fifth D A+, (Re Dha+) (ancient Sa Pa), is perfect, which is indispensable if Re is tonic.

The other scale presents the following succession:



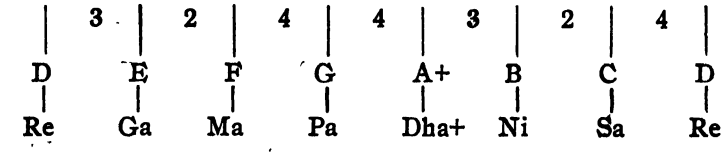
śrutis : . . . . . 4 . . . . . 3 . . . . . 4 2

This is the Western (theoretical) modern scale. It is called the scale of the fourth (Ma grāma) because its real tonic is on the

1. The octave is divided into 22 intervals which are called śrutis; the major tone contains 4 śrutis, the minor tone 3 śrutis, and the half-tones 2 śrutis.

G (Pa) which is the fourth of the scale of D (Re), the fundamental scale of Bharata. The D (Re) could not be fundamental in this scale because its fifth would not be perfect (D A (Re Dha) = 40/27).

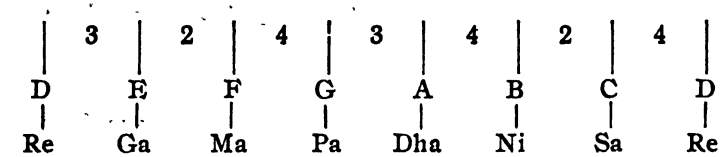
"There are two grāmas that of Sa (Re = D) and that of Ma (Pa = G) containing twenty-two śrutis. In the Sa grāma they respectively appear in the order : 3, 2, 4, 4, 3, 2, 4." (Nāṭya Śāstra, XXVIII, 21) That is :



"In the Ma grāma, the Pañchama (A+) (Dha+) must be lowered by one śruti. The difference of Pañchama is the very measure of śrutis [which can be described as a difference of] softness or accentuation, of expression or of length." (Nāṭya Śāstra, XXVIII, 22)

Similarly, the śrutis of the Ma grāma are :

(starting from Sa (Re) (D))



The Ga Grāma.

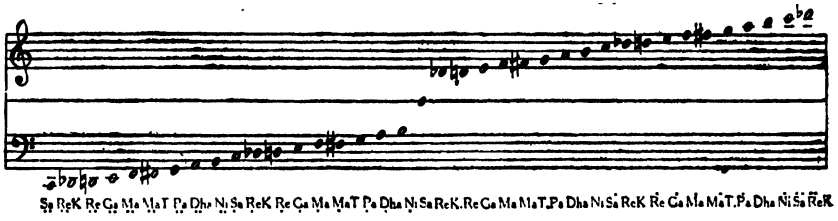
In ancient times, there was another scale, non diatonic, based on a different principle, in which all the intervals, except one, were equal to three śrutis. But this scale, the Ga grāma (scale of the third), whose tonic was the modern note F (Ma), being the representation of celestial spheres, is, in our corrupted times, hidden from the eyes of ordinary mortals. There is some grounds to believe that it corresponds to a division of the scale of sounds according to numerical properties which in geometry are particular to the pentagon. The third, as we shall see later, is particularly connected with

the number "Five." This division would also have been known to Pythagoreans, as is shown by the term "apotome" used for its characteristic interval, a term which, for the Pythagorean, had a very particular significance in relation to the "sectio aurea" and the pentagon.

"Directa linea rationalis extrema et media ratione secta fuerit : utrumque segmentorum irrationale est appellaturque apotome." (Euclid, book XIII, 6th proposition, translation of Campanus.)

The Scale of Nine Sounds and the Mūrchhanās.

The diatonic scale (Sa or Ma grāmas) appears under the indefinite form :



If we take, successively, as the practical tonic, the seven principal notes of this scale, we shall obtain seven[1] different plagal scales or *mūrchhanās* which, by eliminating certain of their notes, will be used for the establishment of expressive modes or rāgas, of respectively 9, 8, 7, 6 or 5 notes. Most of the musical modes come within this classification.

The mūrchhanās which contain only the seven principal notes are called "śuddha mūrchhanās" (pure mūrchhanās). Those which make use of antara Ga (Ma tīvra) (F sharp), and thus have eight notes, are called "śuddha-antara mūrchhanās." The mūrchhanās of eight notes which utilize only kākalī Ṅi (Re Komal) (D flat) are called "śuddha-kākalī mūrchhanās."

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1. The two accessory sounds cannot be taken as the tonic of a scale.

If, at the same time, antara Ga and kākalī Ni are used, we have the "śuddha-kākalī-antara mūrchhanās" of nine notes. See: Firoze Framjee, Theory and practice of Indian music, p. 71.)

In this way we obtain, in both grāmas,

14 śuddha mūrchhanās of 7 notes,

16 śuddha-kākalī mūrchhanās of 8 notes,

16 śuddha-antara mūrchhanās of 8 notes,

18 śuddha-kākalī-antara mūrchhanās of 9 notes,

totalling sixty four mūrchhanās, on which are based the greatest number of modes (rāgas).

All these mūrchhanās are not utilizable, nor are they all utilized in modern music. Generally, those of which the fifth and the fourth are perfect are used, that is to say No: 0, 2, 5, 6, 10, 12, 14,[1] although there are some modes with a larger fourth (F+) (Ma+).

When comparing this classification with that of the Greeks, we shall see that modes, or rāgas, can be called diatonic if the seven principal notes only are used while the introduction of the two accessory sounds allows the construction of chromatic scales.

Among these scales we can note that the modern Western major mode corresponds to the Mārgī mūrchhanā of Ma grāma and not to the Rajanī mūrchhanā of Sa grāma which contains A+ (Dha+).

When Somanātha, in his Rāga Vibodha, says, for example, that Pauravī and Uttarāyatā mūrchhanās begin from Dha (A), he takes, as a general tonic, the mediæval one: Re (D). This means that the pure (unaltered) scale is considered to be that of Kāfī which comports, in relation to the tonic C (Sa), a flat E (Ga) and a flat B (Ni). We have chosen here to keep the modern unaltered scale, Bilāval, the major mode, as the pure scale. Therefore, the same Pauravī and Uttarāyatā begin for us with a B (Ni). This does not in any way alter the order of the nctes in these mūrchhanās. The difference is merely one of conventional notations.

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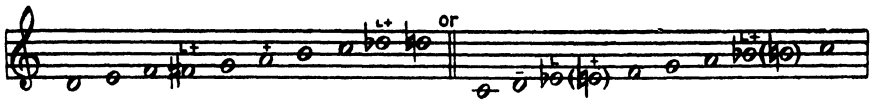
1. see: p. 119-120.

The Fourteen Mūrchhanās.

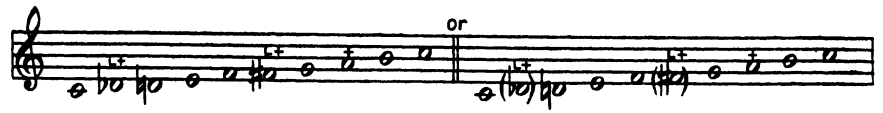
The mūrchhanās of Sa grāma are : (modern notation)

1. Uttaramandrā



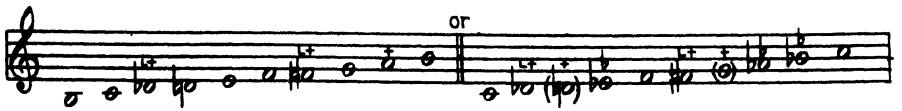
Re Ga Ma MaL+ Pa Dha+ Ni Sa ReL+ Re or Sa Re- GaL (Ga+) Ma Pa Dha NiL+ (Ni) Sa

2. Rajanī



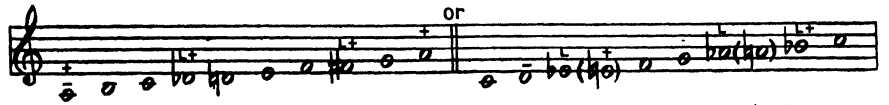
Sa ReL+ Re Ga Ma MaL+ Pa Dha+ Ni Sa or Sa (ReL+) Re Ga Ma (MaL+) Pa Dha+ Ni Sa

3. Uttarāyatā



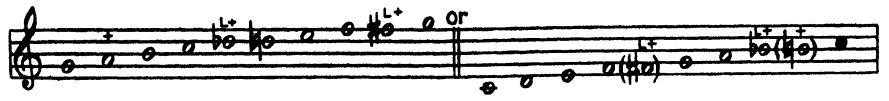
Ni Sa ReL+ Re Ga Ma MaL+ Pa Dha+ Ni or Sa ReL+ (Re+) Gab Mu MaL+ (Pa+) Dhab Nib Sa

4. Śuddha Ṣaḍjā



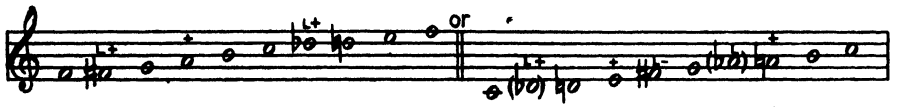
Dha+ Ni Sa ReL+ Re Ga Ma MaL+ Pa Dha+ or Sa Re- GaL (Ga+) Ma Pa- DhaL (Dha) NiL+ Sa

5. Matsarīkṛta



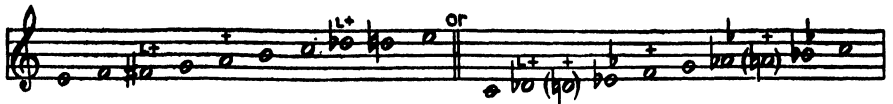
Pa Dha+ Ni Sa ReL+ Re Ga Ma MaL+ Pa or Sa Re Ga Ma (MaL+) Pa Dha NiL+ (Ni+) Sa

6. Aśvakrāntā



Ma MaL+ Pa Dha+ Ni Sa ReL+ Re Ga Ma or Sa (ReL+) Re Ga+ MaL- Pa (DhaL) Dha+ Ni Sa

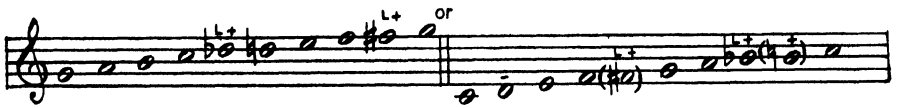
7. Abhirudgatā



Ga Ma MaL+ Pa Dha+ Ni Sa ReL+ Re Ga or Sa ReL+ (Re+) Gab Ma+ Pa Dhab (Dha+) Nib Sa

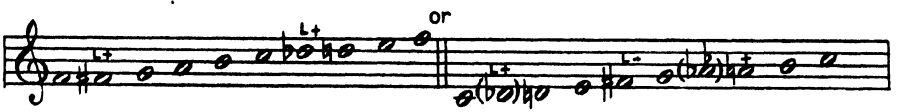
The mūrchhanās of Ma grāma are :

8. Sauvīrī



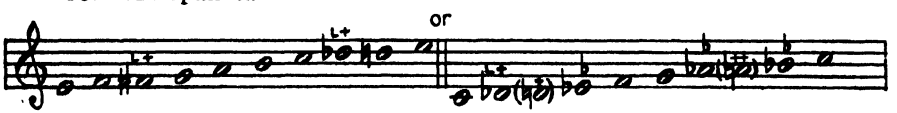
Pa Dha Ni Sa ReL+ Re Ga Ma MaL+ Pa or Sa Re- Ga Ma (MaL+) Pa Dha NiL+ (Ni+) Sa

9. Hāriṇāśvā



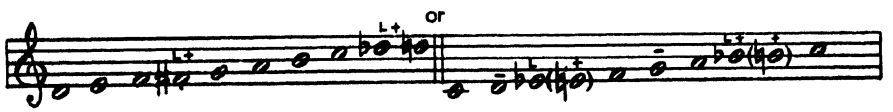
Ma MaL+ Pa Dha Ni Sa ReL+ Re Ga Ma or Sa (ReL+) Re Ga MaL- Pa (Dhab) Dha+ Ni Sa

10. Kalopanatā



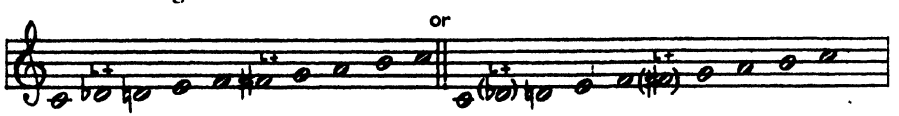
Ga Ma MaL+ Pa Dha Ni Sa ReL+ Re Ga or Sa ReL+ (Re+) Gab Ma Pa Dhab (Dha+) Nib Sa

11. Śuddha Madhyā



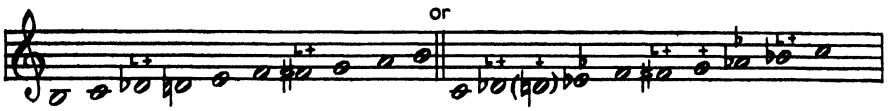
Re Ga Ma MaL+ Pa Dha Ni Sa ReL+ Re or Sa Re- GaL (Ga+) Ma Pa- Dha NiL+ (Ni+) Sa

12. Mārgī

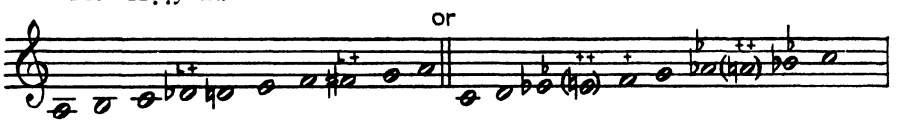


Sa ReL+ Re Ga Ma MaL+ Pa Dha Ni Ṣa or Ṣa (ReL+) Re Ga Ma (MaL+) Pa Dha Ni Ṣa

13. Pouravī



14. Hṛṣyakā

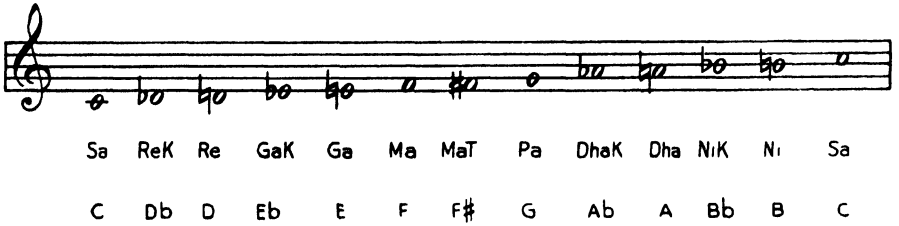


To the mūrchhanā scales are to be added the scales made on the basis of tetrachords, which are directly obtained on the Vīṇā and other stringed instruments. Such scales have generally their two tetrachords indentical.

There are also other scales obtained by changing the śruti of the tonic. A certain number of them are described in the Saṅgīta Ratnākara.[1]

Chromatic and Enharmonic.

If, leaving aside the details of tuning, we assemble the notes of the different mūrchhanās, we get a chromatic scale which corresponds to what the Westerners call the "harmonic" form of the chromatic scale.



But, if we are careful of tuning particularities, we can find that, to transpose all the mūrchhanās in the same pitch, we require,

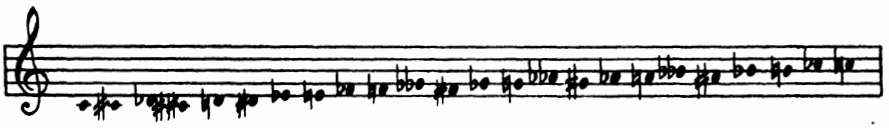
1. The interpretation of a few of these is given by Paṇḍit Firoze Framjee in his "Theory and Practice of Indian music", pp. 33 to 107.

for each note, two distinct positions separated by an interval of one comma, giving the enharmonic scale :

C, D♭ D♯♭, D–D, E♭ E♭+, E E+, F F+, F♯ F♯♯, G G+, A♭ A♭+, A A+, B♭ B♭♯, B B+, C.

Sa, ReL – ReL+, Re – Re, GaL Gab, Ga Ga+, MaMa+, MaL – MaL+, PaPa+, DhaL Dhab, DhaDha+, NiL–NiL+, NiNi+, Sa,

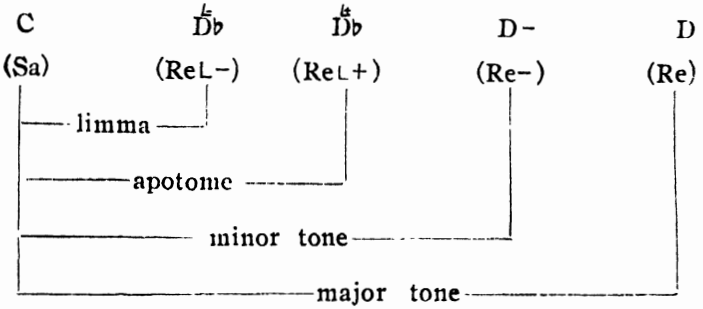
This series can be represented in Western notations by :



If we exclude from this series G+ (Pa+) (A♭♭), the fifth being invariable, we obtain a scale of twenty-two sounds, the śrutis, grouped by couples, each of which couple forms an interval of one comma. According to Bharata (Nāṭya Śāstra, XXVIII, 22) the method employed to obtain this scale consists in tuning two identical instruments (Vīṇās) in the Sa grāma. Then, by adapting one of them to the Ma grāma, with the help of the difference between the perfect fourths EA and A+D (Ga Dha and Dha+ Re), as previously explained, the A+ (Dha+) is lowered by one comma to A (Dha). If we then keep this new A (Dha) as fixed sound, and tune the instrument in the Sa grāma, we obtain all the notes of this instrument one comma lower than those of the first instrument. The combined notes of the two instruments then give the scale of the twenty-two śrutis.

This scale is identical to the one given by Arab mathematicians as having been that of the ancient Greeks, and, it still remains the division used by the Arabs themselves. The major tone

is thus divided into minor tone, apotome (or major half-tone) and limma.



These twenty-two positions of the notes, or *śrutis*, are said to be those which correspond to definite and distinct expressions. According to certain authors they can be further divided into sixty-six positions, so as to allow, in every case, perfect consonance. But this is only a question of more or less perfect tuning, as, anyhow, the possible distinct expressions remain limited to twenty-two.

This division of the octave into twenty-two intervals has been considered arbitrary by all modern sanskritists and musicologists, who have written against it the most amusing abuses. Yet, such a division is not only logical but essential. It is, in reality, used in every country and is valid for all music, from the point of view of acoustics as well as that of mathematics or metaphysics, and even from the point of view of musical expression, as we shall presently see.

Acoustic Definition of the Division of Śrutis.

After the elementary division of the octave into twelve half-tones, which can be called "division of the first order", all acoustically acceptable divisions of the octave must, necessarily, take into account the difference formed by twelve fifths and seven octaves.

This is called the Pythagorean comma, and, approximately, it represents the fifty-third part of one octave. Its harmonic equivalent, the comma diesis, is the difference of the major and minor tones. The simplest divisions are those which take the comma as a unit and which can be called "divisions of the second order". The first division of the second order is obviously the complete division into fifty-three intervals. But, in this division, if we keep only the most important values for each of the twelve notes, removing, twelve by twelve, those values which are less employed in practice, the fifty-three original notes are successively reduced to fourty-one, then twenty-nine and finally seventeen, which is the minimum division of the second order, and is the basic division used by the Arabs.

But the fifty-third fifth, as we already saw in connection with Chinese music, again goes beyond the octave by a fraction smaller than the comma. If we take as a unit this fraction of the comma, we obtain the "divisions of the third order". The complete system divides the octave into 358 intervals which, through elimination of the less important fifths, twelve by twelve, can be reduced to the minimum division of the third order, which is of twenty-two intervals. This is the division adopted by the Hindus, for metaphysical as well as musical reasons. As we have seen, the Chinese division stands in between, as it utilizes the division of the second order up to its maximum (fifty-three fifths) and then, up to the sixtieth fifth, uses intervals of the third order.

These divisions can be pursued indefinitely into divisions of the 4th, 5th, *n*th order. But the Hindus, although they showed by this division the extent of their knowledge of acoustics and mathematics, have been able to avoid abstract speculations and to stop at the intermediary division of the twenty-two śrutis ; this division, alone, is in perfect agreement with musical practice, since any further

1. See : 'The Hindu division of the octave with some additions to the theory of systems of higher orders', by R. H. M. Bosanquet, Proceedings of the Royal Society of London, from March 1877 to December 20, 1877. (Hindu music).

division would go beyond that which, in terms of sounds, is equivalent to the third dimension, and, being therefore beyond the limits of this Universe, could have no interest as regards musical practice.

Symbolic Necessity of the Division into 22 Śrutis.

From the point of view of numbers, the division of the modal octave must necessarily be of twenty-two intervals. This division is not particular to music, but represents a law of universal character. Effectively, the relation of those twenty-two intervals with the seven notes of the scale is the only one which can give to music a complete and logical under-structure. M. René Guénon explains:—(L'Esotérisme de Dante, p. 66)

"The number twenty-two is related to seven by the ratio 22/7, which is the approximate expression of the relation between the circle and its diameter, so that the group of these two numbers represents the circle, which is considered as the most perfect shape by Dante as well as by the Pythagoreans (and each division of each of the three worlds has this circular form): besides, in 22 are united the symbols of two of the "elementary movements" of Aristotelian physics: the *local movement*, represented by 2, and that of *alteration*, represented by 20, as Dante himself explains in his *Convito*."

The symbolic correspondences of the number seven and the number twenty-two are so numerous that it is not possible to attempt to study them here[1]. We should only remember that the Hebrew alphabet, whose rôle is so important in the *Kabbala*, has also twenty-two letters and seven double letters and that, just as seven planets determine, by their orbits around the Sun, the limits of the visible world, in the same way also twenty-one cosmic circles separate us from the metaphysical sun, the central

1. In accordance with this symbolism, the Vīṇā, the sacred instrument of Hindu music, is made of two spheres joined together by a straight axis on which seven strings are played over twenty-two frets.

eye, which sees everything : circles which we shall have to cross, before we can reach the final resorption into absolute knowledge.

The Arabic division of the octave into seventeen intervals is also based on considerations of symbolism connected with Musalman esotericism. This by no means excludes their physical actuality. The fact that the Arabs divide the octave into seventeen intervals does not imply that those intervals are bigger than the śrutis, as many Westerners have lightly considered. Those divisions refer, necessarily, to identical notes, in conformity with the needs of musical expression, because they are the representation of metaphysical realities corresponding to the very nature of sounds, as well as of all other aspects of the three worlds. The seventeen notes of the Arabic octave can, in reality, be identified with seventeen of the śrutis. The śrutis left out are those which are least employed, since, following the deterioration of the cycle, the scale of tonic C (Sa grāma) is the only one employed in modal music. In the ancient law, Hebraic or Hindu, the numbers and śrutis of the lost grāmas (scales) are piously kept, but, in the new law (Islam), they are left out in the general theory because they are so rarely used. This is what al-Fārābī explained[1] : "the two cycles that we have established each contain twenty-two degrees ; these are the totality of the notes which are used on the lute, some frequently, others more rarely. We shall deal only with the notes which are ordinarily used and which, consequently, are the more natural." Elsewhere, speaking of the tuning of the Hūrāsān's ṭunbūr, he says[2] : "the scale of this instrument contains, in this tuning, thirty-two degrees ; the doubled notes being ten in number."

The number seventeen, which was considered inauspicious in ancient times, in the Occident as well as in the Orient, has, on the contrary, been sometimes taken as representative of the new gospel, Christian or Musalman.

1. Kitābu al-Mūsīqī al-Kabīr, transl. d'Erlanger, p. 25.
2. ibid., p. 253.

"The number seventeen can be divided in two ways; into ten and seven to represent the fusion of the ancient law and the new law (the law of fear is represented by the number ten, and the law of love by the number seven, says saint Augustine); it can also be divided into eight and nine, and, therefore, signifies the union of angels and men." (Treatise: *de Pane Eucharistico*, by the Bishop Hildephonse, posthumous works of Mabillon, vol. 1.)

"One finds in the number seventeen . . . . . a wonderful mystery. It is not without reason that psalm seventeen is the only one to be found in the book of Kings, because it has for its subject the glory of the eternal kingdom in which we shall have no more enemies." (Saint Augustine, De Rit. Eccles. ad Sannar, epist. CXIX.)

On the other hand, Plutarch says:

"The Pythagoreans . . . . . have for the number seventeen an absolute and sacred repulsion. This is in relation to the fact that between the square number 16 and the rectangle number 18, which are the only plane numbers whose perimeters happen to be equal to their areas, comes the number 17, which interferes between these two numbers, separates them from each other, and divides their ratio, $1+1/8$, into two unequal parts." (Isis and Osiris) Effectively: $9/8 = 18/17 \times 17/16$.

According to the Hindu Sāṅkhya, the number seventeen represents the subtle body (sukśma śarīra) which is composed of the five principles of the elements (tanmātras)[1], the five senses of perception (jñāna indriyas), the five senses of action (karma indriyas), intellect (buddhi) (in which ahamkāra, the notion of individual 'ego', is included), and mind (manas). $5+5+5+2=17$.

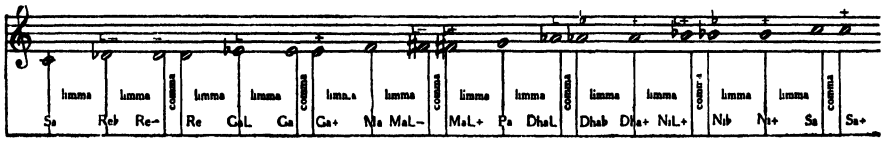
This subtle body remains in existence through all the forms of posthumous life, and is destroyed only at the time of final

1. For the five tanmātras, the Māyāvādins substitute the five 'vital airs' (prāṇas).

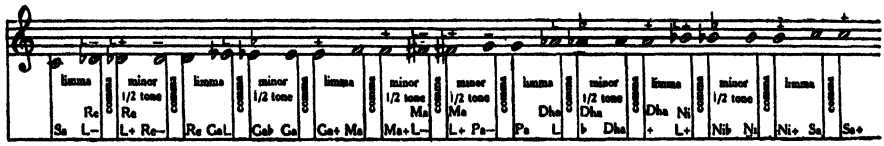
liberation (mokśa), which means complete resorption into the First Principle (Brahman).

Therefore, the metaphysical doctrine (Pythagorean, and Vedāntic) considers the subtle body as mortal, and even takes it as the fearful symbol of ultimate death. Whereas the religious doctrines, to which Christianity and Islam belong, and which do not envisage the final stage of liberation (mokśa), but take Heaven (svarga) to be the ultimate end, consider the subtle body, which is then called the soul, as immortal. The number seventeen, therefore, becomes the glorious symbol of immortality.

The seventeen divisions of the octave are given by the Arab writers as follows : (see : Ṣafiu d-Dīn's, Aš̌ Šarafiyyah, dis. IV, transl. d'Erlanger, p. 127, and, al-Fārābī, Kitābu al-Mūsīqī al-Kabīr, transl. d'Erlanger, p. 248.)



But, in the tuning of instruments, particularly the ṭunbūr of Hūrāsān, the second string, used on the same frets and being tuned either on the second (D) (Dha), the minor third (E♭) (Gab), the fourth (F) (Ma), the fifth (G) (Pa) or the sixth (A+) (Dha+), gives, according to modes, all the missing notes, forming the complete scale :



If we leave aside the modified fifth and octave, which are never used, this brings us back exactly to the Hindu division,

We see, therefore, that, although the Arabs use only limmas and commas in the establishment of their scale, they supplement the lack of the second form of certain flats and sharps by the superposition of several plagal forms. Although this means a somewhat different classification, it does not create, in practice, any difference from the Hindu division.

Musical Definition of the Śrutis.

Musical intervals can be accurately defined in two ways, either by numbers (string lengths, numbers of vibrations, etc.), or, with no less accuracy, by their psychological correspondences, such as the feelings and images they necessarily evoke in our minds. There is no sound without a meaning, assert the Vedantists. In the guise of sounds, it is only the manifested idea that we perceive[1] and, therefore, it is logical to conceive a theory of sounds based on the ideas represented by the sounds rather than on their numerical values. "We hold that it is quite possible to build a rational theory of music without the help of numbers," says Rājā S. M. Tagore. (Hindu music, p. 360).

In spite of the extreme confusion resulting from the use of equal temperament, Occidentals still appreciate, in singing, the difference which is felt between a brilliant timbre and a sombre timbre given to the seemingly same note, a difference which corresponds, in reality, to a difference of pitch, generally equal to one comma, that is, a difference similar to that which exists between the major and the minor tones. This means that, even when our spoiled ears can no longer appreciate the difference in the pitch of the sound, we remain able to define a difference of intervals by a difference of colour or expression, by emotional correspondences.

1. See : Śabda and Artha, by Swāmī Hariharānand Saraswatī, Siddhānt, I, 45.

Although there are definitions of the śrutis by lengths of strings in the Nāṭya śāstra and particularly in the Saṅgīta Pārijāta of Ahobala, Hindu theorists generally prefer to define intervals by their expression rather than by numbers. They consider this system to be quite as accurate and more practical because, without any mechanical verification, it allows the gifted musician, who alone is expected to take interest in music, to know immediately the accurate interval from the feelings it evokes.

For example : if, hearing continuously the tonic C (Sa), we try to sing or play the major third E (Ga) with a peaceful and loving expression, we shall obtain the harmonic third, E (Ga) = 5/4, corresponding to the śruti Ratikā. But if our feelings had been 'energy', 'wonder' or 'heroism' we would inevitably have sung the third of the scale of fifths (ditone), E+ (Ga+) = 81/64, corresponding to the śruti Raudrī[1].

Similarly, the minor third E♭ (Ga komal), or the minor seventh B♭ (Ni komal), corresponding to a sentiment of pity, karuṇā rasa, will be respectively $\overset{\downarrow}{E}\flat$ (GaL) = 32/27 and $\overset{\#}{B}\flat$ (NiL+) = 16/9, śrutis : Dayāvatī and Madantī. While the minor third and the minor seventh, corresponding to the sentiment of love (śṛingara rasa) or of amusement (hasya rasa). are respectively $\overset{\flat}{E}\flat$ (Ga♭) = 6/5 and $\overset{\flat}{B}\flat$ (Ni♭) = 9/5, śrutis : Rañjanī and Rohiṇī.

The natural A (Dha) of the harmonic scale, A (Dha) = 5/3 = 222 savarts, is peaceful and happy (Sandīpanī śruti), but the A+ (Dha+) of the scale of fifths, A+ (Dha+) = 16/27 = 227 savarts is immodest and enervating : Ālāpinī śruti, etc..

1. On temperate instruments these different expressions will become clear only when the structure of the underlying chord imposes the interpretation of the particular third either as an harmonic third or as a ditone.

Temperate instruments can, therefore, be used only for harmonic music provided the structure of the chords is specially built to make up for their deficiencies, but their use in modal music is impossible because the expression of the notes remains indeterminate, and, therefore, without appeal.

The expression of the śrutis depends exclusively on their position in relation to the tonic. An augmented sixth (Dha tivra) or a diminished seventh (Ni komal), for example, have, if they belong to the same śruti, the same expression.

The ancient Sanskrit names of the śrutis allow one easily to remember their signification, and, consequently, to sing or to play them accurately.

We shall give here a list of the śrutis according to the system of Śārṅgadeva[1].

The śrutis are counted below the note, so that the starting point of the series of śrutis, being the first śruti of Sa (modern D (Re)), corresponds to D♭ (ReL−).

Śrutis

Ancient			*Modern*
Ni	0.	Kśobhiṇī (irresolute, agitated)	C (Sa)
	1.	Tīvrā (intense, acute, poignant, dreadful)	D♭ (ReL−)
K. Ni	2.	Kumudvatī (white lotus, moon-flower)	D♭ (ReL+)
	3.	Mandā (slow, wicked, lazy, cold, apathetic)	D− (Re−)
Sa	4.	Chhandovatī (the basis of harmony)	D (Re)
	5.	Dayāvatī (compassionate, tender)	E♭ (GaL)
	6.	Rañjanī pleasing, colouring, lustful)	E♭ (Ga♭)
Re	7.	Ratikā (pleasure, sexuality)	E (Ga)
	8.	Raudrī (burning, terrible, calamitous)	E+ (Ga+)
Ga	9.	Krodhā (anger, wrath)	F (Ma)

1. More ancient works such as the Saṅgīta Makaranda use different names and start from another tonic. Many questions have been raised concerning the interpretation of the śrutis as given by Śārṅgadeva, because of the change of tonic which since has taken place. As we are only attempting to give a general idea of the method through which the study of scales should be approached, we cannot enter here into a discussion of such difficult questions, which will be dealt with at length in another work.

	10.	Vajrikā (thundering, steel, diamond, severe, abusive)	F+ (Ma+)
A. Ga	11.	Prasāriṇī (diffusing, pervading, shy)	F♯ (MaL−)
	12.	Prītiḥ (pleasure, love, delight)	F♯ (MaL+)
Ma	13.	Mārjanī (cleansing, adorning, excuse)	G (Pa)
	14.	Kṣitiḥ (forgiving, destructible, Earth)	A♭ (DhaL)
	15.	Raktā (red, impassioned, coloured, playful)	A♭ (Dha♭)
	16.	Sandīpanī (stimulating, inflaming)	A (Dha)
Pa	17.	Ālāpinī (speaking, conversing)	A+ (Dha+)
	18.	Madantī (lust, spring, intoxication)	B♭ (NiL+)
	19.	Rohiṇī (adolescent girl, lightning, growing)	B♭ (Ni♭)
Dha	20.	Ramyā (night, love, pleasure, rest, calm)	B (Ni)
	21.	Ugrā (sharp, passionate, cruel, formidable, powerful)	B+ (Ni+)
Ni	22.	Kṣobhiṇī (irresolute, agitated)	C (Sa)

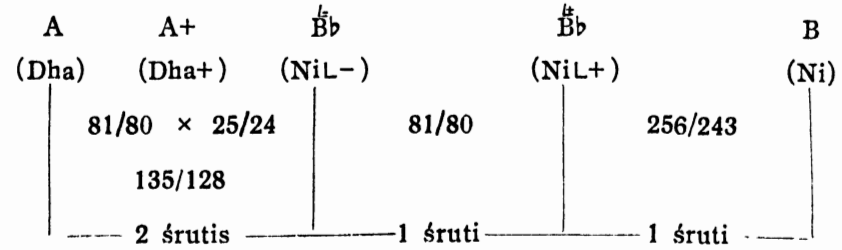
Further Subdivisions of the Śrutis.

The śrutis are represented, in practice, by their characteristic notes, but they are, theoretically, regions of the octave. Within the limits of each śruti several positions may be possible, allowing an adjustment of the tuning of the notes according to modes or rāgas. As long as the notes do not trespass the limits of the śruti their expression keeps the same characteristics. This expression will only be the clearer and stronger if, within the limits of the śruti, that note is utilized which forms, with the tonic, the most rational and simple ratio. This leads to the utilization, within the octave, of the fifty-three (and sometimes sixty-six) positions which allow, inside the śrutis, the necessary adjustments of tuning according to modes or rāgas.

The limits of the śrutis are strictly determinate, a fact which has induced the Hindu physicists carefully to differentiate the limma 256/243 = 22.63 savarts from its complement to the minor tone 135/128 = 23.12 savarts (256/243 × 135/128 = 10/9). Those two

intervals, although almost equal, represent respectively one śruti and two śrutis according to a rule called in Sanskrit treatises "śruti sādharaṇa prākara."[1]

For example, the four śrutis of the major tone can be divided as follows :



Misinterpretations of the Śrutis.

The "enharmonic" division of the octave into twenty-four "quarter tones", by the Greeks as well as by Southern Indians, seems to be the result either of the addition of two theoretical intervals, the modifications of the fifth and the octave, which are never employed and would not bring out a distinct expression, or of a confusion in traditional data. It was the double octave, the "ambitus", which was necessary in ancient Indian and Greek music, as is still the case with Arab and Turkish music today, for the definition of the mode. This double octave was divided into twenty-four (twice twelve) regions assimilated to the zodiacal signs, among which move the seven notes, similar to the seven planets.

The Śruti is not a temperate interval. All śrutis are not equal, but their division suffices to allow the classification of all the notes which have a distinct significance and which are utilized in the definition of Hindu modes (rāgas), in fact, of all possible musical modes. In reality, the division into twenty-two is the minimum division which allows a clear definition of the expression of intervals.

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1. See : Paṇḍit Firoze Framjee, Theory and practice of Indian music, p. 24.

The division of the tone into several intervals is necessary for accurate playing and, although it is very easy for a well-trained ear to discern whether an interval is accurate or not, yet it is extremely difficult, if not impossible, to find out, without special instruments, in what proportion an interval is bigger or smaller than another. This is why Greek musicians, appreciating intervals by ear, and noticing that they were utilizing two or three intermediary positions in the tone, may, like the Hindus, have considered them, in practice, as approximately equal[1]. This is quite understandable. But, to take this approximation for a mathematical reality and make, on such basis, complicated calculations and lengthy theories, to come finally to the conclusion that the Greeks and Hindus were enjoying queer intervals which have no appeal for other ears, is an absurdity. Like every practical division of the octave, the division of the śrutis is theoretically insufficient, but to believe it to be a temperate division is to lower to the level of modern musical practice the scientific knowledge of the Hindus ; it is also in absolute contradiction to the Sanskrit treatises. Therefore, when after many others, M. J. Grosset[2] taking the śrutis to be equal divisions, compares them with the Western temperate scale, and, for this purpose, takes the help of a "professor of mathematics" and of endless logarithms, numbers of vibrations, etc., he may be doing mathematical exercises, but these have no connection whatsoever with the theory or the practice of the śrutis.

The term "śruti", like the Greek "quarter-tone", is an expression which indicates the displacement of a note by an interval smaller than a half-tone in order to realize an harmonically accurate interval. This has nothing to do with an 'equal tempera-

1. "They do not pretend that those minute intervals (śrutis) are equal, but consider them as equal in practice." (William Jones, Musical modes of the Hindoos) (Hindu music, p. 141.)

2. Dictionnaire du Conservatoire, Inde, p. 294.

ment' either by half-tones or quarter-tones. Such calculations as above bear no relation to this.

The school of Aristoxenes, in the fourth century, divided the tone into four quarter-tones "rigorously equal", but this division, in reality, was not considered as exact because Aristoxenes did admit, in practice, a certain "freedom of variation of the intervals", a certain "latitude" for each note[1]. This, obviously, annihilates the rigorism of the definition and clearly shows that such a division is, in reality, a simplified and approximative division, which replaces, as it can, accurate divisions. But, in no case, is it able to allow any precise observations on sounds.

It is difficult to understand why Europeans, who pride themselves on such impartiality and unbiassed views in the field of scientific research, should be so blind in music as generally to accept such a debatable theory as that of temperament for the only basis of comparison, and this for the only reason that it is used in Europe.

The importance of the comma, equal to 81/80 or 5 savarts, which forms the difference of the major and minor tones, is such that it can easily appear as equivalent to the minor half-tone, 25/24 or 18 savarts. This has been noted by E. Clements in his "Introduction to the study of Indian Music" :

"The ancients held the erroneous opinion[2] that these intervals (śrutis) were equal. Their system was, however, a convenient one for distinguishing between the major tone (four śrutis), the minor tone (three śrutis) and the semi-tone (two śrutis). By an interval of "one śruti" they understood the comma 81/80." Though simplified, this view is not inaccurate.

M. Yekta Bey, in his study on Turkish music (Dictionnaire du Conservatoire, p. 2950.), also says :

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1. See : d'Erlanger, La musique Arabe, Vol. I., p. 318.

2. E. Clements cannot refrain from attributing to ancient Hindus a mistake which exclusively belongs to modern Occidentals.

"Oriental instrumentalists, who care only for the practice of their music, having noted that the interval of major tone contains three notes and that the major tone is thus divided into four parts, have given the name of *quarter-tone* to each one of these four parts. Europeans, who have heard this expression, understood that Orientals divide the tone into four equal parts. But no theorist, whether Arab, Turk or Persian, has ever spoken of the division of the major tone into four equal parts . . . . In the interval G A[+] (Pa Dha+), starting from G(Pa), we have :

1° 243/256 (limma) [G(Pa) $\overset{\flat}{\text{A}}$♭(DhaL−)], 2° 2048/2187 (apotome) [G(Pa) $\overset{\sharp}{\text{A}}$♭(DhaL+)], 3° 59049/65536 (minor tone) [G(Pa) A(Dha)].

The intervals obtained by this method certainly do not divide the tone into four equal parts."

Nine centuries earlier, Avicenna (Abū'Āli al-Ḥusayn ibn 'Abd-Allāh ibn Sīnā) was already laughing at the theorists who believed that the "limma" was a mathematical half-tone and that the "irka" was a quarter-tone ; and he explains the exact value of their ratios. (See : J. Rouanet, la Musique Arabe, Dictionnaire du Conservatoire, p. 2715.)

Western division of the Octave into 22 Intervals.

Westerners, always ready to criticize the cut-into-four tones of the Orientals, themselves acknowledge within the octave twenty-one different sounds, which they note by distinct signs ; the Western notation is, in fact, based on the triple septenary :

7 naturals, 7 sharps, 7 flats

which, if the octave is added, gives :

$3 \times 7 + 1 = 22$

The fact that, in the temperament, two notes are represented by one in no way implies that they are really identical. And they are so far from being identical that, to indicate the same temperate note, two signs are maintained, which would be illogical if it were

really one sound. This division differs only by two notes from the Hindu division, and this deficiency is supplemented by the use of the signs ## and bb (double sharp and double flat).

Not even noticing that their own notation implies twenty-two sounds in the octave, too 'civilized', probably, to care for the elementary laws of physics and mathematics which necessitate such a division, Occidentals often speak in contemptuous terms of the "mystico-mathematic sense of Asiatic races . . . . . which led to the tonal aberrations of an enharmonic scale of seventeen or twenty-two sounds";[1] others speak of "diseased degeneracy", or, "obstinacy in cutting the tone into ugly little pieces" (M. Emmanuel), and describe Orientals as "like the Greeks, more intent in splitting tones into quarters and eighth parts, of which they compute the ratios to show their arithmetic, than on displaying the principles of modulation as it may affect the passions." (W. Jones, On the Musical Scale of the Hindus, Hindu music, p. 134.)

Such regrettable views only show that these otherwise learned scholars are as unaware of the realities of musical practice in their own country as they are of the strong acoustic and mathematical grounds of the Eastern musical theory which they so lightly venture to ridicule. They do not seem to realize that the intervals used by the Eastern musicians and by the great Western violonists are, for the impartial ear of sound-measuring instruments, generally identical, although the simplifications necessitated by their practical notation may, sometimes, hide this identity because it dissimulates the true nature of the component sounds. It is unfortunate that this deficiency as regards the knowledge of the elements of acoustic reality has not prevented many a Western scholar from writing books about scales.

Such an approach to purely scientific questions may be culturally most destructive because the musical systems concerned

1. E. Britt, La lyre d'Apollon, p. 17.

often belong to peoples who are politically dependent and whose culture is, therefore, at the mercy of education officials who can, at will, open or close educational institutions, and are, for music at least, obviously not qualified to form an independent opinion.

When, therefore, an apparently unbiassed scholar like M. J. Grosset, who is generally considered in Western countries as an authority, speaks of "this musical past . . . . . whose asserted splendour, if it ever existed, has been for long forgotten,"[1] and describes the classification of notes by saying "those childish speculations, which do not deserve any attention except as a characteristic indication of Hindu mentality", he may help or perhaps inspire with all the weight of his authority the actions of officialdom who, misled by such authority, may, in the name of civilization, destroy some of the most precious monuments and greatest treasures of human culture.

Again we read, in Sir W. Ouseley's "Anecdotes of Indian Music" (Oriental collections, vol. I):

"In Ragas and Raginees , ... the time is broken and irregular, the modulation frequent and wild." We should have thought it sufficient for any one, even if not a musician, to have heard Indian music only once to note that modulation is there absolutely unknown and forbidden, as in every modal system, and that the rigidity of rhythm does not admit of any variation and is always given, with mechanical precision, by an independant battery.

Unfortunately, such utterances as the above may do incalculable harm, for, to the layman, they are the opinions of experts, and the layman cannot be expected to know that these same experts are as ignorant as he is himself of the intricacies and significance of the things about which they speak in such contemptuous and authoritative terms.

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1. Inde, Dict. du Conservatoire, p. 258.

Influence of Hindu Theory in Europe.

It seems that some of the conceptions which are the basis of Hindu theory were known in Europe at the end of the middle ages, probably not through direct influence, but by way of Egyptian and Pythagorean tradition transmitted to the Arabs and Byzantines. This lengthy way of transmission can explain the numerous mistakes in the application of such conceptions to musical practice. The three scales, or *grāmas*, have become the three hexacordum :

Hexacordum naturale C, D, E, F, G, A (Sa Re Ga Ma Pa Dha),
Hexacordum durum G, A, B, C, D, E (Pa Dha Ni Sa Re Ga) and
Hexacordum molle F, G, A, B, C, D (Ma Pa Dha Ni Sa Re).

To the symbols of the Greek alphabetic notation of the scale, A, B, C, D, E, F, G, a, b, c, d, e, f, g, aa, are added five upper sounds and one lower sound, gamma, to realize a scale of twenty-two sounds. And the word "gamut" (French "gamme" ; Latin "gamma") itself resembles singularly the Sanskrit "grāma"[1] or Prākrit "gama". We have no qualification to decide whether this word comes from Greek or Sanskrit ; the fact that in two different places the same word is used to represent the same thing is not a proof in itself.[2]

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1. 'grāma' means : a village, an agglomeration.

2. Professor A. Weber believes that from the Sanskrit 'grāma' (which became in Prākrit 'gama') are derived the French 'gamme' and the English 'gamut' borrowed from the 'Gamma' of Guy d'Arezzo, and he sees there a direct proof of the Hindu origin of the Western scale of 7 notes (See : A. Weber, *Ind. Lit. Geschichte*, and *Indische Studien*), The Western scale would, according to him, have come from India through the Arabs and the Persians. The Arab word for scale "Jamā ah", pronounced in certain provinces "Gamā ah", seems to confirm this theory. (See : A. Grosset, Dictionnaire du Conservatoire, Inde, p. 292, and, d'Erlanger, La musique Arabe, vol. II, p. 312.)

The Jātis.

According to their expression, the twenty-two śrutis are divided into five families, or jātis. The different relations which can be established between these five families allow the determination of the notes in the different modes (rāgas) according to their expression.

According to the Saṅgīta Ratnākara and the Saṅgīta Parijāta, the five jātis are :

First family : Dīptā (shining, illustrious) contains the śrutis : Raudrī, Vajrikā, Ugrā and Tīvrā (E+, F+, B+, D♭) (Ga+, Ma+, Ni+, ReL−) to which correspond the *rasas*, or emotional flavours : marvellous, heroic, and furious.

Second family : Mṛduḥ (soft), of which the rasa is 'love', contains the śrutis : Ratikā, Prītiḥ, Kṣitiḥ and Mandā (E, F♯ A♭, D−) (Ga, MaL+ DhaL, Re−).

Third family : Āyatā (abundant), of which the rasa is comic, contains the śrutis : Krodhā, Prasāriṇī, Sandīpanī, Rohiṇī and Kumudvatī (F, F♯, A, B♭, D♭,) (Ma, MaL−, Dha, NiL+, ReL+).

Fourth family : Madhyā (moderate) ; rasas : comic and love ; śrutis : Chhandovatī, Rañjanī, Mārjanī, Raktā, Ramyā and Kṣobhiṇī (D, E♭, G, A♭, B, C) (Re, Gab, Pa, Dhab, Ni, Sa).

Fifth family : Karuṇā (compassionate) ; rasas : pathetic, odious and terrible ; śrutis : Dayāvatī, Ālāpinī and Madantī (E♭, A+, B♭) (GaL, Dha+, NiL+).

The jātis are not scales, but analogies of expression. It is impossible to build a scale in which all the notes have a similar expression, that is, in which all the notes belong to the same jāti. It is only when the scale has been built according to the general rules of proportions that it can be seen whether it's different notes can incline themselves towards a certain expression, enter into a certain jāti, or not.

The Five Jātis

The tuning of the notes according to mood will, therefore, be :

	Ancient Sa grāma	Name of Śruti	Jāti and Rasa (expression)	Modern exact note	Intervals
0	Ni	Kṣobhiṇī	.....	C (Sa)	.....
1		Tīvrā	Dīptā (marvellous, heroic, furious)	$\overset{L}{\text{D}}\flat$ (Re$\llcorner-$)	limma
2	Kākali Ni	Kumudvatī	Āyatā (comic)	$\overset{\natural}{\text{D}}\flat$ (Re$\llcorner+$)	comma
3		Mandā	Mṛduḥ (Love)	D− (Re−)	minor half-tone
4	Sa	Chhandovatī	Madhyā (comic and love)	D (Re)	comma
5		Dayāvatī	Karuṇā (compassion)	$\overset{L}{\text{E}}\flat$ (Ga$\llcorner$)	limma
6		Rañjanī	Madhyā (comic and love)	$\overset{\flat}{\text{E}}\flat$ (Ga$\flat$)	comma
7	Re	Ratikā	Mṛduḥ (love)	E (Ga)	minor half-tone
8		Raudrī	Dīptā (marvellous, heroic, furious)	E+ (Ga+)	comma
9	Ga	Krodhā	Āyatā (comic)	F (Ma)	limma
10		Vajrikā	Dīptā (marvellous, heroic, furious)	F+ (Ma+)	comma

11	Antara Ga	Prasāriṇī	Āyatā (comic)	F♭ (MaL−)	minor half-tone
12		Prītiḥ	Mṛduḥ (love)	F♯+ (MaL+)	comma
13	Ma	Mārjanī	Maḍhyā (comic and love)	G (Pa)	limma
14		Kṣitiḥ	Mṛduḥ (love)	A♭ (DhaL)	limma
15		Raktā	Madhyā (comic and love)	A♭ (Dhab)	comma
16		Sandīpanī	Āyatā (comic)	A (Dha)	minor half-tone
17	Pa	Ālāpinī	Karuṇā (compassion)	A+ (Dha+)	comma
18		Madantī	Karuṇā (compassion)	B♭ (NiL+)	limma
19		Rohiṇī	Āyatā (comic)	B♭ (Nib)	comma
20	Dha	Ramyā	Madhyā (comic and love)	B (Ni)	minor half-tone
21		Ugrā	Dīptā (marvellous, heroic, furious)	B+ (Ni+)	comma
22	Ni	Kṣobhiṇī	Madhyā (comic and love)	C (Sa)	limma

There are two kinds of Jātis. One, as shown here, refers to the classification of the śrutis according to their expression: this is called śruti-jāti. The other refers to the classification of scales according to the number of notes used in ascending and descending; this is called rāga-jāti,

Affinities of the Musical Notes.

As we have already seen, the different aspects of the perceptible world are parallel manifestations starting from undifferentiated common principles. Their development consequently follows parallel courses, having similar divisions. There are, therefore, natural and irresistible correspondences between the different aspects of manifestation and one can easily, starting from one particular aspect, reach or evoke the corresponding stages in the other aspects.

According to this principle, the notes and chords of music have exact equivalents in every category of existence; only the knowledge of such correspondences can allow us to understand the real meaning of sounds and to use them rationally as a means of evocation.

We shall give here some of the principal correspondences indicated in the Sanskrit treatises. Such correspondences are always envisaged from the point of view of the geometry of sounds and, therefore, they are equally valid for the modal degree and the polyphonic interval, which are only the two diverse applications of one relation. What is said here of the fifth degree G (Pa), for example, applies to the polyphonic interval of the fifth.

In his Saṅgīta Pārijāta, Ahobala says :

84 "Sa (C), Ga (E♭) and Ma (F) are born from the family of Devas (Angels).

85 Pa (G) is born of ancestors, Re (D) and Dha (A) are born of the family of sages (munis), Ni (B♭) is born of the family of demons.[1] This is the distinction of families.

86 Sa (C), Ma (F) and Pa (G) are Brāhmaṇas (priests); Re (D) and Dha (A) are Kṣatriyas (knights); Ga (E♭) and Ni (B♭) are Vaiśyas (traders); the altered notes (sharps or flats) (tīvras or komals) are Śūdras (slaves).

1. This is one of the reasons why the corresponding mode of the modern diatonic scale, the mode of C (Sa), the Western major mode or Indian Bilāval thāṭ, was prohibited in Europe in ancient times and up to the end of the middle ages.

87 Thus the learned scholars have described the distinction of castes.

88 The note Sa (C) is like a lotus, Re (D) is of a reddish yellow, Ga (E) is like gold, Ma (F) is like jasmine.

89 Pa (G) is black, Dha (A) is yellow and Ni (B♭) is variegated. Such are the colours of the notes.

90 There are seven continents : Jambu, Śāka, Kuśa, Krauñcha, Śālmalī, Śveta and Puşkara. The seven notes are born respectively from the seven continents.

91 Agni (fire deity), Brahmā, Mṛgāṅka (the moon), Viṣṇu, the sage Nārada, [the celestial singer] Tumburu and [the god of wealth] Kuvera are the seers respectively of the seven notes. (By 'seeing the notes' is understood the direct knowledge of their absolute pitch.)

92 Vanhi (fire), Brahmā, Sarasvatī (Goddess of learning), Śarva (Śiva), Śrī (Lakşmī), Gaṇeśa and the Sun are the respective Gods of the seven notes . . . . . .

94 Sa (C) and Ma (F) in comic ; Dha (A) and Ni (B♭) in erotic ; Pa (G) in odious, pathetic and terrible ; Ri (D) in erotic, Ga (E♭) in comic.

95 Tīvra (sharp) in heroic, marvellous and horrible, tīvretara (sharp of two śrutis) in comic, and even "tīvretama Ma" (Ma sharpened by 3 śrutis = Pa−) (G−) in erotic.

96 Even "tīvretama Ma" in erotic and "mṛdu Ma" (Ma−) (F−) in comic. Thus is truly the distinction of the expressions (rasas) of the seven notes. Here ends the description of notes."

There are several systems of correspondences between notes and planets, angels or Gods, colours, castes, seasons, emotions (rasas), etc., which, at first sight, can appear contradictory, but, in reality, refer to different fundamental (śuddha) scales. We shall study them in detail when we deal whith Hindu rāgas. We should only note here that the names of animals attributed to the notes in the tradition of the Sāma Veda are in the same order as those used by mediæval and modern authors, but transposed. So that the cry of

the peacock, which represents the Pa(G) in Sāma Veda, now corresponds to Sa(C). If, as is asserted by Hindu musicians, the pitch of the cry of these animals is always the same, this would indicate that the pitch of the diapason has risen by one fourth since Vedic times.

The Chinese, who attach great importance to the exact pitch of the diapason, have kept, to this day, this primitive pitch, which is also that of the "Yekah", or tonic, in Arabic music. The "mesa" of Greek music had, according to the calculations of Gevaert, the same pitch as the modern Occidental F sharp, which, if we take into account the difference of one half-tone existing between the usual Hindu pitch and the Western actual diapason, brings us again to the same note.

The Modes or Rāgas.

The term "rāga", which is generally translated by "mode", is much more accurate than the term "mode" as usually understood by Occidentals. Its meaning is rather "passion" and it stands for a group of sounds utilized for the representation of a definite emotional state. A rāga could only be compared to that which, in Western music, is a figured bass, leaving every possibility open for variations but having the outline of the expression defined in advance.

Insisting upon only one form of emotion, the mood slowly penetrates the hearers, even if inattentive, and establishes itself in their minds. This is why the power of suggestion of modes is so much stronger than that of other musical forms in which the mood is always changing. This influence can be strong enough to bring about physical and psychological transformations which seem unbelievable to those who are accustomed only to the powerful but superficial effects of harmonic music.

Like all ancient peoples, the Greeks attached great importance to the power of modes as a means of imposing upon the mind certain conceptions and points of view. Their value as instruments

Affinities of the Notes.

according to :		*Nārada*	*Śārṅga-deva*	*Nārada Śārṅga-deva Ahobala*	*Nārada Śārṅga-deva Ahobala*	*Śārṅga-deva*	*Śārṅga-deva Ahobala*	*Śarṅga-deva Ahobala*	*Śārṅga-deva Ahobala*	*Bharata Śārṅga-deva*	*Ahobala*
Ancient notes	**Modern notes**	**Deities (Devas)**		**Colour**	**Caste**	**Uttered by :**	**Family**	**Seer (Ṛṣi)**	**Birth place**	**Rasa[1]**	
Sa Chaturtha (4th) Svarita	**Re (D)**	**Brahmā**	**Vanhi (fire)**	**lotus**	**Brāhmaṇa (priest)**	**Peacock**	**Devas (angels)**	**Agni (fire)**	**Jambu dwīpa**	**heroism wonder anger**	**comic**
Re Tṛtīya (3rd) Anudātta	**Ga (E)**	**Fire**	**Brahmā**	**green or orange**	**Kṣatriya (knight)**	**Chātaka[2]**	**Ṛṣis (sages)**	**Brahmā**	**Śāka**	**heroism wonder anger**	**love**
Ga Dvitīya (2nd) Udātta	**Ma (F)**	...	**Saras-vatī**	**gold**	**Vaiśya (trader)**	**Goat**	**Devas (angels)**	**Moon**	**Kuśa**	**compas-sion**	**comic**
Ma Prathama (1st) Svarita	**Ma T.(F♯)**				**Śūdra (slave)**						

Antara Ga	Pa (G)		Viṣṇu	white jasmine	Brāhmaṇa (priest)	Heron	Devas (angels	Viṣṇu	Krauñ-cha	comic love	comic
Pa Kṛṣṭa Svarita	Dha (A)	Soma	Śiva	black	Brāhmaṇa (priest)	Kokila (black cuckoo)	Pitṛs (ances-tors)	Nārada	Śālmalī	comic love	disgust terror compas-sion
Dha Pañchama (5th) Anudātta	Ni (B)		Gaṇeśa	yellow	Kṣatriya (knight)	Frog	Ṛṣis (sages)	Tumbu-ru	Śveta	disgust terror	
Ni Atisvāra Udātta	Sa (C)	Sun	Sun	all colours	Vaiśya (trader)	Eleph-ant	Asuras (genii)	Tumbu-ru	Puṣkara	compas-sion	love
Kākali Ni	Re K. (C♯)				Śūdra (slave)						
other altered notes					Śūdras (slaves)						

1. In the system of Hanumanta, used by Ahobala, the general tonic is said to have been the Sa (modern Re=D), while in the system of Bharata, used by Nārada, Bharata, and Śārṅgadeva, the general tonic would have been the Dha (modern Ni=B); this explains the difference in the expressions attributed to the notes.

2. The Chātaka is a mythical bird which lives only on rain drops.

of education, or means of influencing the masses, was, therefore, recognized, and their use regulated.

Aristotle tells us : (Politics, book V, 5th chapter, § 8.)

"Some modes, such as the Mixolydian, incline people towards melancholy, towards more concentrated feelings. Others, such as the relaxed modes, inspire carelessness and laziness. Another intermediary harmony brings to the soul calm and peace ; it is the Dorian mode which alone can produce this effect, while the Phrygian mode stimulates enthusiasm. . . . . All hymns consecrated to Bacchus, and all such movements, take their particular character from their adaptation to the Phrygian mode ; such is also the case for the Dithyramb, which is considered by all as a Phrygian invention . . . . . As for the Dorian harmony, all are unanimous in recognizing its character of constant gravity and male firmness. . . . . To it can be added other similar modes which are adequate for the education of children because they are, at the same time, able to instruct them and to raise in them the notion of decency."

Definition of Modes.

A mode, or *rāga*, is defined by four indispensable factors :

I. *A tonic*, constantly played, upon which the whole modal structure depends.

II. *A scale*, containing at the most nine notes, or at the least five notes. The melodies which make use of more than nine notes are mixtures of modes, and compositions of less than five notes are only "melodic figures" (tāna).

This scale can present, and generally does present, a difference in ascending (āroha) and in descending (avāroha.)

III. *Certain melodic figures*, and ways of attacking the notes, which are called the form (rūpa) of the mode. They constitute the 'thema'.

IV. *A dominant.* In each mode, a note which is distinct from the tonic, though in some cases it may be the same note, is played

more often than the others. It is always acccentuated, and has long pauses. This note is called "vādī" (that which speaks). It is said to be the rājā (king) of the melody.

A second note, of almost equal importance, is called "samvādī" (consonant): it is one fourth or one fifth above the "vādī".

The other notes of the mode are called "anuvādī" (assonant). The notes which do not belong to the mode are called "vivādī" (dissonant).

These four elements, the tonic, the scale, the shape imposed by the "rūpa", and the dominant note, are sufficient to determine a mode and its expression. Within these limits all combinations of rhythms and melodies are allowed, but the slightest use of a "vivādī" note, or of melodic figures belonging to the rūpa of another mode, spoils the atmosphere and expression of a "rāga".

If the four elements of a mode are known, the mode is perfectly determined, but, if one of those elements is missing, the mode remains indeterminate, and it is impossible to define its signification or expression. This is the case, for example, with Gregorian plainchant where the tonic is always uncertain.

The classical treatises describe, generally, 72 principal modes, to which are added derived modes reaching a total of several hundreds. This is only the number of modes actually in use, because the number of theoretically possible modes is much greater. Ahobala speaks of 13,726,560 different combinations of the notes and of 18,678 modes of seven notes, 31,050 modes of six notes, and 17,505 modes of five notes in the Ma grāma alone.

The Periods of the Day.

Much importance is attached in Hindu music to the connection between musical modes and the periods of the day. Westerners recognize that certain musical works can represent morning, midday or night, but they have never tried to define the

intervals by which they are characterized, and they find it quite natural to play them at any hour. Hindus do not approve of such a lack of sensibility: modes of the night should be played at night, and those of dawn at dawn. Then, only, can we fully understand and enjoy them without effort, because we ourselves change according to the hour; and the day, in its brief cycle, is the image of life.

Played at times other than those which they represent, musical modes can, for a moment, change the course of Nature. Musicians, playing in day time the modes of night, have been seen to appear gradually surrounded by intense darkness.

This connection of modes with the hours of the day is also known to the Persians and Arabs, but their calculation is not as accurate as that of the Hindus.

There are three main divisions of the day:

1° the day, of which the Sun is the luminary,

2° the night, of which the Moon is the luminary,

3° the twilight, of which Fire is the luminary.

The Sun is said to have 116 rays, the Moon 136, and Fire 108. Their sum is equal to $116+136+108=360$.

To this corresponds the division of the day into three hundred and sixty units of four minutes each. Six of them form one Ghaṭikā of 24 minutes, of which there are 60 in 24 hours. These have been connected with the division of the octave into commas. Twelve of these small units form one Muhūrt, of 48 minutes, of which there are 30 in a day, each of them being dedicated to a particular deity.

The day is further divided into eight watches (praharas), of three hours each, and, further, into twenty-four hours (twice twelve) assimilated to the twelve regions of the octave, the signs of the Zodiac, etc, .

The day and the night comport an ascending part, of male character, and a descending part, of female character, because "manifestation or growth is masculine, disappearance or decline is

feminine, and neuter is the intermediary condition." (Kallinātha, Commentary on the Saṅgīta Ratnākara, 3rd chapter, p. 264).

All these elements have their importance in determining the proper time for the playing of the different modes, principally regulated by the respective value of the notes in regard to Sun, Moon and Fire. The main divisions are therefore :

I. *Sandhiprakāśa rāgas*, figuring the conjunction of day and night (sunset and sunrise), whose general characteristics are Re komal and Ga tīvra (D flat and E natural).

II. *After Sandhiprakāśa* (first part of the day or night), usually characterized by Re, Ga and Dha śuddha (D, E and A natural.)

III. *Before Sandhiprakāśa* (second part of day and night), characterized by Ga and Ni komal (E flat and B flat).

Those periods are further defined by the following particularities :

I. *Between midday and midnight*, the vādī (predominant note) is in the lower tetrachord (pūrvāṅga), i. e. between Ṣa and Ma (C and F).

II. *Between midnight and midday* the vādī is in the upper tetrachord (uttarāṅga), from Pa to Sa (G to C).

III. *The augmented fourth* (Ma tīvra) (F sharp) belongs to the critical times of midday and midnight, sunrise and sunset, solstices and equinoxes. It may also exist in morning, but is then dominated by a flat E (Ga komal). There are some exceptions to that rule, the F sharp (Ma tīvra) corresponds, then, to an expression of fear and pain.[1]

IV. *In the defective modes* of six or five notes, the evening modes never leave out E and B (Ga and Ni) (udātta notes), the

1. The use in Hindu music of the augmented fourth (tritone) at the critical times of midnight and midday reminds us of the magical importance attached to those hours, and the fact that the tritone (diabolus in musica) is utilized by Western musicians for the representation of magic, which is nothing else than the possible intersection, at certain critical hours, of worlds which

morning modes never leave out D and A (Re and Dha) (anudātta notes.)

The Modal or Harmonic Division of the Scale.

Hindu Deśi music is essentially modal, which means that the relations of sounds, on which the musical structure is built, are calculated in relation to a permanent note, the tonic. This does not mean that the relations between sounds other than the tonic are not considered, but that each note will be established first according to its relation to the fixed tonic and not, as in the case of the cycle of fifths, by any permutation of the basic note. The modal structure can then be compared to the proportional division of a straight line, and no longer to the periodical movement of a spiral. According to the symbolism of numbers, those proportional divisions are connected with certain ideas, certain forms, certain emotions.

The object of harmonic science is to classify these proportions according to their symbolism and their expression. On this basis only can modes be logically constructed, and their expression precisely defined. All the notes obtained in the harmonic system are distinct from those of the cyclic system which is based on different data. But, though the notes are theoretically distinct and their sequence follows completely different rules, yet, in practice, they lead to a similar division of the octave into fifty-three intervals.

We shall give here the scale of proportions, basis of all modal music[1].

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normally cannot communicate. It is used conspicuously in this way by Schumann for the personnage of Manfred, by Wagner every time a magician appears, by Berlioz in the 'Symphonie fantastique', by Weber in the Freischütz, etc.

In Chinese Music, the lyŭ Jwēi-pīn, which corresponds to the augmented fourth (F sharp) (Ma tīvra), represents the summer solstice, critical moment in the annual cycle, when the male influx, hot and creative, gives place to the female influx, cold and destructive.

1. For its correspondence with the scale of fifths, see the eigth part.

Harmonic Division of the Octave.

	C Sa	+	++	1/4	♯	L-	L+	♭	3/4	--	-	D Re
Relation to the tonic C (Sa)	1	81/80	46/45	30/31	25/24	256/243	16/15	27/25	135/124	11/10	10/9	9/8
Interval (between two successive notes)	com.	com.	disjunction	com.	com.	com	disjunction	com.	com.			
	0.	1	2	3	4	5	6	7	8	9		

	D Re	+	++	1/4	♯	L	♭	3/4	--	-	E Ga
relation to tonic	9/8	256/225	15/13	93/80	75/64	32/27	6/5	75/62	128/105	100/81	5/4
intervals	com.	com.	disjunction	com.	com.	disjunction	com.	com.			
	9	10	11	12	13	14	15	16	17		

	E Ga	+	++	1/4	--	-	F Ma
relation to tonic	5/4	81/64	32/25	31/24	125/96	320/243	4/3
intervals	com.	com.	disjunction	com.	com.		
	17	18	19	20	21	22		

	F Ma	+	++	1/4	♯	L-	L+	♭	3/4	--	-	G Pa
relation to tonic	4/3	27/20	512/375	62/45	25/18	45/32	64/45	36/25	90/62	375/256	40/27	3/2
intervals	com.	com.	disjunction	com.	com.	com.	disjunction	com.	com.			
	22	23	24	25	26	27	28	29	30	31		

	G Pa	+	++	1/4	♯	L	♭	3/4	--	-	A Dha
relation to tonic	3/2	243/160	192/125	31/20	25/16	128/81	8/5	50/31	81/50	400/243	5/3
intervals	com.	com.	disjunction	com.	com.	disjunction	com.	com.			
	31	32	33	34	35	36	37	38	39		

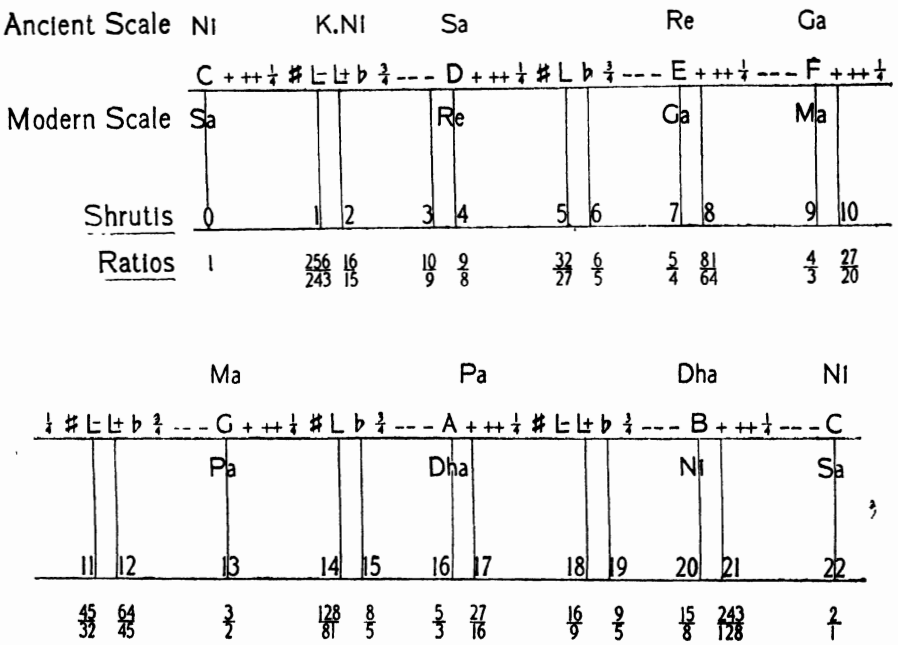
	A Dha	+	++	1/4	♯	L-	L+	♭	3/4	--	-	B Ni
relation to tonic	5/3	27/16	128/75	31/18	125/72	225/128	16/9	9/5	29/16	11/6	50/27	15/8
intervals	com.	com.	disjunction	com.	com.	com.	disjunction	com.	com.			
	39	40	41	42	43	44	45	46	47	48		

	B Ni	+	++	1/4	--	-	C Sa
relation to tonic	15/8	243/128	48/25	31/16	125/64	160/81	2/1
intervals	com.	com.	disjunction	com.	com.		
	48	49	50	51	52	53		

This scale is made of a succession of commas diesis (81/80 = 5 savarts), with disjunctions of eight savarts. The disjunctions can be divided into two equal parts by an intermediary sound which corresponds to the quarter-tone.

In this scale, according to the definitions of the ancient treatises, corroborated by the practice of present traditional musicians, the place of the twenty-two śrutis is thus :

The twenty-two Śrutis.



SIXTH PART

CONFUSION OF THE SYSTEMS

The Music of the Greeks.

"Because analogy is the law of all things. . . . . things, in this world, could not be independant; indeed, of necessity, there had to be a certain relation between them."

(Plotinus, third Ennead, book II, ch. 18.)

"There seems to be in the nature of harmony and rythm something similar to human nature. Therefore, some philosophers assert that the soul is an harmony."

(Aristotle, Politics, V, 4, 7.)

Sixth Part

CONFUSION OF THE SYSTEMS.

Greek Music.

If we try to study Greek music from the works of Western scholars it is extremely puzzling. A great number of ill-assorted intervals seem to be assembled in genera and modes which appear strange and ill adapted to the necessities of acoustics as well as to those of art. In addition to which, these genera, modes or intervals, are represented by ratios which, although mathematically very accurate, yet differ according to each theorist. When intervals are so ill-determined that such laxity in definition is possible, so much precision in measurement seems rather arbitrary.

If, however, we consider the peculiar position of Greek civilization, it is easy to find the key of the enigma. But, first, we shall have to repudiate the legend by which we are made to believe that the Greeks invented everything. Far from having invented anything in music, the Greeks received all the elements of their musical system from Egypt and the Near East, a fact which they never attempted to conceal. But where they really showed their originality was when their physicists tried to explain the laws of that music with the help of a theory which they had received from another source, and which, in reality, was applicable to another system. Since the physicists' theory could never coincide with the system as used by the musicians, many compromises had to be invented. This explains the multiplicity of combinations and ratios proposed for each mode according to the fancy of the physicists.

Greek music, as it was actually played by musicians, being of modal form, is necessarily included in the definitions of ancient Hindu music, because those definitions cover all the possibilities of such music. Greek music, like Egyptian music, most probably

had its roots in Hindu music, or, at least, in that universal system of modal music of which the tradition has been fully kept only by the Hindus. In opposition to this modal system, the cyclic system of the Greek physicists, based on the properties of numbers according to the doctrines of Pythagoras, is represented, in its most complete form, by the Chinese musical theory.

As usual, the Greek physicists, the "scientists", unable to realize the limits of their own knowledge, accused the musicians of being ignorant and obstinate. Like all reformers, they considered as normal the stage of development reached in their time by the art they pretended to explain and improve, and they would have been most astonished had they been able to realize that any music built according to the logic of their theories would have been of quite a different nature and would have had little resemblance to the art which they loved. Such music, as Chinese music for example, would have hurt their ears, and would certainly have been rejected by them as "barbarous".

This is what was observed by the Arabs. "When, under the rule of the Abbaside Khaliphs, the Arabs came into direct contact with the Persian and Byzantine populations, their artists soon realized the very great differences which existed between the teachings of Greek theoricians and the art practised by those populations : that living and real art which, more than scholarly works could do, has imprinted upon Arab music a mark of which, up to our day, there remain deep traces." (d'Erlanger, La musique Arabe, p. 590.)

This conflict of theories gives rise to so much confusion that Greek music would not be a subject of particular interest for the study of scales — since we can study, in their complete form, in China and India, the systems themselves from which it originated — if Western music had not inherited from it, in addition to certain classifications, its ambiguous position between two systems, and also its insufficient theory. And, because of the extravagant fanaticism with which the most arbitrary theories are so often

imposed upon the whole world in the name of "civilization", simply because they came from Europe, such theoretical confusions cannot be too strongly opposed, for, under the guise of reforms and progress, they undermine the basis of musical systems most logically and most solidly established, but which do not have their roots in Europe.

We can have only a very faint idea of what Greek music really was from the prejudiced explanations of theorists. About the technique and musical expression we can often get better data from the criticisms made of the musicians than from the explanations of theorists, for these criticisms allow comparisons to be made with modal systems still in existence today. Such, for example, is the much criticized habit of "pulling the strings", which indicates the use of the "glissando" between the notes, just as is practised in Hindu music, and by which good musicians can draw such wonderful "arabesques"; but which can also be merely the formless twittering in which bad musicians of India today, like those of ancient Greece, endlessly delight.

To study Greek music, we must be somewhat cautious about Greek theorists, but we must above all fear the works of modern Westerners, because, as has been remarked with humour by M. Yekta Bey[1], "the writings of Europeans on ancient Greek music are so filled with errors and baseless hypotheses that, if we had to refute all of them, five volumes of encyclopedic size would not suffice."

Besides, Europeans have no right to the title of sole heirs to and authorized commentators on Greek music. In reality, the Arabs and the Turks happened to be those who directly received the inheritance of Greece. It is through the Arabs that, in many cases, the works of Greek philosophers and mathematicians reached Europe. The most serious studies on Greek music were written by Arab scholars such as al-Fārābī in the 10th century and a

1. La Musique Turque, Dict. du Conservatoire, p. 2958,

little later Avicenna, while Westerners, Boetius in particular, had already made the most terrible mistakes. It is the Arabs who maintained a musical practice in conformity with this theory, a practice and theory which are still those of Arab music today. It would, therefore, seem elementary for Western scholars to take into account the interpretation of Greek theory given by the Arabs before starting the fantastic reconstructions which have so prolifically flourished in Europe in recent years. Such a comparison is all the more necessary because the differences of interpretation concern the most fundamental definitions.

We are not in a position, as yet, to start such a comparative and detailed study by means of which there is alone any possibility of practically defining Greek modes and the technical details necessary to their execution. Instead, therefore, of presenting them, as is commonly done, as vague atonal scales, absolutely insufficient from the point of view of musical expression, we shall have to limit ourselves, in this brief study, to an attempt broadly to outline what is generally known of the Pythagorean theory, its approximate application to modes, and the musical classifications of the Greeks.

As we have seen, in connection with Hindu modes, three elements at least are necessary for the definition of modes, as for that of chords. Those elements are, for the mode, the scale, the tonic constantly present, and the dominant notes, which can be one or two (the vādī and samvādī of Hindu music). The position of the mobile notes between the fixed ones (tonic and dominant notes), produces exactly the same numerical relationships as do chords. But, whereas in modulating systems, where every sound is mobile, it is necessary to repeat again, with each note, the "body of harmony" (tonic, fifth or fourth, and octave), in the modal system, one note alone, by changing its place, can produce the effect of a perfect major or minor chord, of a chord of fourth and sixth, of a chord of seventh, etc.. The modal frame, being fixed and firmly established in the memory by the prelude, no longer needs to be constantly repeated, as is the case for the

chords of harmonic music, and can sometimes even be entirely left to be understood.

Probably because of the commentators' ignorance of modal music, the three elements, without which a mode cannot be defined, do not appear clearly in any transcription of Greek modes, the study of which should probably be done over again, bearing in mind the particularities of modal systems instead of trying, at any cost, to find in them the principles of harmony.

The Theory of the Scale.

The Pythagorean theory can be very briefly expressed as follows :

"The demiurge has divided the composition [of the soul of the world] into seven parts which are, between themselves, like the terms of two geometrical progressions, one of ratio 2, (1, 2, 4, 8), and the second of ratio 3, (1, 3, 9, 27). With the help of these two progressions, the demiurge has formed a single progression . . . . . (1, 2, 3, 4, 9, 8, 27)". (A. Rivaud : Foreword to his translation of the 'Timaeus', p. 43.)

This Pythagorean progression, with its characteristic inversion of the fifth and sixth numbers, is to be found in every traditional system and is, for example, the basis of the scale on which the Sāma Veda is sung, a scale which, in much more ancient times, showed the same inversion.

The Nārada Śikṣā gives the Vedic scale (descending) as corresponding, in classical Sanskrit notations, to :

Ma (F), Ga (E♭), Re (D), Sa (C), Dha (A), Ni (B♭), Pa (G),

that is, in modern notation :

Pa (G), Ma (F), Ga (E), Re (D), Ni (B), Sa (C), Dha (A),

the symbolic representative numbers of which would correspond to those of the Pythagorean progression.

If we compare the numbers of those progressions, two by two, "we find six intervals and twelve relations . . . . . .

1/2 - 2/1, 2/3 - 3/2, 3/4 - 4/3, 4/9 - 9/4, 9/8 - 8/9, 8/27 - 27/8.

"The harmonic problem, according to the last passage of the *Republic*, consists in 'unifying' the intervals, in filling the spaces between them with other terms which will form, with the first ones, definite ratios. This operation is called 'harmonizing' (ἁρμόττειν) . . . . . The result is the consonance (συμφωνία) of intervals, or their accord . . . . . .

Plato will thus fill the intervals of the primitive series :

1 : 2 : 3 : 4 : 9 : 8 : 27, so as to find the musical intervals and their divisions." (A. Rivaud, ibid, p. 45-47.)

To fill the first interval 1-2, he chooses, among the ratios formed by the terms of the series, the harmonic medium division 3/2 and the arithmetic medium division 4/3 whose relation 9/8 is divided into two unequal parts : the limma (256/243) and the apotome 2187/2048. The limma is the difference between two tones (81/64) and one fourth (4/3), and the apotome the difference between the limma and the tone (256/243 × 2187/2048 = 9/8).

In this way is realized the series :

1 9/8 81/64 4/3 3/2 27/16 243/128 2.

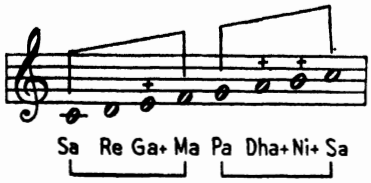
Interpreted according to modern ideas, that is, upwards, this numerical scale would give :

	C	D	E+	F	G	A+	B+	C
	(Sa)	(Re)	(Ga+)	(Ma)	(Pa)	(Dha+)	(Ni+)	(Sa)
	1	9/8	81/64	4/3	3/2	27/16	243/128	2
intervals :	9/8 major tone	9/8 major tone	256/243 limma	9/8 major tone	9/8 major tone	9/8 major tone	256/243 limma	
savarts :	51	51	23	51	51	51	23	

In this way we obtain two equal tetrachords, each containing two major tones and one limma, separated by a major tone.

This scale is identical to the scale of fifths, if we take as tonic the F(Ma) ; but, if the tonic is kept as C(Sa), we find in

it the arithmetic mean 4/3 = F (Ma) instead of the seventh fifth F♯ (Ma tīvra) = 512/729.



This is, in the Pythagorean system, the equivalent of the Western major scale or the Hindu Bilāval ṭhāṭ.

According to Hindu theory, this interpretation of the Pythagorean scale should be correct for our times, as it corresponds to the actual cosmic data But, in other periods, another interpretation must be given to it. This leads to somewhat different basic scales. The fact that the numerical Pythagorean scale can adapt itself to these diverse interpretations, in accordance with the peculiarities of cosmic periods, speaks in favour of the accuracy of the data on which it is based.

In Greek times, the sounds which we call high were called low, therefore the numerical ratios were used in the opposite order.

Starting from the higher C (Sa), that is, the half-string as a unit, we must divide by two the numbers of the Pythagorean series to obtain the proportions on the full string.

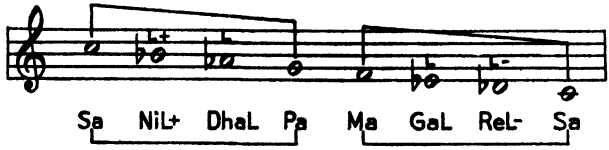
The string lengths, therefore, become :

1 : 2 = 1/2, 9/8 : 2 = 9/16, 81/64 : 2 = 81/128, 4/3 : 2 = 2/3,
3/2 : 2 = 3/4, 27/16 : 2 = 27/32, 243/128 : 2 = 243/256, 2 : 2 = 1.

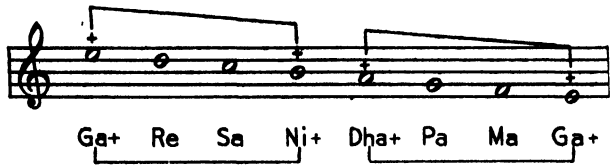
These give the ratios of vibrations :

C	B♭	A♭	G	F	E♭	D♭	C
(Sa)	(NiL+)	(DhaL)	(Pa)	(Ma)	(GaL)	(ReL−)	(Sa)
2	16/9	128/81	3/2	4/3	32/27	256/243	1
intervals :	9/8	9/8	256/243	9/8	9/8	9/8	256/243
	major tone	major tone	limma	major tone	major tone	major tone	limma

This scale is exactly the opposite of the former one. It is also exclusively composed of major tones and limmas, but, being a descending scale, it has its half-tone at the lower end of each tetrachord. That is :



which can also be written :



It is the Dorian mode, also called "diatonic of the physicists", and it corresponds to the "Bhairavī ṭhāṭ" of the Hindus.

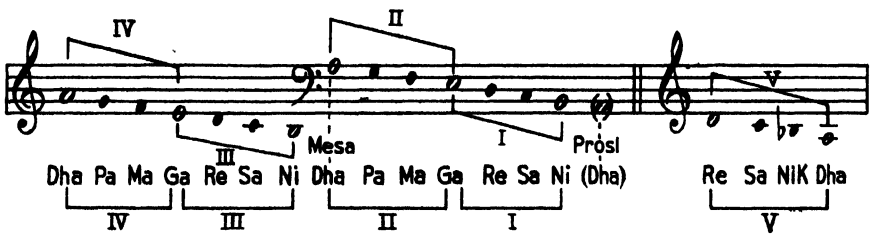
Genus.

According to modern conceptions, a scale or mode is defined by the respective place occupied by the notes within the interval of one octave, but for the Greeks it was otherwise, as it still is today for the Arabs. It is the relative place of the mobile notes within the fixed frame of the tetrachords which defines genus and mode. "Genus est certa quaedam tetrachordi divisio", wrote Aristides Quintilian in his "De musica". For the modal definition to be complete, four tetrachords are required which, though they are generally similar, have a different function. This is why, in Greek music, to transpose a melody one octave higher changes its character, while a transposition of two octaves will bring back the same expression.

The frame of the tetrachords is fixed and is formed by the tonic, the fourth, the fifth and the octave. These are invariable and are called by Aristotle the "body of harmony". But, within the tetrachords, the two other sounds are mobile and, according to their position, form the genera : enharmonic, chromatic and diatonic. This classification is somewhat artificial and has given rise to the most amusing mistakes in interpretation and to the most violent invectives which are certainly not justified.

The tetrachords are four. The lowest (I), the medium (II), the disjunct (III), and the highest (IV). To these four tetrachords must be added a lower note, the *Proslambanomenos*, and a fifth tetrachord similar to the others, but ending downwards on the "mesa", and called "conjunct" tetrachord (V). In the diatonic genus, the whole of these tetrachords formed the scale of the Pythagorean great-perfect-system within the frame of which the two groups of Dorian (national) harmonies and Barbarian (Phrygian) harmonies developed.

These five tetrachords gravitate around the *mesa* which is the highest note of the medium tetrachord, and which was dedicated to the Sun because it was the centre of the whole musical system, the permanent note, constantly heard and in relation to which all other notes had a signification. Western scholars interpret this scale as follows :—



But Şafiu d-Dīn, as interpreted by d'Erlanger, gives the following definition of the scale (to which we have added the corresponding Hindu notations) :

Perfect group (disjunct).

Arabic scale	Ancient Hindu scale	Modern scale	Arabic denomination	Greek denomination
G (Pa)	Ma	C (Sa)	Lowest given	Proslambanomenos
A (Dha)	Pa	D (Re)	Lowest of the principal tetrachord	Hypate hypaton
B (Ni)	Dha	E (Ga)	Medium „ „ „	Parypate „
C (Sa)	Ni	F (Ma)	Highest „ „ „	Lichanos „
D (Re)	Sa	G (Pa)	Lowest of the medium tetrachord	Hypate meson
E (Ga)	Re	A (Dha)	Medium „ „ „	Parypate „
F (Ma)	Ga	B♭ (Ni komal)	Highest „ „ „	Lichanos „
G (Pa)	Ma	C (Sa)	Central sound	Mesa
A (Dha)	Pa	D (Re)	Disjunctive of the central sound	Paramesa
B (Ni)	Dha	E (Ga)	Lowest of the disjunct tetrachord	Trite diezengmenon
C♯ (Sa T.)	kākali Ni	F♯ (Ma tīvra)	Medium „ „ „	Paranete „
D (Re)	Sa	G (Pa)	Highest „ „ „	Nete „
E (Ga)	Re	A (Dha)	Lowest „ highest „	Trite hyperboleon
F♯ (Ma T.)	antara Ga	B (Ni)	Medium „ „ „	Paranete „
G (Pa)	Ma	C (Sa)	Highest „ „ „	Nete „

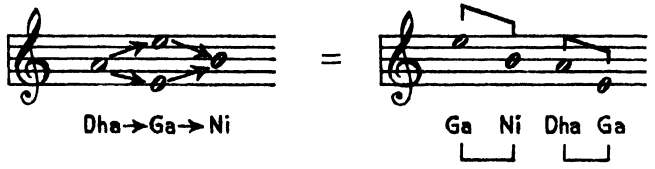
The different genera and modes found in Greek music are still in use in Hindu music today, although under an apparently different classification. But this classification, more convenient in practice for musicians, requires some experience of music and, therefore, allows itself to be less easily handled by scholars. These always comment bitterly about quarter-tones, and do not apparently recognize a fifth from a fourth. There are two classifications of sounds because sounds have two aspects, a physical aspect and an intellectual one. The physical aspect, the 'form', is a material vibration which can be known by measurements or numbers, while the intellectual aspect, the 'meaning', or expression, is directly perceived. The Hindus prefer to study musical sounds under this latter aspect only. They consider this system as more practical because it can always be accurately established without the help of any measuring instrument.

According to Western scholars, the diatonic division of the scale was not the most ancient in Greece. It would be more accurate to say that it was not the basic definition. In spite of all the efforts of philosophers and mathematicians, it could never, in musical practice, replace the ancient enharmonic conception of the scale. And enharmonic notations always remained in use even for the diatonic.

In reality, as we have already seen in Hindu music, there can be no opposition nor anteriority between the enharmonic scale (śrutis) and the diatonic scale (grāmas) which necessarily co-exist and are only two forms of the same thing. Because they have not meditated upon acoustics, and because of the undoubted tendency of Western scholars to assume that ancient theories are as arbitrary as their own, oppositions are seen where there is only a difference of approach.

"The graphic system used by the Greeks to represent musical sounds is in formal contradiction with the Pythagorean division of the octave which is based on tuning by means of fifths : it is called the vulgar or vocal diatonic. It is true that professional musicians, and dilettanti, partly aceepted the Pythagorean construction. The

fixed sounds, the 'body of harmony', were placed in their true place with the help of the consonance of fifths according to the process already seen. Starting from the mesa the three other fixed sounds were obtained.



But, within this rigid frame, they attempted to insert mobile sounds not issued from the fifths and, therefore, placed according to intervals smaller than half-tones or bigger than tones." (M. Emmanuel, Grèce, Dictionnaire du Conservatoire, p. 418.)

We shall see what these contemptible intervals really are, which, without regard for twentieth century decency, the Greeks had the pretension to insert into the tetrachords, and against which M. Emmanuel felt all the more indignant because, according to him, the Greeks had "so regrettably succeeded".

The Greeks divided musical modes into three Genera.

1. the *diatonic*, in which each tetrachord is divided into two tones and one half-tone,
2. the *chromatic*, characterized in each tetrachord by a trihemitone, or minor third ; the remaining tone being usually divided into two half-tones,
3. the *enharmonic*, whose characteristic interval is, in each tetrachord, a major third, or ditone ; the remaining half-tone being usually divided into two diesis, or "quarter-tones".

Western scholars claim that the chromatic genus is characterized by a succession of two half-tones, and the enharmonic by a succession of two quarter-tones, but the Arabs assert that, although this may accidentally happen, it is not at all a necessary feature of these genera.

According to al-Fārābī, a chromatic genus is that in which each tetrachord contains a minor third, whatever may be the disposition of the other intervals; an enharmonic genus is that in which each tetrachord contains a major third; while a diatonic genus is that in which each tetrachord contains two full tones.

"Greek authors, in fact, use the denomination "enharmonic", which Avicenna well translates by the term "ta'līfiyyah", to designate the genus which contains the natural third of ratio 5/4, and the denomination "chromatic", which is exactly translated by the Arab term "mulawwanah", to designate the genus in which one of the three intervals is a minor third of ratio 6/5 or 7/6." (d'Erlanger, La musique Arabe, tome II, p. 578.)

On the question of quarter-tones and their use in the enharmonic genus, the most astonishing theories have been constructed by Western scholars in which, needless to say, the poor Greeks are always proved to have been wrong. The intemperance of language and imagination shown can only be attributed to the fact that the users of "equal temperament" have lost all notion of the variety of intervals which are harmonically and melodically accurate.

To understand the genera of Greek music, we must first study the fundamental genus, the enharmonic, because, in conformity with definitions imported into Greece from Egypt and Asia, it was the basic genus of Greek music, from which the others were born. It was by no means, as we are sometimes made to believe, a degeneracy, a refinement of Greek music.

M. Emmanuel himself had to acknowledge that : "It is the enharmonic genus, graphical standard of all the scales, which is the primordial genus"[1] and he adds : "The professionals stated this strange principle that the melodic succession the most regular, the 'most exact', was the enharmonic." (ibid., p. 418.)

Let us see what this genus actually was.

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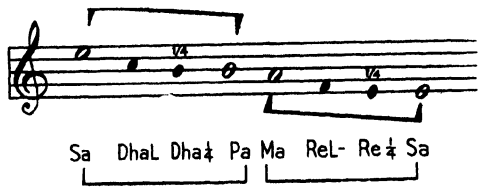
1. Op. cit., p. 419.

The Enharmonic.

According to Western interpretation, the enharmonic genus divides each tetrachord into 8, 1 and 1 "diesis", that is to say, into a *ditone* (two major tones) and two "quarter-tones".



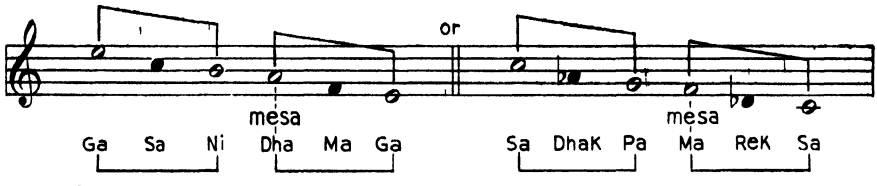
This division forms what M. Emmanuel calls "ugly little pieces", impossible to sing accurately, even if we can sing them at all. He says :

"It is difficult to believe that the human voice can commonly permit of such an artificial mechanism. The vocal cords, which every singer possesses, cannot allow an unlimited liberty. I mean : a singer is always liable to sing out of tune and to produce unknowingly intervals smaller than the half-tone. It is his undeniable right, which he often over-uses. But can he, at will and with accuracy, produce intervals (1/3 of tone, 1/4 of tone) without taking the help of the fundamental consonances (fifth, fourth, natural thirds) to build or measure them accurately ?" (Dict. du Conservatoire, Grèce, p. 417).

What the natural thirds are, M. Emmanuel is careful not to say, because they are in goodly number and prove exactly the opposite of his thesis. In particular, the third produced by the fundamental consonances of the fifths is the *ditone* (81/64) and not the natural major third (5/4) which is smaller by one comma. It is the *ditone* that singers without accompaniment will, in many cases, sing most easily, and not the third called natural (5/4). But such inaccuracies do not embarass scholars when they wish to reduce the most ancient of the genera of Greek music to a

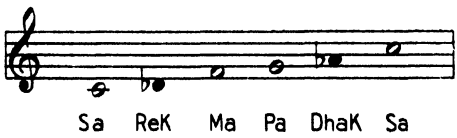
matter of singing out of tune : doubtless, equal temperament has become for them the art of being in tune. The prejudices of scholars are unfathomable, but it might seem preferable for the scholar who shows such prejudices, to refrain from discoursing on a particular art which he shows so little capacity to understand and so much partiality in judging. It would almost seem as though the object of the labour of some of the Western scholars is so completely to disfigure Greek musical art as to be able to declare it absurd.

The enharmonic, says the legend, originated from the *vocal enharmonic* invented by the aulete Olympos.



The enharmonic genus, according to Gevaert, had been obtained by dividing the half-tones to realize a modal scale of seven tones. This conception somewhat disfigures reality because it brings onto the same level sounds whose function is different.

In Hindu music, the *vocal enharmonic* of Olympos, as it is given here, would correspond to the mode "Guṇakalī".



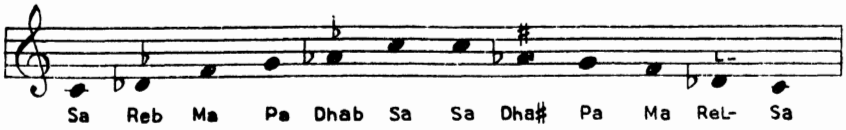
But good musicians, whenever they play or sing a melody in this mode, utilize two distinct notes for the D flat (Re komal)

as well as for the A flat (Dha komal). The one, generally used in ascending, forms, with the starting note, a large half-tone (C $\overset{\flat}{D}\flat$ (Sa Reb) = 27/25) in the lower tetrachord and a major half-tone in the upper one (G $\overset{\flat}{A}\flat$ (Pa Dhab) = 16/15). The large half-tone 27/25, which is bigger by one comma than the major half-tone is an interval unstable but often utilized in the ascending scale to which it gives strength and movement. But, in opposition to it, the flat A (Dha komal) and flat D (Re komal) are, in the descending scale, expressive notes attracted by the fifth and the tonic, their pitch is, therefore, necessarily only a minor half-tone or a limma above them ($\overset{\#}{A}\flat$ G (Dha# Pa) = 25/24 and $\overset{\flat}{D}\flat$ C (ReL– Sa) = 135/128), forming a pathetic interval which necessitates a resolution on the fifth and the tonic respectively.

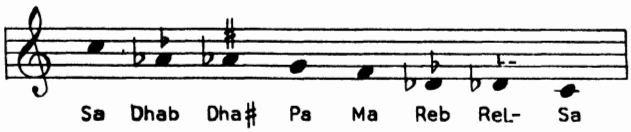
There is nothing illogical in this, and all the subtle expression of the mode comes from that dash towards joy which falls back into melancholy. The affirmation, which, after many others, M. Emmanuel advances, that these intervals cannot be clearly differentiated by the ear, is baseless. We have many times measured these intervals, with the very accurate instruments which are at our disposal, and we have always found a perfect accuracy in their differentiation by singers as well as by instrumantalists. In reality, the expression of these two intervals is so widely different that, once they have been heard and understood, it is impossible to confuse them. We could have agreed with M. Emmanuel if he had been satisfied by saying what he knew, namely, that Western singers have become unable to sing accurate intervals, because Western vocal as well as instrumental technique always tends to the creation of hazy sounds with strong vibrato, the purpose of which is to hide the discord of voices and instruments constant in orchestral music. Unfortunately such a vocal technique diminishes in an equal proportion the intensity of expression and, for this reason, is prohibited in Eastern music. And there is no ground to believe that the case was different with the Greeks. When the voices and the sounds of instruments are freed from vibrato, the differentiation

of intervals becomes clear, and musical education quickly permits them to be recognized and reproduced.

The scale of the mode "Guṇakalī" can be thus expressed in the following manner :



If we bring side by side ascending and descending notes, the scale becomes :



The intervals between the notes are :

C $\overset{\flat}{A}\flat$ (Sa Dhab) = major third 5/4 = 96 savarts

$\overset{\flat}{A}\flat$ $\overset{\sharp}{A}\flat$ (Dhab Dha♯) = two commas $(43/45)^1 = 10$ savarts

$\overset{\sharp}{A}\flat$ G (Dha♯ Pa) = minor half-tone 25/24 = 18 savarts

G F (Pa Ma) = major tone 9/8 = 51 savarts

F $\overset{\flat}{D}\flat$ (Ma Reb) = small major third 100/81 = 92 savarts

$\overset{\flat}{D}\flat$ $\overset{\downarrow}{D}\flat$ (Reb ReL-) = two commas $(46/45)^1 = 10$ savarts

$\overset{\downarrow}{D}\flat$ C (ReL- Sa) = limma 135/128 = 23 savarts.

When we come to consider Hindu scales in detail we shall explain the small difference of the two tetrachords, due to the functional difference between the tonic and the fifth.

In this Hindu mode, we thus find an enharmonic division in accordance with Greek and Arabic definitions which assert that this division is but the division of the tone, according to harmonic intervals, into four unequal parts. This is much more probable and

1. Approximate ratio.

brings us back within the laws of acoustics from which there is no ground to suppose that Greek music ever went astray. As for the idea of cutting temperate tones into four equal parts, it could only have occurred to the minds of Greek physicists who had no musical practice nor accurate instruments, or to modern Westerners who, to these two handicaps, add that of being accustomed to the simplified temperate scale which induces them to forget that there are several kinds of half-tones, utilized in all the non-temperate systems, including Western music. Violinists and singers are usually most surprised if one measures the intervals they are actually using. These often differ widely from those they firmly believe themselves to be reproducing.

Furthermore, it should be remembered that to divide the tone into several intervals does not necessarily mean that one uses intervals smaller than a half-tone, because those divisions are never played in succession but only in relation with other notes. In Hindu music the interval of 'one śruti' is prohibited. Generally one of these "quarter-tones" is utilized in the ascending scale, the other in the descending one, as is the case of Guṇakalī. Even if these two notes are very near to each other, one comma for example, it does not mean that the comma is utilized as a musical interval, but that both the major and the minor tones, whose difference it is, are used.

The same mistake inserts itself into the conception that Europeans have of modal music in general. M. Yekta Bey (Op. cit.) remarks: "When speaking of Oriental music, people always say that it is composed of small intervals. I do not see any reason for that legend because the smallest interval there utilized is the limma whose ratio is 243/256, and no interval smaller than the limma is ever used melodically."

There is no doubt that Greek physicists, showing already a very modern spirit, found it amusing to invent numerous ways of dividing the tetrachords. But, as their calculations were based on the arithmetical properties of number, and not on their metaphysical

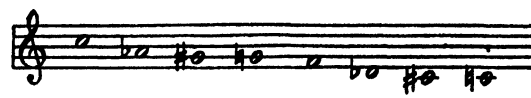
correspondences, they did not bear the test of experience and were never practised because they were impracticable. Victims of the same mistake, the moderns cannot understand Greek music because they stop at these amusing calculations instead of looking for the real modes which necessarily come within the range of acoustically possible intervals.

The enharmonic is not a mode but a genus. The example we gave above shows only one of the numerous modes based on the enharmonic principle which are used by Hindu musicians. Further, many other modes, which apparently belong to other genera, are susceptible to an enharmonic interpretation for certain of their notes. This interpretation allows an intensification of the expression, an increase in the beauty and accuracy of the form. In reality, a careful study will show that every mode is, in practice, of enharmonic structure. In this way the enharmonic scale is truly, as described by the Greeks, the fundamental scale of all music, and corresponds to the Hindu division of the Śrutis, which is the only rational and indisputable basis of music. If the Greeks maintained a division of twenty-four intervals instead of twenty-two it was only because they were keeping, probably for reasons of symetry, the modifications of the tonic and the fifth which are never utilized in modal music and are, therefore, non-existent. In any event, the accurate division by "quarter-tones" was applicable only to one octave, the other octaves being played by ear and by pulling the strings, as is the case to day on the Hindu Vīṇā and Sitār. Aristides Quintilian, in the first century of the Christian era, was also saying: "The first octave develops in twenty-four diesis (quarter-tones), and the second rises by half-tones." This division is still employed in our day by Turkish and Persian musicians in the tuning of the 'ṭunbūr', and the alleged 'quarter-tones' become merely the differences between major and minor tones, major half-tones and limmas.

The enharmonic division, which we have indicated for the Hindu mode "Guṇakalī", is not the only possible enharmonic

division. In the mode "Guṇakalī" the predominant notes (vādi and samvādi) are first the Ab (Dha komal), then the Db (Re komal), the tonic being C (Sa). From the different data it follows that Guṇakalī is a morning mode expressing melancholy. If, however, these characteristics change, we can obtain other modes, the scale remaining apparently the same but the tuning of the different notes being adjusted to their new function. The tuning can, therefore, present slight differences. Without knowledge of the different data which would allow the differentiation of the distinct modes belonging to the enharmonic genus, it is difficult to criticize the measurements given by the Greek physicists, measurements, which, though they do not tally, are not necessarily irreconcilable.

Each tetrachord of the enharmonic genus, containing 8, 1 and 1 diesis, is divided, by different authors, as follows:



		Sa	DhaK	DhaK	Pa	Ma	ReK	ReK	Sa
According to Archytas	5/4, 36/35, and 28/27	·	b	♯	·	·	L+	♯	·
" " Ptolemeus	5/4, 24/23, " 46/45	·	b	++	·	·	L+	++	·
" " Didymus	5/4, 31/30, " 32/31	·	b	¼	·	·	L+	¼	·
" " Boetius	81/64, 499/486, " 512/499	·	L	¼	·	·	L−	¼	·
Raga Gunakali being:									
in the lower tetrachord:	5/4, 46/45 and 24/23					·	b	L-	·
and in the upper tetrachord	100/81, 46/45, 256/243	·	b	♯	·				

If we analyze these ratios in the light of the Hindu theory of the Śrutis, we see that 36/35 (12.23 savarts) and 46/45 (9.55 savarts) belong to the same śruti and are, therefore, approximate expressions of the interval of two commas ($81/80 \times 81/80 = 10.8$ savarts).

28/27 (15.8 savarts) and 24/23 (18.48 savarts) belong to the same śruti, the minor half-tone ($25/24 = 17.73$ savarts). The scale given by Archytas and that noted by us are thus musically, if not arithmetically, identical. That of Ptolemeus inverts the places of the minor half-tone and that of the double comma. It refers to a different scale which we shall meet with also in Hindu music.

The division of Didymus and that of Boetius form, approximately, temperate quarter-tones and are, therefore, purely theoretical.

Divisions like that of the major half-tone into $31/30 \times 32/31 = 16/15$, or that of the limma into $499/486 \times 512/499 = 256/243$, etc., are purely conventional, and indicate only an approximation of the temperate division represented by comparatively simple ratios, while the temperate division itself is incommensurable. It is, therefore, useless to attempt to see in them definite intervals or ratios because their differentiation exists only on paper. This does not mean that, if they were actually realized, such differences of intervals could not produce any effect, particularly as a means of action on the inanimate world (in both cases one is an ascending interval and the other a descending one), but such an effect is beyond the range of music proper and can only, in ordinary cases, be produced by the aid of such mechanical means as the Chinese lyŭ for example. As such means do not appear to have been used by the Greeks, these intervals must be considered as approximations. Ignorance of, these small artifices of calculation leads to endless classifications of intervals deprived of all reality.

This sort of division is the one indicated by the Arabs to find the approximate half of an interval. The method given by al-Fārābī[1] is as follows: establish the ratio between the numbers representative of the two notes forming the interval; multiply by two each one of these numbers, and, taking half the excess of the greater number over the smaller one, add this half to the smaller and subtract it from the greater. The two ratios obtained divide the interval into approximate halves. For example, to find the half of the interval of fourth (4/3), we shall have:

$$4 \times 2 = 8 \qquad 3 \times 2 = 6$$
$$8 - 6 = 2 \qquad 2 : 2 = 1$$
$$6 + 1 = 7 \qquad 8 - 1 = 7.$$

the fourth is thus divided into halves as:

$$8/7 \times 7/6 = 4/3.$$

1. See translation d'Erlanger, p. 97.

In the same way, the major half-tone (16/15) divides into halves as :

$$32/31 \times 31/30 = 16/15,$$

the minor tone (10/9) as : $20/19 \times 19/18 = 10/9$,

the large tone 8/7 as : $16/15 \times 15/14 = 8/7$, etc..

This method has not, so far as we are aware, been explained in those Greek texts still available although it has obviously been utilized by them. Whenever we meet with a division of this form, we should remember that it stands for an equal division, and by no means for two different intervals.

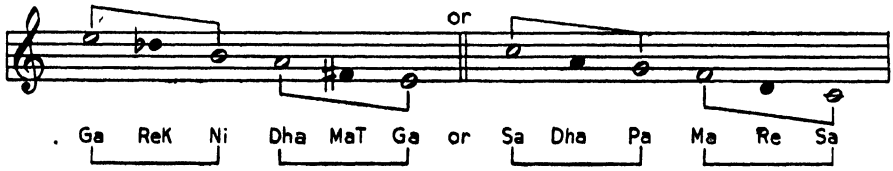
The Chromatic.

In the Chromatic genus, each tetrachord contains a minor third ; the remaining tone being usually divided into two half-tones. This division was, according to the musicians, of 6, 3 and 1 diesis in each tetrachord, but was simplified by the physicists into 6, 2 and 2 diesis. To understand these divisions we have to be familiar with the conception of śrutis (diesis), which can in no case be considered as equal mathematical intervals. An interval of one śruti implies, in the present case, only the smallest interval melodically possible above the lowest note of the tetrachord. This interval is generally of one limma (23 savarts) in relation to the tonic, and of a minor half-tone ($25/24 = 18$ savarts) in relation to the fifth. The interval of two śrutis, indicated by the physicists for reasons of symetry, supposing that it were to correspond to a musical reality, could only indicate an interval bigger than the limma by one or two commas, like the major half-tone ($16/15 = 28$ savarts) for example. It can never represent a double interval, such as the minor tone (2 limmas) which is equal to three śrutis or diesis.

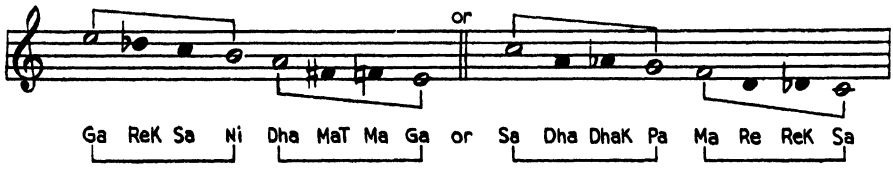
While the enharmonic division of the octave is fundamentally based upon a scale of five notes, the chromatic division contains, normally, seven sounds, and, if some of its notes lend themselves to the refinements of the enharmonic, these will give supplementary

sounds added to the other notes. Just as the enharmonic was taken as the typical basis for the division into twenty-four diesis (or twenty-two śrutis), the chromatic will, quite naturally, be representative of the division of the octave into twelve half-tones, and the diatonic represent the division into seven sounds. But we should be careful not to take literally such classifications, more theoretical than practical. There is, in reality, no discontinuity between the different genera and almost every mode or scale could be taken as a basis for the establishment of the three fundamental divisions of the octave into twenty-two, twelve and seven intervals.

Each tetrachord of the chromatic genus is thus divided into a minor third and one tone (or two half-tones), as, for example :



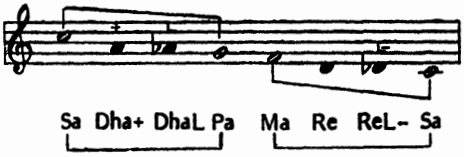
This is the Hindu rāga Durgā. But, if the tone is divided into two half-tones, this scale becomes :



of which we get the following definitions :

The *Chromatic of the physicians* **or** *vulgar chromatic* **gives, in each tetrachord, the intervals :**

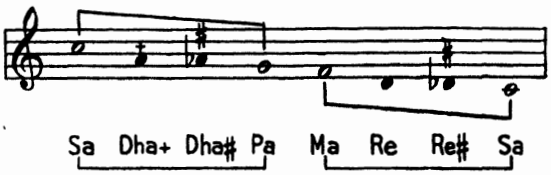
32/27 (trihemitone = 74 savarts), 2187/2048 (apotome = 28 savarts), and 256/243 (limma = 23 savarts). This, in our notations, gives the scale :



The two tetrachords are separated by a major tone 9/8.

The Chromatic of the musicians gives, in each tetrachord, the intervals 32/27, 243/224 and 28/27.

248/224 (35.36 savarts) can be identified with the large half-tone (27/25 = 33.42 savarts), one comma larger than the major half-tone, and 28/27 (15.3 savarts) belongs to the same śruti as the minor half-tone (25/24 = 17.73 savarts). The tuning is therefore :

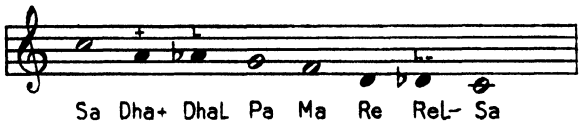


In the *vulgar chromatic*, the interval C A+(Sa Dha+) is a trihemitone (major tone + limma = 32/27). In the *softened chromatic*, C A (Sa Dha) is a minor third (major tone + major half-tone = 6/5), therefore one comma larger than in the vulgar chromatic.

The tone G A+(Pa Dha+) was, in the *vulgar chromatic*, a major tone (9/8). G A (Pa Dha), in the *softened chromatic*, becomes a minor tone.

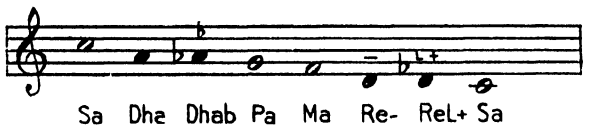
This minor tone is divided, according to Didymus, into a major half-tone and a minor half-tone (16/15 × 25/24 = 10/9), but, according to Eratosthenes, it is 19/18 × 20/19 = 10/9 which stands for an equal division, and is called by the Arabs *weak chromatic*. According to Ptolemeus, the minor tone is divided as : 5/14 × 28/27 = 10/9. This is yet another scale, and called by the Arabs *strong chromatic*.

The *vulgar chromatic* being given as :—

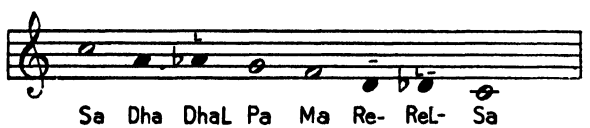


The *softened chromatic* will be :—

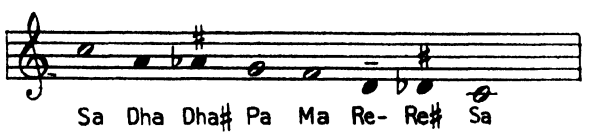
1° according to Didymus, 6/5, 25/24, 16/15,



2° according to Eratosthenes, 6/5, 19/18, 20/19, (called by the Arabs *weak chromatic*),



3° according to Ptolemeus, 6/5, 15/14, 28/27, (called by the Arabs *strong chromatic*),



We can easily see that, in the division of Didymus, (minor third, minor half-tone and major half-tone), and in that of Ptolemeus (minor third, major half-tone and minor half-tone), the order of the

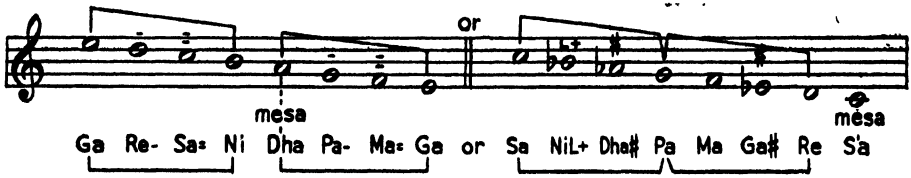
the second and the sixth notes one diesis lower than the physicists wished them to be; this gives in each tetrachord,

4, 5 and 1

which, according to Archytas, are equivalent to the ratios :

9/8	8/7	and	28/27
major tone	large major tone		small minor half-tone

that is :



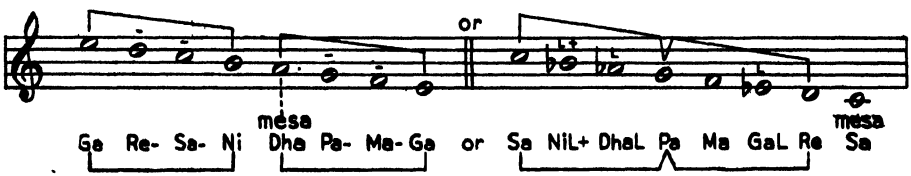
while physicists were asking for :

4, 4 and 2

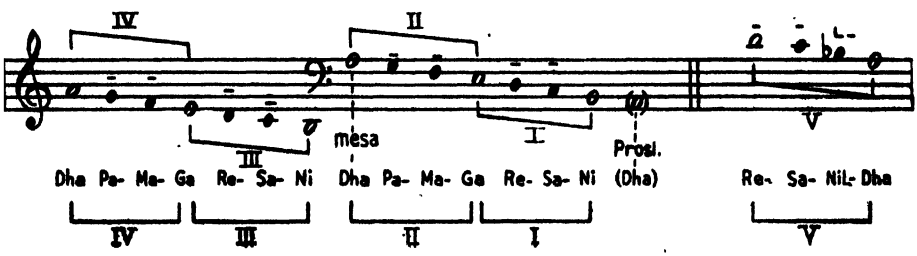
equivalent to the ratios :

9/8	9/8	256/243
major tone	major tone	limma

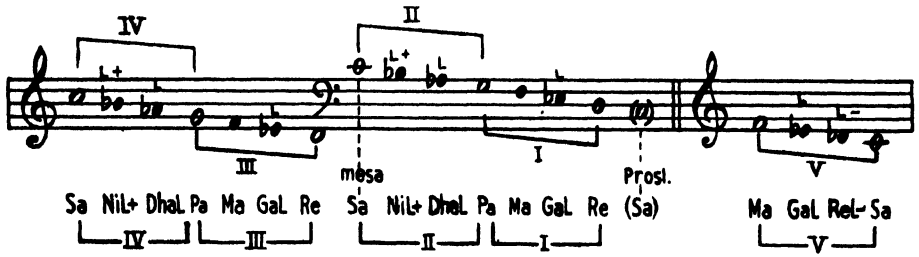
that is :



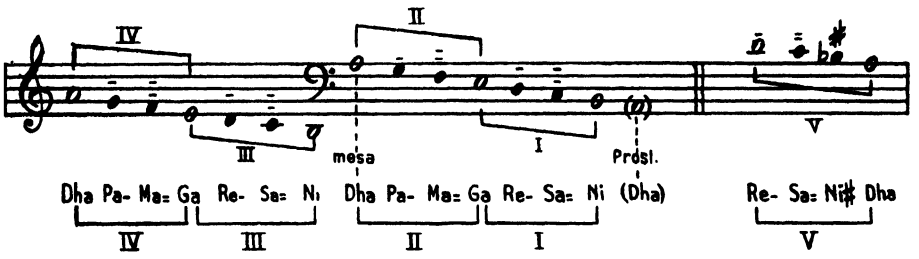
So that the great perfect system of the physicists :



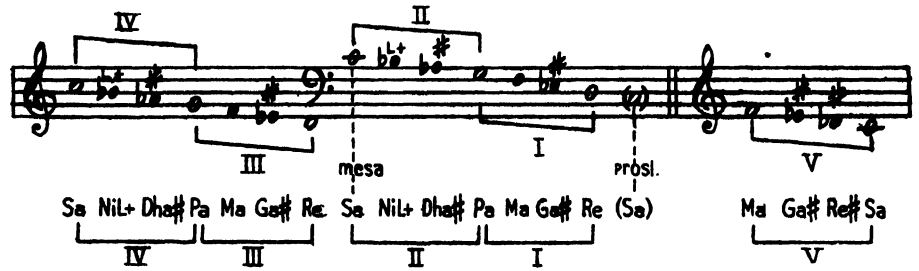
or :



even in the fundamental Dorian mode, was, in reality, tuned:



or :

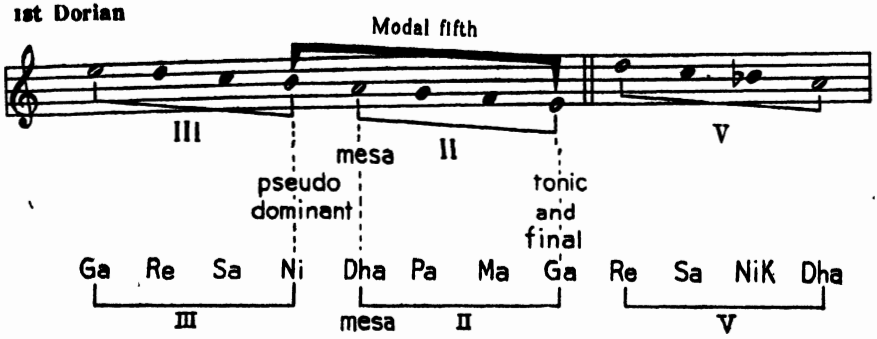


In other modes the differences were still more striking.

Dorian harmonies.

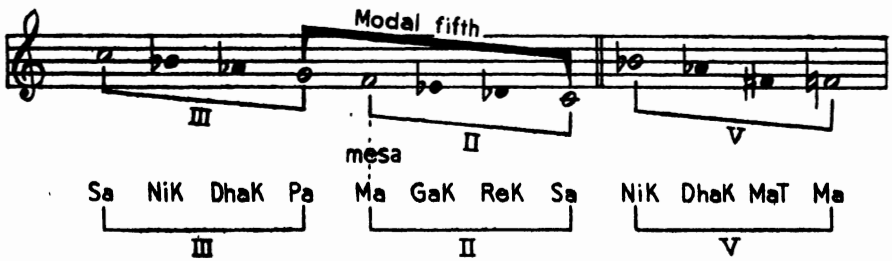
In Greek music, the general tonic was in the middle of the scale, a fact rather troublesome to modern minds and difficult to understand. But the lowest note was also, in many cases, taken as tonic, just as is the general practice today. This led to the division of the Dorian mode, which corresponds, in the great perfect system (white keys of piano and organ), to the octave E to E (Ga to upper Ga), into two distinct modes.

The first Dorian has for its tonic, fundamental and final the lowest note : the E (Ga).



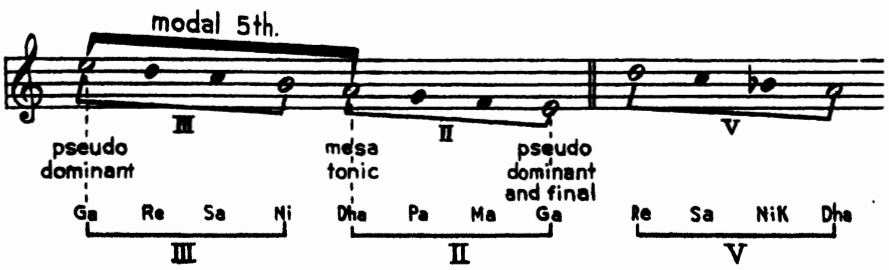
It corresponds to what the Hindus call Sa grāma, the scale having the Madhyama (mesa), the modern tonic, as its fourth note.

If we transpose it into the Hypodorian tone (mesa F (Ma)), whose tonic is C (Sa), the first Dorian is written like the Hindu scale Ṣhaṭ :



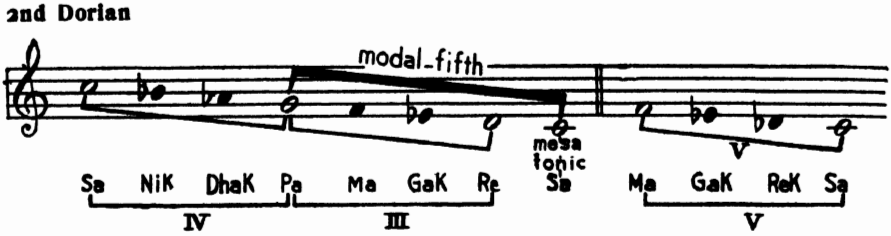
In the second Dorian, the mesa is at the same time the fundamental and the tonic :

2nd Dorian

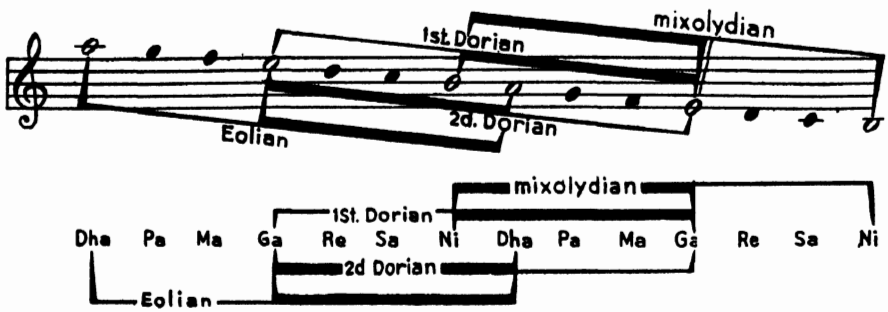


This corresponds to what Hindu treatises call Ma grāma, that is, a scale in which the mesa (Madhyama) is tonic and fundamental.

If, considering the mesa as true tonic, we start the scale from it, and then transpose the second Dorian into the Phrygian tone (mesa C (Sa)), we obtain the familiar Hindu scale Yavanpūrī Toḍī (Eolian mode). By adding the conjointed tetrachord (V) this scale is changed into that of Bhairavī.



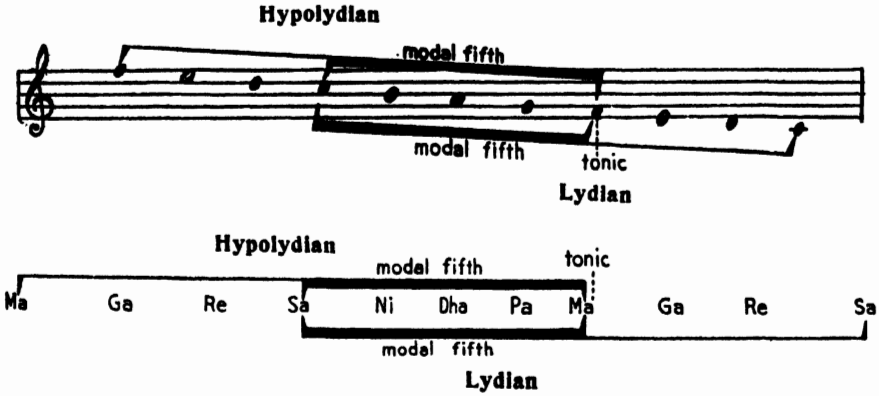
Take again the great perfect system :



We can here see that on the fixed degrees (the body of harmony) we can establish two other modes, the Eolian and the Mixolydian which, with the two Dorians, complete the group of Dorian harmonies.

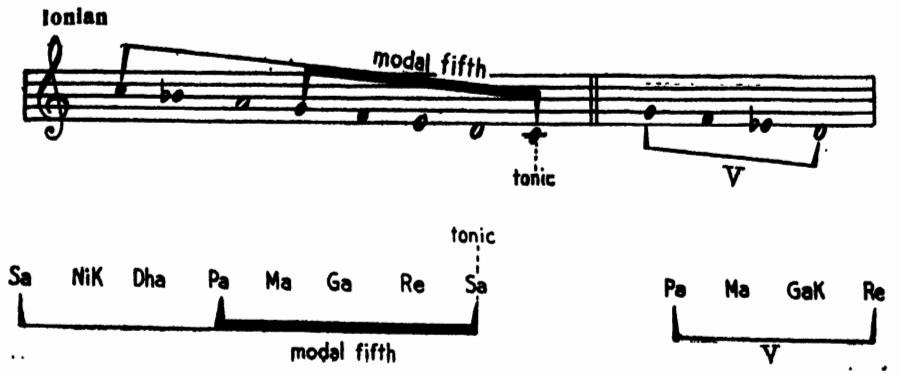
Corresponding to the octave A to A (Dha to upper Dha), the Eolian mode has the same modal fifth as the second Dorian, but develops into the highest tetrachord.

The first belongs to the category of the Ma grāma, the second to that of the Sa grāma.



The Greeks considered the Ma grāma (tonic on the fourth) as the basic system. They expressed the relation from the Sa to the Ma grāma by the prefix "Hypo" which indicates the relation of two modes having the same modal fifth but complementing the octave either downwards (normal mode) or upwards (sub-mode = Hypo). This conception may be the origin of the classification of authentic and plagal modes in Gregorian music. Thus the Ionian mode was also called Hypophrygian and the Eolian mode Hypodorian. Alone, the first Dorian, probably because of its national character, remained free from this nominal servitude in regard to the Mixolydian which also kept its ancient name.

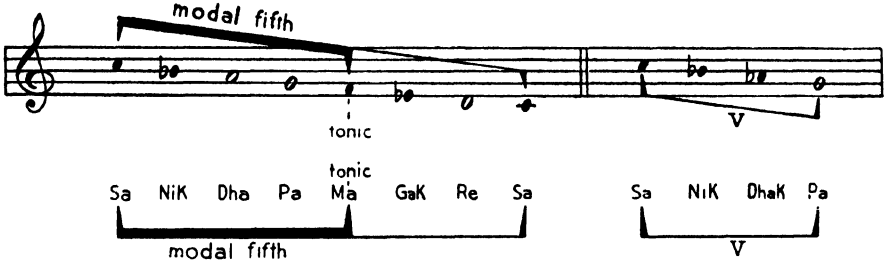
Transposed into the Hypodorian tone, the Ionian mode becomes :



Without the conjointed tetrachord this would be the scale of Chhāyānaṭa, and, with the conjointed tetrachord, that of Jayjavantī.

The Phrygian mode can be expressed by the same scale continued downwards, or by :

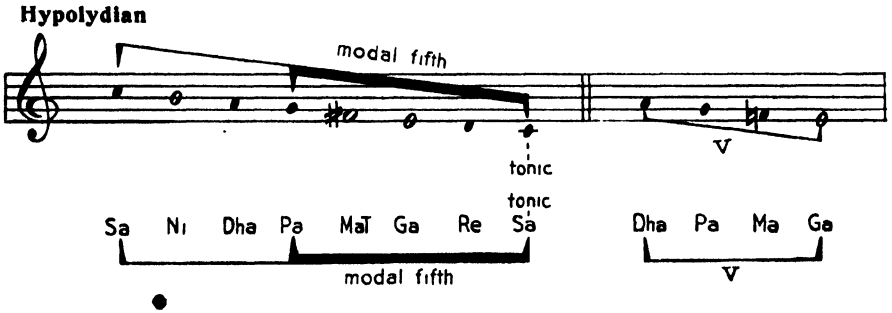
Phrygian



Without the conjointed tetrachord, it resembles the scale of the Hindu mode Kāfī.

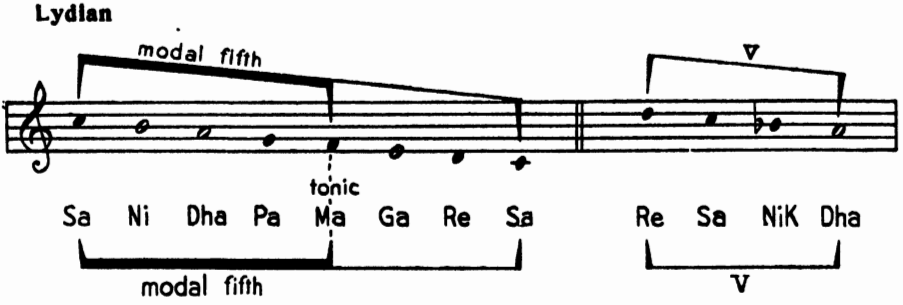
Similarly the Hypolydian mode, transposed into the Hypodorian tone, (tonic C (Sa)) becomes :

Hypolydian



Without the conjointed tetrachord, it is the scale of the Hindu mode Yaman, and with the conjointed tetrachord, that of Gaur Sārang.

The Lydian mode remains :



Without the conjointed tetrachord, it resembles the scale of Naṭa, and, with the conjointed tetrachord, that of Khammāj.

In the great perfect system, the notes C and D (Sa and Re) are never used as fundamental. The only scales starting from C (Sa) and D (Re) are those of the Phrygian and Lydian which both have their tonic on their fourth note, respectively F and G (Ma and Pa).

It is very interesting to note that those essential modes of modern music, the major mode of C (Sa) and the minor mode of D (Re), were considered as unpleasant and were forbidden by the Greeks and probably all peoples of ancient times ; and, although they were classified by the Hindus, they were not given any prominence by them until very recent times. M. Emmanuel remarks[1] :

"The modes of D (Re) and C (Sa) had been banished from the Greek musical language . . . . . There was among the Greeks and their successors, the primitive *Cantores* of the Christian Church, a sort of repulsion for the modes D A D (Re Dha Re) and C G C (Sa Pa Sa). We shall note that our major mode is among the two proscribed ones ; it was later to take its revenge. As for the modern pseudo minor . . . . . it will come out from the D A D (Re Dha Re) scale."

1. Grèce, Dictionnaire du Conservatoire, p. 444.

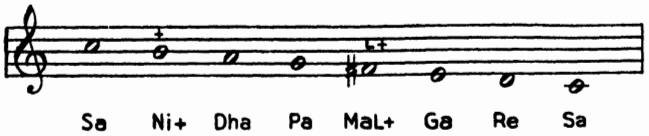
We can find here a remarkable confirmation of the theory by which it is stated that, the fundamental modes being connected with the cosmic developments of the cycle, only those modes which are related to the cosmic condition of a certain period appear natural during that period. In India, as in Europe, the ancient Dorian mode (Bhairavi), the mode of E (Ga), has slowly given place, as basic scale, to the mode of D (Re), Kāfī, only to be, in turn, replaced by the mode of C (Sa), Bilāval.

When we study in greater detail the significance of the notes according to Hindu theory, we shall understand why the major mode was formerly rejected. We shall see that its intervals express materialism, sensual egotism, hardness and other qualities which could not be given a dominant place in Art so long as it was subordinate to considerations of an intellectual and spiritual order.

When we want to pass from the abstract theory of the great perfect system to musical practice, we immediately notice the discrepancy. All these modes were, in reality, in use before their classification was made, and this way of bringing different modes within the frame of one scale, however clever it may be, does not really, nor in fact can it ever, fully correspond to the reality of modal systems. Therefore, the tuning of the notes in the general scale corresponds only approximately to the actual tuning for each mode. The tuning of all the notes in a mode, is done in relation to the tonic of that mode, and any note cannot arbitrarily be chosen as fundamental; or, if this be done, the modes so obtained can only be pseudo modes which, although they may outwardly appear as different modes, are only plagal forms of the original scale.

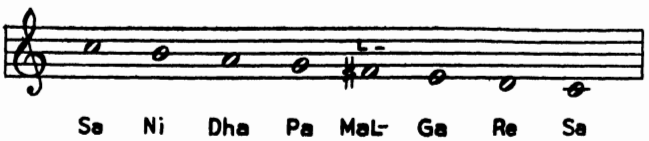
For any of these pseudo modes to become a real mode, it would be necessary to adjust the tuning of each note so as to establish, with the new tonic, the ratios which would justify this function. At first sight the notes might appear the same, but, in reality they present differences of one or two commas. This changes their expression and allows for the establishment of logical ratios.

For example, the Hypolydian mode, conceived as plagal mode of the Dorian, would be expressed as:



But the Hypolydian mode was actually played by musicians with differences in the tuning which made of the C (Sa) the real tonic, while the tonic remains here acoustically the B (Ni), tonic of the Dorian mode from which, according to this classification, the Hypolydian mode is born.

Its real tuning was probably that of the Hindu Yaman rāga:



We shall meet with similar adjustments of tuning also in Western music every time we pass from the cyclic system upon, which all modulations and transposition depend, to the modal system, which rules chords and modes, since it is the modal system which allows the establishment of harmonic ratios in relation to a basic sound. Disregard of these differences leads inevitably to the dead end of temperament, as had been foreseen by Aristoxenes, because in temperament, chord and modulation being equally wrong, at least neither can be said to have been sacrificed to the other.

The classification of modes, as well as the interesting divisions used by Greek physicists, as they have been presented by Western scholars, seem bound to remain mere abstractions, amusing mental gymnastics. They do not correspond to any acoustic system nor to a definite metaphysical system, but rather seem a play upon the arithmetical properties of numbers: a game to which modern scientists are also prone. It by no means follows that

Greek music was not as marvellous as has been described, but explanation for this is not to be found in the calculations of physicists.

All the intervals utilized in musical practice are necessarily based upon those simple acoustic intervals which can be sung easily, can be recognized by the ear, and represent definite and different expressions: expressions which can be determined with the help of the Hindu division of the śrutis. Therefore, when the Arab Hellenists assert that the intervals used by the Greeks were the minor tone, the limma and the apotome, the which intervals allow of the division of the major tone into four unequal intervals, it is highly probable that they are right.

The Fifteen tones of Transposition.

In Greek music, it is very important not to mistake modal scales (mūrchhanās) for tones (pitches of tonic), as Boetius himself so awkwardly did.

The tones are only a system of transposition, similar to the modern Western system, by which any mode can be brought to a pitch easily practicable for singers or instruments.

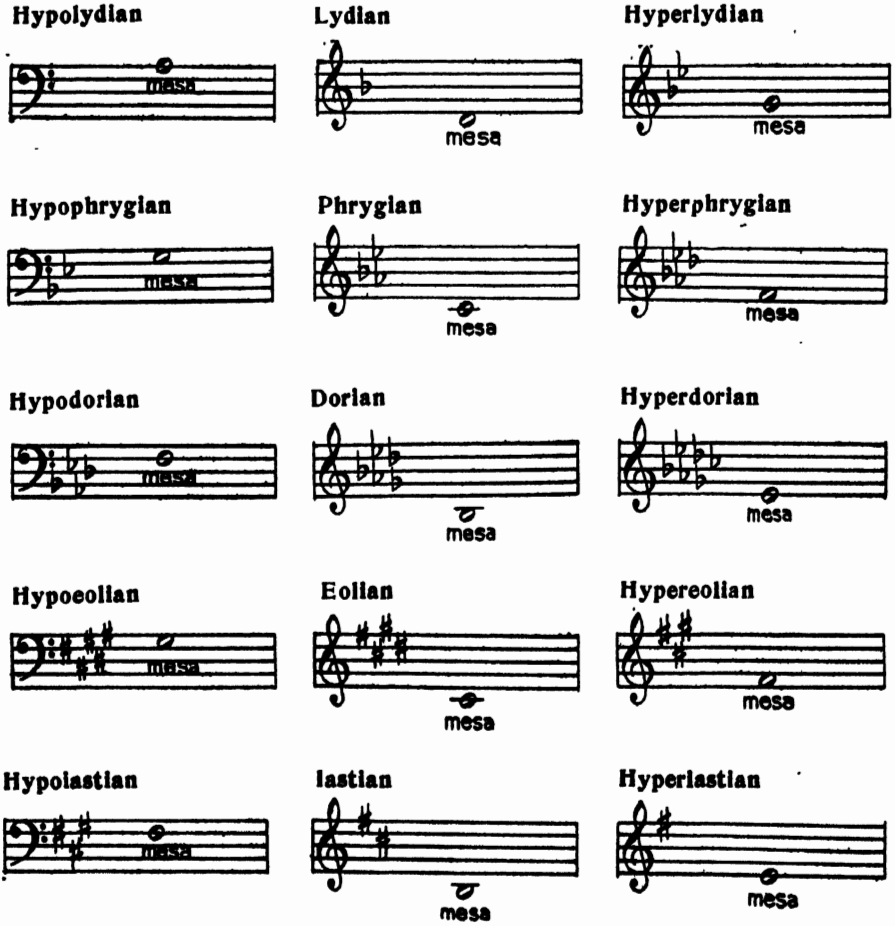
The tones are classified according to the respective pitches of the mesa. The fundamental tone being the Hypolydian, whose mesa is the A (Dha) of the Greek unaltered scale, its exact pitch would be, according to the modern Western diapason, F sharp (Ma tīvra), approximately Ga of the usual Hindu diapason.

Here is the list of the different tones:

In the	Hyper-lydian	tone the mesa is the higher	G	(Pa)
„	Hyper-eolian	„ „	F sharp	(Ma tīvra)
„	Hyper-phrygian	„ „	F	(Ma)
„	Hyper-iastian	„ „	E	(Ga)
„	Hyper-dorian	„ „	E flat	(Ga komal)
„	Lydian	„ „	D	(Re)
„	Eolian	„ „	D flat	(Re komal)

In the	Phrygian	tone the	mesa is the	higher	C (Sa)
„	Iastian	„	„	medium	B (Ni)
„	Dorian	„	„		B flat (Ni komal)
„	Hypo-lydian	„	„		A (Dha)
„	Hypo-eolian	„	„		A flat (Dha komal)
„	Hypo-phrygian	„	„		G (Pa)
„	Hypo-iastian	„	„		F sharp (Ma tīvra)
„	Hypo-dorian	„	„		F (Ma)

Thus the armatures for the Dorian mode in the diatonic genus, according to pitch, are :



SEVENTH PART

THE WESTERN SCALE AND EQUAL TEMPERAMENT.

UT *queant laxis* RE*sonare fibris*
MI*ra gestorum* FA*muli tuorum*
SOL*ve polluti* LA*bii reatum*
Sancte Iohannes.

(Hymn to Saint John the Baptist)

SEVENTH PART

THE WESTERN SCALE AND EQUAL TEMPERAMENT.

Western Music.[1]

THE Western musical system has been formed by a mixture of various traditions which, because of complete confusion in the theoretical definitions, were brought together in a rather haphazard way. The resulting system is cyclic, changing constantly its tonic (modulations); but, on each tonic, and on each note of the scales based on these tonics, the establishment of chords, or harmony, depends upon the modal system, since the different notes of a chord take their meaning only from their relation to the fundamental note of the chord. This system would have had every advantage had it not been based upon a fundamental confusion. The notes which form consonant chords are not the same as the notes required for modulation (changes of tonic).

As long as music was kept within certain limits of simplicity, musicians could, even in an orchestra, adjust by instinct each note to the successive necessities of harmony and modulation. But such adaptations, if they are not accurately done, render the expression hazy and confused, and this compelled composers to complicate the structure of chords in an attempt to render their meaning more definite. But this finally resulted only in more confusion. It would have been sufficient to play the simpler chords accurately for their meaning to become clear and attractive. Added to this,

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1. Only scales and modes come within the scope of this book. As these are extremely simplified to day in the West, modern Western music will have but a very small place in this work. The modal division of the scale as applied to the study of the significance of chords will not be dealt with here, but will be the subject of a further study.

the generalization of equal temperament, by simplifying musical structures to an absurd degree, has led people completely to forget the most elementary acoustic realities and, by distorting all the intervals, has rendered the signification of chords vague and unclear. It is generally said that the ear does recognize a true relation through the temperate relation. This is a fact, but each ear makes a different adaptation according to individual tendencies, and the same chord may have for different people, or according to mood, different significations; the meaning of an accurate chord, on the other hand, is determined absolutely and perceived by all.

The result is that, more and more, Westerners have lost all conception of a music able to express clearly the highest ideas and feelings; they now expect from music mostly a confused noise, more or less agreeable, but able to arouse in the audience only the most ordinary sensations and simplified images. This is a complete misconception of the true rôle of music, "because music, whose movements are of the same kind as the regular revolutions of our soul, does not appear, to the man who has an intelligent intercourse with the Muses, to be good merely to give a physical pleasure, as seems to be the case in our days. On the contrary, the Muses have given music to us as an ally of our soul in its attempt to bring back order and harmony into those periodic movements which had become disorderly in us." (Plato, Timaeos).

But who in modern times tries for an intelligent intercourse with the Muses ? People try only for technical progress which allows virtuosity, and for extravagant theories which make their authors famous.

"Zarlino, to whom we owe the theoretical principles on which our modern theory rests, ... though he well knew the legitimate proportions which should be those of diatonic, chromatic and enharmonic tones, and although he recognized that it is these proportions which are given by nature and science, by Pythagoras and Plato, nevertheless, following Ptolemaeus, created a series of

artificial ratios and wrong intonations, to conform himself, he said, to the march of counter-point which necessitates them. Thus, according to him, *harmony is only made possible by the violation of the principles of harmony,*[1] and one cannot form chords without making voices and instruments discordant . . . . . Salinas, ... who otherwise fights Zarlino, ... agrees with him on this point and sincerely believes, like him, that one must abandon the accuracy of sounds in order to build a simultaneous harmony . . . . . The Italian authors . . . . . adopted the artificial proportions of this theorist although they all recognized them to be wrong. The famous Rameau in France, and Martini in Italy had only one aim, ... that is, to find a basis for those proportions which they believed to be a necessity of harmony." (Fabre d'Olivet, La musique expliquée comme Science et comme Art, p. 41.)

It is often proudly asserted that the actual Western musical system is sufficient to express everything, but the slightest true contact with other musical systems proves immediately the contrary. The power of evocation of the harmonic system, as it is conceived today, is weak and confused if compared with any modal system. It oscillates between abstractions and extremely conventional imitative harmonies; because what is called an imitation of a bird, the wind, the rain, a fountain, a factory, or any other much utilized subject, is, in reality, so far away from the model that a deep knowledge of musical conventions is required to be able to see the connection. Such conventions can become so familiar that one believes them to be realities and derives from them real pleasure; but any one unfamiliar with them could never guess what it is all about. The idea of representing natural phenomena, or the movements of things and beings, by imitating the noises they may make, appears to the Oriental childish, and is really a "primitive" conception, in the sense which is now-a-days given to this word. It is not the noise or the external appearance of things, but their essence, that

1. Our italics.

the relations of sounds should be able to express. And it is the knowledge of those subtle relations which has always been considered, in the East, as the basis and the true object of Art. It is because of those relations that the effect of music can be so deep and directly perceptible without requiring any conventions or taxing the imagination of hearers. For example, when the Hindu mode of the rains, Megh-Mallar, is played, no sound will attempt to imitate the noise of rain drops or of thunder, but the relations between the sounds will be so similar to those between the elements when a storm is approaching, that not only trained musicians, but animals even, will inevitably feel the rain in the air.

Modern Western music was able to develop its polyphonic system only by deliberately sacrificing the greater part of its possibilities and breaking the ties which connected it with other musical systems. Formerly, all the musical systems were near to each other and, in spite of differences, could generally be understood from one country to another; this can be clearly seen in the success that the musicians who came with the Turkish Empress had in China, in that of some Negro musicians in the Mussalman world during the first centuries of Islam, or in that of Gypsies in Europe. But since the middle ages, there has been, in the West, a tendency to accept those simplifications of the theory which had already been rejected everywhere else as being incompatible with a refined form of Art. Therefore, when, in the words of M. Amédée Gastoué,[1] "Guido d'Arezzo [990-1040], having reduced everything to the diatonic, and given the last blow to the quarter-tones inherited from Greek melody, directs our scale towards temperament and facilitates the progress of polyphony", d'Arezzo, in reality, only gives a blow to all popular forms of music whose very complex modal and rythmic forms will give place to an official art, heavy and simplified.

1. Dict. Conserv., Moyen-age, p. 559.

Fabre d'Olivet explains that "the voices compelled by certain instruments — and particularly those used in musical education such as the piano, the harpsichord the harp or the guitar — to follow artificial intonations, in turn compel all the other instruments which accompany them to take those intervals in the same way, so as not to be out of tune; from this it results, that our diatonic genus is sometimes correct and sometimes incorrect, that our chromatic is always incorrect and that we have no enharmonic genus. We must admit that if, as has been suggested by Zarlino, Salinas and Martini, and as Rameau believed, it is to have some sort of harmony that we have adopted such a system, our harmony surely does not deserve the name, and it would have been better to keep its Gothic name of counter-point; we must also realize that our symphonists have no reason to be astonished if their modern music does not produce the effects of ancient music, since they do not hesitate to trespass in this way against the true laws of nature and to corrupt the sensitiveness of the ear to the point of habituating this organ to receive three wrong sounds out of the diatonic seven, never to hear a correct chromatic sound, and completely to ignore the charms of the enharmonic genus. Had the Greeks had a musical system similar to ours, I would find it difficult to believe in the marvels of which they were proud, because I should see a definite contradiction between the weakness of the cause and the strength of the effect." (La musique expliquée comme Science et comme Art, p. 42.)

Following such deformations, the Western musical language finds itself artificially aloof from acoustic realities and from the laws on which are based the metaphysical correspondences of sounds, a fact which renders it incomprehensible to other people. Therefore, when, compelled by circumstances, people like the American Negroes or the Malays are made to adopt the Western musical system, they quickly transform it, so that it is brought back into logical modal forms. This is why their songs, though usually very simple, have such an emotional quality and appeal.

The Modes of Plain-Chant.

Very little is known to-day about the modal forms used in Europe during the Middle Ages. There remain very few documents and no means of comparison with actually existing modal systems. In the Middle Ages, the musical systems were not isolated from each other as they later became. It seems, for example, that, in Spain, when Alphonso X the Wise introduced the teaching of music into the University of Salamanca, points of comparison were numerous between Christian art as codified by Saint Ambrosius and Saint Gregory, ancient art as explained by Boetius, and Arab art as defined by Avicenna in conformity with Greek tradition. The reforms of Guido d'Arezzo had not as yet ruined popular art and that rich musical folk-lore which the troubadours were hawking from one end of Europe to the other, and of which few people now realize the importance, the richness and the beauty. In our times traces of it are rare and have never been studied by a musician having sufficient knowledge of modal music. It is mostly in the Nordic countries that some remnant of this "pre-harmonic" art of the West has survived, and the transcriptions attempted by Grieg, imperfect as they are, can give us at least an idea of this powerful and vigorous art now almost lost.

The only trace of mediaeval music which has kept some vitality in the West is the religious music called plain-chant codified by Saint Gregory, and which, although extremely simplified, has kept, to our day, a system similar to that of the Greek Doristi (the Dorian modes and its plagal forms). The main difference is that the modes develop upwards instead of downwards and that the fundamental of the first tone is the seventh of the Doriar mode, the D (Re), (we have seen that the Dorian mode was the mode of E (Ga)). The conjointed tetrachord, which contains an augmented fourth, having become an integral part of some of the modes, we may often get an idea of what the practice of Greek modes was more easily from the simplified Gregorian modes than

from the theory of the Doristi which was made too abstract by a desire for symetry.

Imported from the East by Gregory the Great (540 – 604), who, on return from his post of ambassador in Constantinople, codified them in his famous Antiphonary, the eight modes of plain-chant are a transcription of Byzantine modes similar to the eight modes in which the Patriarch Severus of Antioch had already, in the fourth century, published tropes. Unfortunately, during their journey to Rome, these modes had lost the essential element of their differentiation, namely the measuring element, the pedal of the tonic, the Byzantine "Ison", essential element of all modal music, in relation to which each tone and the expression of each note is defined. These melodies are thus devoid of a basis and have a character ill-defined and an absence of expressiveness rather peculiar. Besides, their classification is as arbitrary as it is incomplete, because it has, as its principle, the permutation of the tonic, inspired of the Greek Doristi, a system which, being based on the peculiar concordance of certain modes, can be utilized as a means of classification, but can in no way be considered as the basis of modal structure. This is why the modes of plain-chant do not represent the system of metaphysical correspondences that Saint Gregory thought he had rediscovered. Therefore Dante wrote that Saint Gregory "laughed at himself when he opened his eyes in heaven," and rejected the classification given by him. Saint Gregory had not at all understood the basis of the system he pretended to adopt. He was a violent enemy of pre-Christian culture and whenever he could get hold of ancient books he had them burned; this was obviously not the best way to understand them. The modifications he brought into the modes and the substitution of heptachords for tetrachords are not justifiable and serve no purpose.

Although, on account of these deformations and of the lack of certain elements, they are deprived of their true expression, the Gregorian modes are, nevertheless, by their structure, real modes and, because of this, keep a certain appearance by which their use

is ruled. Formerly this use was strictly regulated and the mixture of modes considered a sin. This is why, "in spite of the permission given by King Louis the ninth to form an Academy of music, the Parliament of Paris had it closed on the ground that musicians did not observe the ecclesiastical rules and were passing too frequently from one mode or one genus to another."[1] At the time of the reformation, Luther was still keeping the custom and saying: "Christ is a gentle Lord and His words are lovely; therefore let us take the sixth tone for the gospel: and since St. Paul is a grave Apostle, we will set the Epistle to the eighth tone."

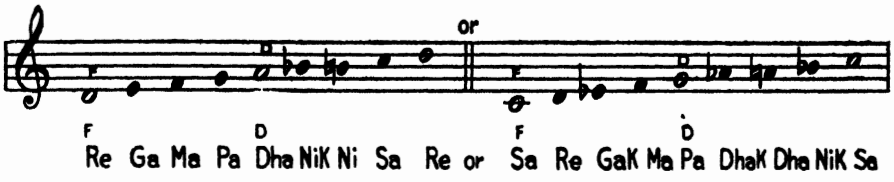
The Gregorian modes being still in use, it is easy to verify their definitions, (contrary to the case of Greek modes), and, therefore, easy to compare them with Hindu modes. When the definitions of Greek modes appear to us sufficiently clear, we shall, with all reserve, indicate their correspondences with the modes of plain-chant without taking into consideration the erroneous mediaeval equivalences due to the confusion made by Boetius between modes and tones.

The Eight Gregorian Modes.

(four authentic, four plagal)[2]

First mode (authentic)

(Śuddha Ṣaḍja mūrchhanā) (Phrygian)

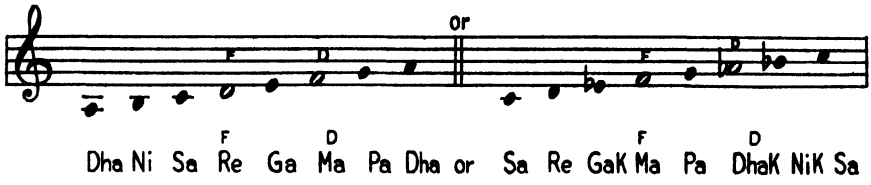


1. Fabre d'Olivet La musique expliquée comme Science et comme Art, p 87.

2. F means final, and D dominant (Vādī).

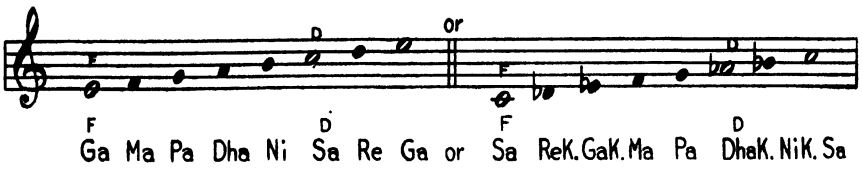
Second mode (plagal)

(Yavanpurī Toḍī)



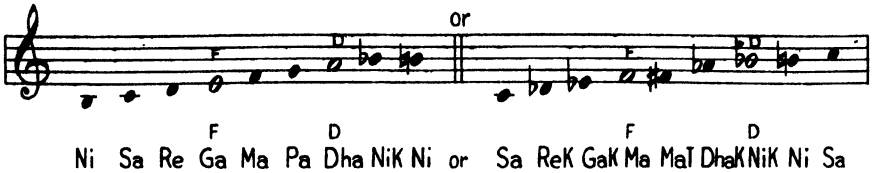
Third mode (authentic)

(Bhairavī) (first Dorian)



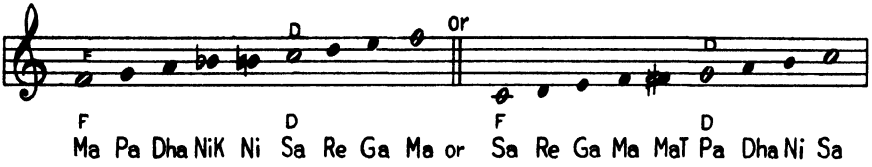
Fourth mode (plagal)

(Aśvakrāntā mūrchhanā) (first Dorian)



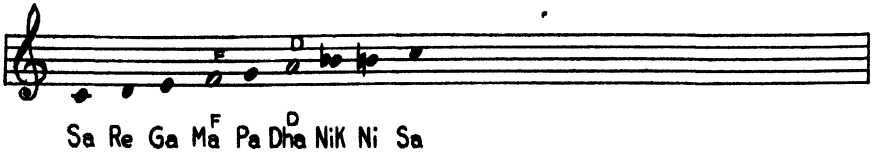
Fifth mode (authentic)

(Gaur-Sārang) (Hypolydian)



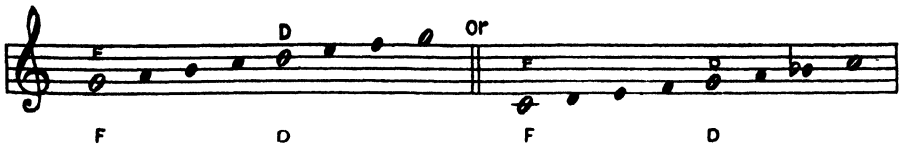
Sixth mode (plagal)

(Khammāj)



Seventh mode (authentic)

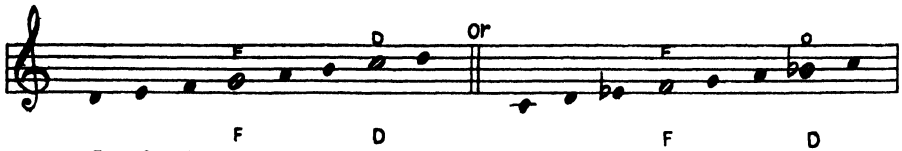
(Matsarīkṛta mūrchhanā)



Pa Dha Ni Sa Re Ga Ma Pa or Sa Re Ga Ma Pa Dha NiK Sa

Eighth mode (plagal)

(Kāfī) (Phrygian)



Re Ga Ma Pa Dha Ni Sa Re or Sa Re GaK Ma Pa Dha NiK Sa

The first and the eighth modes are forms of the Phrygian mode, the third and the fourth are forms of the first Dorian, the fifth mode is a form of Hypolydian, the sixth and the seventh modes belong to the group Hypophrygian-Ionian-Hyperlydian.

The scale of Zarlino.

After numerous changes, mostly due to the attempts of theorists to adapt an incomplete and ill-understood Greek theory to an altogether different musical practice, the scale which was to be the basis of Western modern music was finally established by the Italian Zarlino (1540-1594) on the ruins of popular music.

"What are, according to the generally accepted theory of Zarlino, the elements of our modern system ?" asks Fabre d'Olivet.[1] And he answers : "On seven diatonic sounds, *C*, *D*, *E*, *F*, *G*, *A*, *B*, (Sa, Re, Ga, Ma, Pa, Dha, Ni), three, *C*, *F*, *G*, (Sa, Ma, Pa) are correct : one D (Re) is alternatively correct and incorrect, being con-

1. La musique expliquée comme Science et comme Art. p. 41.

sidered either as *fifth* of G (Pa) or *sixth* of F (Ma), and three, *E*, *A*, *B*, (Ga, Dha, Ni,), are completely wrong.

These seven diatonic sounds give fourteen chromatic sounds, since they can all be altered into sharps (tīvra) and flats (komal). But these fourteen chromatic sounds are all without exception wrong. As for the enharmonic sounds, they simply do not exist."

Zarlino takes the first five notes of the scale of fifths : C (Sa) = 1, D (Re) = 9/8, E + (Ga+) = 81/64, G (Pa) = 3/2, A+ (Dha+) = 27/16, which he reduces to the nearest form of relations to the tonic. That is :

C (Sa) = 1, D (Re) = 9/8, E (Ga) = 5/4, G (Pa) = 3/2, A (Dha) = 5/3, C (Sa) = 2.

To these are added the two accessory degrees F (Ma) = 4/3 lower fifth of the C (Sa), and B (Ni) = 15/8 lower fifth of the E (Ga). In the very elaboration of the scale, we are already changing from an ascending cyclic structure to a descending modal one. This gives us the scale known by the name of Zarlino :

	(Sa)	(Re)	(Ga)	(Ma)	(Pa)	(Dha)	(Ni)	(Sa)
	C	D	E	F	G	A	B	C
The ratios are :		9/8	5/4	4/3	3/2	5/3	15/8	2
the intervals are :	9/8	10/9	16/15	9/8	10/9	9/8	16/15	
or, in savarts :	51	46	28	51	46	51	28	

The intervals are of three different natures : major tone 9/8, minor tone 10/9, and major half-tone 16/15. Therefore, when the tonic is changed, we shall obtain sharps and flats of different natures, and the very notes of the original scale will have to be, in some cases, raised or lowered by one comma (difference of the major and minor tones).

This difficulty comes from the fact that certain notes of the scale of fifths, which alone allows transposition, have been replaced by the ratios which allow correct harmonic intervals. In reality, for modulation, one is compelled to come back to the scale of fifths.

Practically, therefore, in Western music, two scales are used conjointly and not, as is generally believed, only the Zarlino's scale. This ambiguous position, never fully clarified, has led to the general adoption of temperament which, splitting the difficulty, apparently suppresses the problem without solving it.

To modulate from one major tone to the neighbouring major tone, so as to obtain again exactly the same scale, the fourth of the first tone has to be raised by one limma and the sixth by one comma: the new tonic being the fifth of the former tone. Thus, from the very first modulation, we obtain two notes which do not belong to the scale of Zarlino. In the tones in which sharps are added all the notes are in this way raised, one after the other, by one comma: for each additional sharp, another note is being so raised. In the same way, if the modulation starts from a tone containing several sharps towards simpler tones, notes are successively lowered by one comma.

The tones with sharps having every one of their original notes one after the other raised by one comma (to which the sharp is added), while the tones with flats have their original notes one after the other lowered by one comma (to which the flat is added), the result can be that the flats are lower than the corresponding sharps, as musicians often notice, although the sum of the theoretical intervals represented by them is less than one tone, as physicists object. This is simply because the natural notes (śuddha), to which these sharps and flats have been added, are no longer the notes of the original C (Sa) scale, but a note lower in the case of the flat, higher in the case of the sharp.

For example: when we modulate from C major into G major, the A is raised by one comma into A+; when we modulate into B major (which is really B+ major) the A sharp will be added to the A+ giving A♯♯. Besides, the B flat of B flat minor, being itself B♭♭, happens to be the same note as the A sharp of B+ major: but the B flat of D flat major is one comma lower, that is, B𝄫 and, therefore, lower than the A sharp of A+ major. We

can see from this example that all the respective positions of the sharp and the flat are possible and that to say in a general way that sharps are higher than flats or the reverse is completely meaningless. The problem, in reality, is not very complicated and it would be more simple to consider it as it is than to discuss it endlessly on insufficient data. Besides, we are speaking here only of the flats and sharps necessary to obtain the same scale again after modulation. In addition there are, moreover, other flats and sharps necessary for expression, and used by good instrumentalists, which are different again. From this it is easy to understand how inadequate is the scale of Zarlino.

If we follow the progression of scales with sharps and that of scales with flats, the tones of apparently similar tonics (F sharp and G flat, or B natural and C flat for example) can never coincide because their tonics are distant by one or two commas. It is, therefore, always incorrect to pass from one to the other, or, if this be done, it produces relations of a new kind which it would be necessary to define if their effect were to be reasonably utilized. But, accidentally, a sharp and a flat may coincide.

Being based on the cycle of fifths, the chain of modulations can never come back to its original pitch. It can be, like the cycle of fifths itself, symbolized by an indefinite spiral.

The Major mode.

It was only in 1517 that Glareanus, in his "Dodekachordon" published in Basel, for the first time introduced the major mode, which he calls "Ionian mode", as the fundamental scale. In India, the major mode was to be accepted as a basic scale, under the name of "rāga Bilāval", only in 1813 in the "Nagmat e Asaphi" of Muhammad Rezza.

Among the combinations of successive or simultaneous sounds having between themselves simple ratios, the major mode is only a particular case. Its melodic characteristics are not very expressive

but it allows, starting from its diverse degrees, the formation of chords which, by their structure, are somewhat similar to the harmonics of a single sound. It, therefore, rather easily allows, by a small adjustment of tuning, transposition from one degree to another ; and, in order to hide its monotony, Western musicians constantly utilize these changes of tonic which to the Oriental appear artificial, having little significance and, consequently, little justification.

To realize always those perfect chords, which a refined ear perceives in the sound, one yet complex, of a well-toned instrument, Occidentals have sacrificed all the possibilities of modes, as different from each other in their structure and possibilities as can be a square from a circle, from a triangle or from a star polygon : modes which open unlimited possibilities of chords, of which we can sometimes catch glimpses through the temperament, because temperament, by disfiguring the major mode, has brought it onto an equal footing with many other modes equally disfigured by it. This explains why so many harmonic "discoveries" followed the generalization of the modern piano. Until then, the major mode ruled because, as was explained by M. Emmanuel, the Western minor mode is only a variation of the major mode, tyrant of Western music.

In addition to the peculiarity of harmonic transposition, the major mode is, by its structure, in no way more natural than many others, and it is even less pleasant for the ear than modes presenting a more complete series of harmonics. It is mostly habit which makes us prefer it. And we shall see, when we study the symbolism and the emotional correspondences of notes according to Hindu theory, that the intervals of the major mode are those which indicate egotism, vanity, materialism and search for pleasure, thus forming a frame in which the mentality of our times finds itself completely at home. But Westerners, who affect to ignore the fact that all the elements of their music were originally borrowed from Egypt and Chaldea, have no idea of the

significance of the notes they use, and they wonder at their own genius when they discover that some chords can express precise emotions, whereas these same expressions have been defined for thousands of years in those very Śāstras which gave the first definition of these intervals and chords. Let us now see how one of the most recent Western musicologists explains the major mode. M. E. Britt, in his "La Synthèse de la Musique" (Geneva, 1938), writes :

"It is in vain that the explanation of the modern scale has been sought in the physical phenomenon of the vibration of sonorous bodies . . . . . This disposition of elements presents itself, in our diatonic scale, under a concrete and rigorously logical form, otherwise it could never have produced either its own synthesis, or the symphony, or the musical drama, or any of the harmonic forms which are the originality of modern music. And, if the rationalism of the Western genius has been able to triumph over traditional mistakes, if it has been able to create a melodic and harmonic organ so complete and so perfectly adapted to the expression of human feelings, it is because the constitution of the modern scale no doubt corresponds to some law of inner organisation of psychic essence, whose imperious necessity could only be felt at the time when the mental development of humanity was sufficiently advanced to receive its revelation and conceive of its reality."

One could not find expressed in a more blatant form the perverted reasoning which deprives so many otherwise well-documented works of the Westerners of all serious scientific value, and we wonder whether Mr. Britt would really be ready to defend the logical implications of his words. He would have us apparently believe that harmonic forms exist only in modern music, that all modern Western melodies are superior to those of the modal systems, that Western music alone is capable of expressing human feelings, that others than Westerners are consequently either not humans or are deprived of feelings, or, if they have feelings, have no

means of expressing them, that Aristotle and Śaṅkarāchārya were mentally deficient since human beings had not attained to mental development before modern times, that the secrets of harmony have been 'revealed' to some modern Moses by a benevolent Jehovah delighted at the good behaviour of our contemporaries, etc..

In general the reasoning of Western scholars, in relation to music, could be summarized much as follows :

The Western scale is not correct according to the laws of physics or mathematics, but, being used by Westerners, it is therefore superior to all others. And, since it is in contradiction with physical laws, it must therefore be the expression of some superior psychic law, still unknown to us, but which is the measure of genius and progress, etc..

That such methods of reasoning could be printed and accepted certainly does not indicate that the mental development of humanity has yet attained to the elements of logic and, if nobody objects to it, it is probably because the superiority of everything European is an article of faith which should not be discussed.

We hope to be excused for criticizing so harshly these unhappy sentences of Mr. Britt whose works are otherwise well-documented and show a real spirit of research. It is only with the hope that some may understand how high is the wall of prejudice behind which so may Occidentals are prisoned, a prejudice which makes their reasoning absurd and out of place whenever a question relating to other civilizations is involved. Unfortunately, their mistake is difficult to cure because they are not even conscious of being unfair since they ignore everything of the logical methods of discussion taught, for example, by the Hindus, and of which the Greeks had some idea, and which allow the hypercriticism of arguments and the establishment of logical relations between cause and effect.

Equal Temperament.

When, starting from a fundamental sound, a musical scale is established, the problem easily remains within the limits of

harmonic sounds and simple proportions. But when, starting from another note of the mode so established, we try to constitute a scale or chords similar to the first one, some of the notes obtained do not coincide with those of the first scale. In order to simplify the musical problem and the construction of fixed-scale instruments, Western musicians neglect these differences and, choosing an intermediary sound, declare that the ear adapts itself to it and does not perceive the difference. All modes and chords are thus reduced to a series of twelve sounds among which no one has a correct relation to the other. But this system is not really sufficient for melody or successive harmony, nor for simultaneous harmony. Small differences of pitch may, in the case of an isolated note, appear to an untrained ear negligible. But, when notes are brought together in a mode, these slight differences of pitch will bring about considerable differences in the expressive significance of the mode. Similarly, when the notes are grouped in the shape of chords, these same small differences of pitch will create, between the sounds, beats (variations of intensity) which, besides being unpleasant, greatly diminish the significance of the chords.

Just as we cannot see exactly if one brick is slightly bigger than another but, when we come to build, we see immediately a great difference between a plain and regular wall or one where nothing is level, so for the temperate scale, even if we cannot perceive the difference for separate notes, the difference is extremely apparent between a really harmonic chord and a chord which beats: and in the temperate scale every chord beats.

If we carefully examine the structure of the modern Western musical system, however vague may be its theory as it is described in treatises on Harmony, it is not impossible to find in it the elements of a logical and coherent system, but this system is very different from the artificial temperate scale which is actually in use, and which, while it gives some facilities of execution, has twisted the development of modern musical thought in such a strange

direction. The temperate scale to a considerable extent hides from the moderns the thought of the great masters of the past, whose most deep and noble works can appear monotonous and childish when they are so disfigured. But this is very difficult to realize, because modern people have to such an extent lost sensitiveness to simple chords and to modal degrees considered in relation to a tonic, that they can never believe that a single note can perfectly give the effect which not even a massive chord can produce upon their calloused minds.

Helmoltz said :

"The music based on the temperate scale must be considered as an imperfect music . . . . . If we suppose it or even find it beautiful, it means that our ear has been systematically spoiled since childhood." (Blaserna and Helmoltz, Le son et la musique, 2eme edit., p. 120).

Others also :

"The ear became accustomed to the continual approximations of temperament only at the cost of a part of its natural sensitiveness." (A. Langel, La voix, l'oreille et la musique, p. 154.)

Equal temperament is in no way a new thing, it has been many times invented by those half-scholars who always come in to explain and improve that which they do not fully understand. In China for example, "Hô Chhêng-thyēn (370-447)[1] and Lyeû-Chŏ (†610)[1] opposed the system of Kīng-Fâng, that is, the indefinite progression of perfect fifths. They wanted to force the numbers corresponding to the lîn-chōng (G) (Pa), and to all the lyŭ (notes), so that the chóng-lyù (F+, eleventh fifth) (Ma+) would again give birth to the hwâng-chōng (C) (Sa), and the complete cycle be limited to twelve lyŭ." (M. Courant, Dictionnaire du Conservatoire, Chine, p. 90.)

It is again necessary to repeat that to create music with sounds which have no relation between themselves is not possible

1. Our parenthesis.

and that, the more simple are the ratios between sounds, the more their relation is harmonious, and the more complicated the ratios, the more dissonant are the sounds.

This is why equal temperament is musically absurd, because it replaces the simple ratios of the notes (4/3, 5/4, 9/8, 10/9, etc.) by ratios which are near to them but are nevertheless extremely complicated. The ratio of the temperate half-tone is something like 1,059,463,094/1,000, 000, 000., while the major half-tone is 16/15 and the minor half-tone 25/24.

The temperate ratios are, therefore, exceedingly dissonant, and create in every chord such beats that only people whose ears are hardened by the habit of noise, or musicians who follow so intensely the musical thought that they do not hear the false notes of the instruments, can bear them.

Equal temperament has had a very strange effect on some of the musicians of the present generation. As they have never heard a consonant chord, they know the chords only as more or less acute dissonances, and the rules of the old masters, who centre everything in consonant chords, seem to them the effect of timidity and ignorance. Besides, as modal memory can hardly work when notes have harmonically wrong relations, melodies can only have a significance when over-crowded with chords and accents, until they completely disappear under a heap of modulations.

Still, it cannot be doubted that temperament has, along certain lines, brought out considerable developments in Western music. The newly invented modern piano was the means by which Chopin and Liszt could create an extraordinary number of new chords and modulations, and Wagner could not work without his "Erard". This is because this instrument allowed composers to experiment, to search for chords which they could not imagine until they had heard them. And the temperament, while disfiguring all the intervals of the major mode, also opened the door to a number of other modes. These, as we have already seen, were similarly disfigured with the major mode, although not more so.

Each note of the temperate scale and each chord is open to numerous interpretations. The ear, of course, makes some sort of adaptation to find in it those correct intervals which alone it can appreciate, but these adaptations can be widely different. Through this queer back door numerous modes and intervals, which classical music had totally ignored, have unknowingly appeared again in Western modern music. It goes without saying that, if these modes and intervals were played correctly instead of being "tempered", their expression and beauty would be considerably intensified.

But, when this music, conceived on the piano, is to be played by an orchestra, a new difficulty appears, that of notation. Those chords of the piano have introduced into music new intervals which accommodate themselves in some way or other to the temperament. But, if those chords are to be played on non-tempered instruments just as they are noted, the result may be completely discordant. This is the case, for example, with Wagner whose music, conceived on the piano, was much more dissonant in his time, when the musicians of the orchestra made some difference between sharps and flats, than now-a-days when practically all musicians play in the temperate scale. The reason is that, here, the correct play is no longer expressed by the written notation, and to play correctly would be to play what would have been written had a more complete system of notation permitted a better analysis.

This brings us to the observation that Western notations are of such inaccuracy that all sorts of misunderstandings are possible. Therefore, musicians speak of a sharp a little higher, or of a third a little larger, of a brilliant-toned or a dull-toned note, in order to be able to realize, by instinct, intervals whose signification is clearly distinct, whose definitions could be found and are even often implied in the principles of music as described in the treatises of harmony. Such inaccuracy in notations explains also the misrepresentation of ancient modes and Oriental melodies written in Western notations, not to speak of Western popular music also completely disfigured.

The failure of modern musicians to realize any effect from their transcriptions of Greek or Oriental modes comes from the fact that they always saw them through temperament, which disfigured their intervals and flattened their coloration, reducing practically everything to one unique mode, the temperate chromatic. We should not forget that, although it is comparatively easy to recognize a known mode or melody in its temperate approximation, it is often extremely difficult, if not impossible, to imagine its colour and expression if one has never heard its real intervals.

Unfortunately, instead of realizing, by contact with Greek or Eastern modes, the deficiencies of their own musical notations, many Western musicians, aided by their convenient evolutionist prejudice, prefer comfortably to consider that these modes, which they are unable to play, are "primitive", of small interest, and could add nothing to the achievements of modern Western music.

EIGHTH PART

THE SCALE OF SOUNDS.

To what could we not attain could we but discover the physical laws which would allow us to gather together, in more or less great quantity, and according to proportions which remain to be found, a certain ethereal substance which pervades the air, and which gives to us music as well as light, the phenomena of vegetation as well as those of animal life ! Do you realize ! By giving him instruments far superior to actual instruments, these new laws would give to the composer new powers, and, may be, a prodigious harmony as compared with that which rules music to-day.

(Honoré de Balzac, Gambara.[1]*)*

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1. A short story published in the "Revue et Gazette musicale de Paris," 1837.

EIGHTH PART

THE SCALE OF SOUNDS.

Need for a Scale of Sounds.

FOR the comparative study of the different musical systems, as well as for a correct execution of each one, it appears necessary to establish a scale of sounds which will allow a clear and accurate notation of all the usual intervals, an immediate appreciation of their nature and relative value. With the help of an accurate notation, the reproduction of the different scales on an appropriate instrument becomes very easy.

If we collect the intervals utilized in the different systems, we can see that their number and their combinations are not unlimited in practice. We have seen, while studying the Hindu theory, that the number of acoustic ratios having a distinct significance in relation to one sound considered as tonic is only twenty-two. But, by the permutation of that tonic, or simply by the permutation of the ratios between the different notes, the number of the different sounds within one octave is raised to fifty-three principal sounds, to which are added, in certain systems, either six secondary ones, — bringing the total division to sixty sounds, — or twelve quarter-tones, — giving a total division of sixty-six distinct sounds. This scale can be identified with the scale of fifths if the Pythagorean comma (5.88 savarts) is assimilated to the comma diesis (81/80 = 5.4 savarts), which means an approximation of one hundredth of a tone. This division is by no means arbitrary. It corresponds to the ideal structure of the octave. This is why it can be established on the basis of any one of the systems, either by the progressive rising of the notes in a series of modulations within the scale of Zarlino, or by the combinations and permutations of the intervals necessary for melodic expression in the

Hindu, Arabic or Greek (musicians') systems, or, again, by the development of the Chinese scale of fifths. In each case we get the same number of divisions.

Many intervals, which are musically identical, can be expressed by slightly differing ratios in the scale of fifths or in the scale of proportions. Such is the case for the major half-tone and the apotome which are only two expressions of the same interval: one is the harmonic relation to the tonic 16/15 (major half-tone), the other is the cyclic ratio 2187/2048 (apotome). Their significance, their "śruti", is identical. Their measure in savarts is, for the major half-tone, $16/15 = 28.03\sigma$, and, for the apotome, $2187/2048 = 28.52\sigma$, which means that their difference in scarcely one hundredth of a tone.

The Pythagoreans, and later the Arab and Turkish theoricians, for mathematical reasons always considered the cyclic interval as the correct one and the harmonic interval as an approximation. But, musically, it is the harmonic interval which is really used and which must, therefore, be considered as the correct one.

There are, however, some intervals whose difference is so slight that the ear cannot easily detect it but whose functional difference is important; such is the case for the limma $256/243 = 22.63$ savarts and its complement to the minor tone which is $135/128 = 28.12$ savarts.

$$256/243 \times 135/128 = 10/9$$

In practice, these two intervals are identical, but their function, as we saw in connection with Hindu music, is different. According to the Hindu theory, one of them, 135/128, is a melodic interval, — i. e., the two notes which constitute it can be played one after the other — and contains two śrutis, while the other, the limma proper, 256/243, contains only one śruti and should, therefore, be considered as a difference between intervals.

"3" cyclic number and "5" modal number.

To render the classification of intervals easier, we have kept here, to represent certain intervals, the simpler ratios in which the

numerical element "7" appears. From the point of view of the symbolic signification of numbers and, consequently, from the point of view of physics, this is an error. In this world limited to five elements, in which we live, no prime number higher than "5" can enter into the composition of the substance from which a melodic or an harmonic relation is made. The Chinese system, the abstract scale of fifths, even refuses to go beyond the number 3. All its intervals are expressed in terms of powers of 2 and 3. The introduction of the factor 5 gives us the harmonic scale of which the characteristic intervals are the harmonic major sixth (5/3), the harmonic major third (5/4), the minor third (6/5), the major half-tone ($16/15 = 2^4/3 \times 5$), the minor half-tone ($25/24 = 5^2/3 \times 2^3$), the comma diesis ($81/80 = 3^4/2^4 \times 5$), etc..

The number 5 "humanizes" music. It makes it the instrument of the expression no longer of abstract prototypes but of a tangible reality. The introduction of any higher prime number would take us beyond this reality into dangerous regions which are not within the scope of our normal perceptions and understanding. 7 is the number of the heavenly worlds as well as that of the infernal regions, and we have usually no means of knowing to which side it may lead us.

The intervals which contain the element 7 cannot be physically pleasant, being, by definition, beyond the limits of physical harmony; their magical effect also is normally beyond our control. Consequently, their utilization in music and its theory serves no useful purpose. We shall indicate some of them here merely as a reference and because they have been spoken of by many theorists past and present.

There is a fundamental difference between the numerical substance from which the intervals are made and their posterior grouping according to certain numbers for symbolic representation.

The substance from which an image is made is necessarily material and cannot be anything else. Even if this image is a mere gesture, it comes necessarily within the limitation of space,

that is, of Ether, the fifth element. But, although it is material in its substance, this image can be used to represent things which are not within the limits of the elements.

In the case of sounds, therefore, the substance, that is, the numerical ratios from which the sounds take their existence, must be limited to the numbers which are those of Nature, of physical reality. On the other hand, the notes, once built on the basis of their natural ratios, can be grouped according to non-physical numbers and thus become the symbols or the images of supernatural reality. The seven-note scale is thus taken to symbolize the transcendental rôle of music.

The number "5" is the highest prime number utilized in harmonic intervals. Similarly, in the scale of fifths, we cannot go melodically beyond the fourth ascending or the fourth descending fifth, which is, in either case, the fifth sound. This leads, naturally, to the scale of nine sounds which is the most extensive simple melodic scale possible in any music. Scales of more than nine sounds being necessarily mixtures of scales.

In reality, the completely manifested scale has only seven sounds because, in the scale of fifths, only three successive fifths remain within the limits of the third power, beyond which we go out of this world's extension. But, because of the rôle of the fourth and the fifth as subsidiary tonics, this limit is pushed back by one more step. Thus appears the scale of nine sounds, the absolute basis of the structure of all music.

When, on the tonic, we build a series of four ascending and four descending fifths, we obtain a series of nine sounds which constitutes the first element of the universal harmonic scale.

The four ascending fifths are: 1) G (Pa) = 3/2, 2) D (Re) = 9/8, 3) A+ (Dha+) = 27/16, 4) E+ (Ga+) = 81/64. The 5th fifth would give: B+ (Ni+) = 243/128 = 278.14 sav.. This 5th fifth forms, with C (Sa), a Pythagorean limma (256/243) which conflicts with the slightly larger and softer harmonic limma formed by the B+ (Ni+) whose ratio is 256/135 = 277.91 sav., and of which we shall presently

explain the origin. In the series of fifths, intervals beyond the 4th fifth 81/64 are, in theory as well as in practice, not acceptable harmonically.

The four descending fifths are: 1) F (Ma) = 4/3, 2) B♯♭ (NiL+) = 16/9, 3) E♭ (GaL) = 32/27, 4) A♭ (DhaL) = 128/81. The 5th fifth would be: D♭ (ReL−) = 256/243 = 22.63 savarts, to which is to be preferred the slightly larger harmonic limma 135/128 = 23.12 sav., which is the 4th fifth of the harmonic A (Dha) = 5/3.

In both the ascending and the descending series, the next fifth (the 6th fifth) would give the prohibited augmented fourth, F sharp (Ma tīvra).

The augmented fourth in the ascending series is F♯♯ (MaL+) = 729/512, while the augmented fourth in the descending series is F♭♯ (MaL−) = 1024/729.

The interval between these two augmented fourths constitutes the Pythagorean comma ($3^{12}/2^{19}$), the extreme limit of physical harmonies.

If we now consider the simplest ratio in which the number "5" appears in the numerator, we find it to be the natural A (Dha) = 5/3.

The four ascending fifths built upon this natural A (śuddha Dha) are: 1) E (Ga) = 5/4, 2) B (Ni) = 15/8, 3) F♭♯ = 45/32, 4) D♭ (ReL−) = 135/128. The 5th fifth would be: B♭ (NiL−) = 1280/729.

The four descending fifths are: 1) D−(Re−) = 10/9 the minor tone, 2) G−(Pa−) = 40/27, 3) C−(Sa−) = 160/81, 4) F−(Ma−) = 320/243.

The simplest ratio in which the number "5" enters as denominator is the harmonic minor third E♭♭ (Gab) = 6/5.

The four ascending fifths built upon it are: 1) B♭♭ (Nib) = 9/5, 2) F+ (Ma+) = 27/20, 3) C+ (Sa+) = 81/80, 4) G+ (Pa+) = 243/160.

The four descending fifths are: 1) A♭♭ (Dhab) = 8/5, 2) D♭♭ (Reb) = 16/15, 3) F♭♯ (MaL+) = 64/45, 4) B+ (Ni+) = 256/135.

If we add, to these two series, the two series which comport a square "5" (i.e. 25), we have, on the respective basis of F♭♭♯ (Mab) = 36/25 and F♯♯ (Ma♯) = 25/18, the two following complementary series,

That is, from 36/25 in ascending: $\overset{\flat}{D}\flat$ (Re$\flat$) = 27/25, A−− (Dha−−) = 81/50, E−− (Ga−−) = 243/200, B−− (Ni−−) = 720/400.

From 36/25 in descending: B++ (Ni++) = 48/25, E++ (Ga++) = 32/25, A++ (Dha++) = 128/75 and D+ (Re+) = 256/225.

From 25/18 in ascending: $\overset{\sharp}{D}\flat$ (Re$\sharp$) = 25/24 the minor half-tone, $\overset{\sharp}{A}\flat$ (Dha$\sharp$) = 25/16, $\overset{\sharp}{E}\flat$ (Ga$\sharp$) = 75/64, and $\overset{\flat}{B}\flat$ (Ni$\flat$) = 225/128.

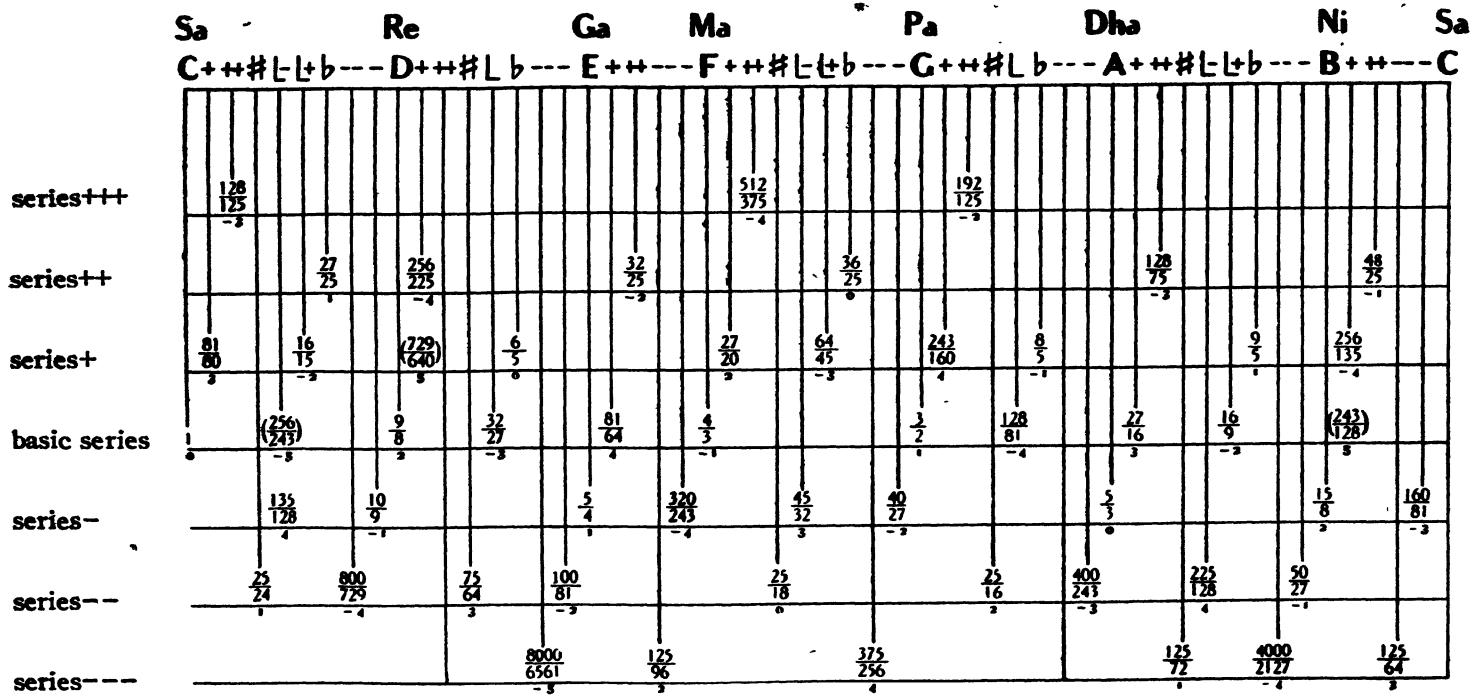
From 25/18 in descending: B− (Ni−) = 50/27, E− (Ga−) = 100/81, A− (Dha−) = 400/243 and D−− (Re−−) = 800/729.

This completes the universal harmonic scale which we had been already utilizing, and whose intervals are shown in the tables p. 235.

It is here necessary to note that the cyclic scale is called scale of fifths because its basic interval happens to be the fifth successive note of the modern diatonic scale. But this unimportant peculiarity, in a scale arbitrarily chosen as basic scale, does not imply that this interval is in any way connected with the number "5". This confusion has led to the complete failure of many recent attempts to explain the symbolism of scales and chords by considering the interval of fifth as representative of the number "5". In reality, the interval of fifth corresponds to the number "3", its ratio being 3/2, and nowhere in the scale of fifths does the numerical element "5" appear. The numerical element "5" is essentially represented by the two minor and major thirds whose respective ratios are 6/5 and 5/4.

Similarities of the Scale of Fifths and the Scale of Proportions.

By the system of harmonic proportions, as well as by that of the scale of fifths, we obtain a division of the octave into fifty-three intervals. But those intervals do not exactly coincide, because the notes of the scale of fifths divide the octave regularly into Pythagorean commas, while the notes of the scale of proportions divide it into commas diesis, with a slight discontinuity at every half-tone.



The notes in each series are one comma diesis (81/80) above or under the notes of the next series. The basic note of each series are : C (Sa)=1 for the basic series, $\overset{b}{E}b$ (Gab) = 6/5 for the series +, $\overset{b}{F}\sharp$ (Mab) = 32/25 for the series ++, A (Dha)= 5/3 for the series −, $\overset{\sharp}{F}\sharp$ (Ma$\sharp$) = 25/18 for the series −−, the theoretical D++ (Re++) = 125/108 for the series −−−, and the theoretical $\overset{\sharp}{A}\sharp$ (Dha$\sharp$) = 216/125 for the series +++. The numbers placed under the ratios represent the rank of the notes in each series of fifths.

The intervals of these two similar scales are expressed by different ratios, the one using the exact cyclic ratios and the other the simpler harmonic ratios. In musical practice, it is the harmonic ratios which are correct, but the question of differentiation can scarcely arise, because these two ratios are practically so near to each other that it is almost impossible to differentiate them directly. It is nevertheless easy to recognize them by the implications of the system to which they belong. This means that, although it is difficult to find out to which system each individual sound belongs, a succession of a few sounds will at once show whether the system is modal or cyclic.

But this unity in the structure of the scales of sounds, though it is inherent in the very nature of sounds, — the different systems being only more or less approximate means to express in terms of gross reality the metaphysical principles of sounds — does not mean by implication that the laws regulating the different systems can be identical, nor that we can go from one to the other without difficulty. The same note can play, in the different systems, a completely different rôle, as is, for example, the case of the fourth F (Ma) which forms, with the tonic, an essential interval (4/3) in the modal system, but which, in the cyclic system, is only the 52nd fifth, and, therefore, forms a very distant relation. Even then the cyclic fourth is never absolutely correct. In a similar way, the 6th fifth, F sharp (Ma tīvra), the "tritone", which is an essential interval of the scale of fifths, has to be, in modal music, cautiously handled.

Furthermore, if the intervals are utilized melodically, small differences, which appear insignificant in the scale of sounds, may, added to one another, result in the difference of a śruti. In other words, we may say that, although the scales of the two systems have the same number of steps, the melodies will not use these steps in the same order.

The division of the octave into fifty-three intervals, in the harmonic and the cyclic systems, is as follows :

The Universal Scale of Sounds.

(53 harmonic or cyclic intervals + 12 quarter-tones = 65 notes)

Notes		near-intervals in savarts	intervals with C (Sa)	HARMONIC SCALE		CYCLIC SCALE		
				ratios with C (Sa)	exact savarts	serial number of fifth	ratios with C (Sa)	exact savarts
1	C (Sa)							
2	+	5	comma	81/80 (comma diesis)	5.4	12th	$3^{12}/2^{19}$	5.88 (Pythagorean comma)
3	++	10	2 commas	128/125 (46/45)[1]	10.3 (9.55)	24th	$3^{24}/2^{38}$	11.74
	1/4	14	quarter-tone	(30/31)	14.24			
4	♯	18	minor half-tone	25/24	17.73	36th	$3^{36}/2^{57}$	17.61
5	L−	23	limma	256/243 (135/128)	22.63 (23.12)	48th	$3^{48}/2^{76}$	23.48
6	L+	28	major half-tone	16/15 (2187/2048)	28.03 (28.52)	7th	$3^{7}/2^{11}$	28.52
7	♭	33	large half-tone	27/25	33.42	19th	$3^{19}/2^{30}$	34.48
	3/4	37	3/4 tone	135/124	36.89			

1. The ratios within brackets are approximate ratios.

Notes		near-intervals in savarts	intervals with C (Sa)	HARMONIC SCALE		CYCLIC SCALE		
				ratios with C (Sa)	exact savarts	serial number of fifth	ratios with C (Sa)	exact savarts
8	--	41	small tone	800/729 (11/10)	40.36 (41.39)	31st	$3^{31}/2^{49}$	40.35
9	-	46	minor tone	10/9	45.76	43rd	$3^{43}/2^{68}$	46.12
10	D (Re)	51	major tone	9/8	51.14	2nd	$3^{2}/2^{3}$	51.14
11	+	56	large tone	256/225 (8/7)	56.07 (57.99)	14th	$3^{14}/2^{22}$	57.07
12	++	61		59049/51300 (15/13)	61.10 (62.15)	26th	$3^{26}/2^{41}$	62.89
	1/4	65		93/80	65.39			
13	♯	69	small minor third	75/64	68.88	38th	$3^{38}/2^{60}$	68.76
14	L	74	trihemitone	32/27	73.79	50th	$3^{50}/2^{79}$	74.63
15	♭	79	minor third	6/5	79.18	9th	$3^{9}/2^{14}$	79.68
	3/4	83		75/62	82.67			
16	--	87		8000/6561 (243/200)	86.12 (84.58)	21st	$3^{21}/2^{33}$	85.53
17	-	92	small major third	100/81	91.51	33rd	$3^{33}/2^{52}$	91.4

18	E (Ga)	97	major third	5/4	96.91	45th	$3^{45}/2^{71}$	97.37
19	+	102	ditone	81/64 (19/15)	102.31 (102.66)	4th	$3^{4}/2^{6}$	102.31
20	++	107	large major third	32/25	107.21	16th	$3^{16}/2^{25}$	108.17
	1/4	111		31/24	111.15			
21	−−	115		125/96	114.64	28th	$3^{28}/2^{44}$	114.04
22	−	120	small fourth	320/243	119.54	40th	$3^{40}/2^{63}$	119 91
23	F (Ma)	125	fourth	4/3	124.94	52nd	$3^{52}/2^{82}$	125.78
24	+	130	large fourth	27/20	130.36	11th	$3^{11}/2^{17}$	130.815
25	++	135		512/375 (2187/1600)	134.70 (135.73)	23rd	$3^{23}/2^{36}$	136.68
	1/4	139		62/45	139.18			
26	♯	143	small augmented fourth	25/18	142.67	35th	$3^{35}/2^{55}$	142.55
27	L−	148	harmonic tritone	45/32 (7/5)	148.06 (146.13)	47th	$3^{47}/2^{74}$	148.42
28	L+	153	cyclic tritone	64/45	152.97	6th	$3^{6}/2^{9}$	153.46
29	♭	158	large augmented fourth	36/25	158.36	18th	$3^{18}/2^{28}$	159.42
	3/4	162		90/62	161.85			
30	−−	166		375/256 (19/13)	165.79 (164.81)	30th	$3^{30}/2^{47}$	165.19

Notes		near-intervals in savarts	intervals with C (Sa)	HARMONIC SCALE		CYCLIC SCALE		
				ratios with C (Sa)	exact savarts	serial number of fifth	ratios with C (Sa)	exact savarts
31	–	171	small fifth	40/27	170.7	42nd	$3^{42}/2^{66}$	171.06
32	G (Pa)	176	fifth	3/2	176.06	1st	$3^{1}/2^{1}$	176.09
33	+	181	large fifth	243/160	181.49	13th	$3^{13}/2^{20}$	181.96
34	++	186		192/125 (19683/12800)	186.39 (187.82)	25th	$3^{25}/2^{39}$	187.83
	1/4	190		31/20	190.33			
35	♯	194	small diminished sixth	25/16	193.82	37th	$3^{37}/2^{58}$	193.70
36	L	199	diminished sixth	128/81 (19/12)	198.71 (199.67)	49th	$3^{49}/2^{77}$	199.57
37	♭	204	diminished sixth	8/5	204.12	8th	$3^{8}/2^{12}$	204.61
	3/4	208		50/31	207.61			
38	−−	212		81/50	209.52	20th	$3^{20}/2^{31}$	210.47
39	–	217	small sixth	400/243	216.45	32nd	$3^{32}/2^{50}$	216.34
40	A (Dha)	222	harmonic sixth	5/3	221.85	44th	$3^{44}/2^{69}$	222.21
41	+	227	cyclic sixth	27/16	227.24	3rd	$3^{3}/2^{4}$	227.24

42	++	232	large sixth	128/75 (12/7)	232.15 (234.08)	15th	$3^{15}/2^{23}$	233.11
	1/4	236		31/18	236.09			
43	#	240	small minor seventh	125/72	239.58	27th	$3^{27}/2^{42}$	238.98
44	L−	245	seventh harmonic	225/128 (7/4)	244.99 (243.04)	39th	$3^{39}/2^{61}$	244.85
45	L+	250	minor seventh	16/9	249.88	51st	$3^{51}/2^{80}$	250.72
46	b	255	minor seventh	9/5	255.27	10th	$3^{10}/2^{15}$	255.76
	3/4	259		29/16	258.28			
47	−−	263		40000/2187 (729/400)	262.21 (260.67)	22nd	$3^{22}/2^{34}$	261.62
48	−	268	small seventh	50/27 (13/7)	267.62 (268.84)	34th	$3^{34}/2^{53}$	267.49
49	B (Ni)	273	major seventh	15/8	273.99	46th	$3^{46}/2^{72}$	273.36
50	+	278	cyclic major seventh	243/128 (256/135)	278.4 (277.91)	5th	$3^{5}/2^{7}$	278.4
	++	283	large major seventh	48/25	283.31	17th	$3^{17}/2^{26}$	284.26
51	1/4	287		60/31 (31/16)	286.79 (287.24)			
52	−−	291		125/64	290.73	29th	$3^{29}/2^{45}$	290.13
53	−	296	small octave	160/81	295.63	41st	$3^{41}/2^{64}$	296.
1	C (Sa)	301	octave	2/1	301.03	53rd	$3^{53}/2^{83}$	301.84

Numbers of Vibrations.

(on the basis of the physicists' pitch)

(C (Sa) = powers of 2, C_4 = 512, A_3 (Dha) = 426.6)

C (Sa)	= 2^9	= 512		F+	= 512	× 27/20	= 691.2
+	= 512	× 81/80	= 518.4	++	= 691.2	× 81/80	= 699.84
++	= 518.4	× 81/80	= 524.88	1/4	= 512	× 62/45	= 705.42
1/4	= 512	× 31/30	= 529.06	♯	= 512	× 25/18	= 711.11
♯	= 512	× 25/24	= 533.33	L−	= 512	× 45/32	= 720
L−	= 512	× 256/243	= 539.35	L+	= 512	× 64/45	= 728.17
L+	= 512	× 16/15	= 546.13	♭	= 512	× 36/25	= 736.88
♭	= 512	× 27/25	= 552.96	3/4	= 512	× 90/62	= 743.22
3/4	= 512	× 135/124	= 557.41	−−	= 758.52	× 80/81	= 749.15
−−	= 568.88	× 80/81	= 561.85	−	= 512	× 40/27	= 758.52
−	= 512	× 10/9	= 568.88	G (Pa)	= 512	× 3/2	= 768
D (Re)	= 512	× 9/8	= 576	+	= 512	× 243/160	= 777.6
+	= 576	× 81/80	= 583.2	++	= 777.6	× 81/80	= 787.32
++	= 583.2	× 81/80	= 590.49	1/4	= 512	× 31/20	= 793.6
1/4	= 512	× 93/80	= 595.2	♯	= 512	× 25/16	= 800
♯	= 512	× 75/64	= 600	L	= 512	× 128/81	= 809.09
L	= 512	× 32/27	= 606.81	♭	= 512	× 8/5	= 819.2
♭	= 512	× 6/5	= 614.4	3/4	= 512	× 50/31	= 825.80
3/4	= 512	× 75/62	= 619.35	−−	= 512	× 81/50	= 829.44
−−	= 632.10	× 80/81	= 624.29	−	= 853.33	× 80/81	= 842.80
−	= 640	× 80/81	= 632.10	A (Dha)	= 512	× 5/3	= 853.33
E (Ga)	= 512	× 5/4	= 640	+	= 512	× 27/16	= 864
+	= 512	× 81/64	= 648	++	= 864	× 81/80	= 874.76
++	= 512	× 32/25	= 655.36	1/4	= 512	× 31/18	= 882.33
1/4	= 512	× 31/24	= 661.33	♯	= 512	× 125/72	= 888.88
−−	= 512	× 135/96	= 666.66	L−	= 512	× 225/128	= 900
−	= 682.66	× 80/81	= 674.23	L+	= 512	× 16/9	= 910.22
F (Ma)	= 512	× 4/3	= 682.66	♭	= 512	× 9/5	= 921.6

3/4	=512	× 29/16	=928	B++	=512	× 48/25	=983.04
--	=948.15	× 80/81	=936.44	1/4	=512	× 60/31	=990.96
-	=512	× 50/27	=948.15	--	=1012.5	× 80/81	=1000.
B (Ni)	=512	× 15/8	=960	-	=512	× 160/81	=1012.5
+	=512	× 243/128	=972	C (Sa)	=512	× 2 = 2^{10}	=1024

Remarks on the Scale of Sounds.

The numbers of vibrations are given here according to the scale of the physicists : C (Sa) = powers of 2, A_3(Dha) = 426.6. To obtain the French A (A= 435), the scale must be raised by more than one comma ; for the American high pitch A (A= 453), the scale should be raised by a little over one limma.

If we want to experiment with all the theoretical intervals indicated by the Greek physicists, these intervals can, with a sufficiently near approximation, be replaced by the neighbouring intervals of the above scale without having their expression perceptibly disfigured. This scale plays in regard to them a rôle opposite to temperament, that is, it brings them back to their harmonic prototype, while temperament disharmonises the harmonic sounds. Furthermore, most of the intervals invented by the Greek physicists are only interesting as attempts to represent the true intervals, their ratios being often by themselves meaningless. According to Hindu theory, all the sounds contained in the twenty-second part of one octave have the same general expression, and are differentiated only by more or less plenitude and intensity.

In musical practice, the following assimilations are acceptable :

the comma diesis, 81/80 = 5.4 savarts, can be assimilated to the Pythagorean comma, $3^{19}/2^{19}$ = 5.88 savarts ;

the double-comma, 128/125 = 10.3 savarts, can be assimilated to 46/45 = 9.55 savarts, 6561/6400 = 10.79 savarts, 512/499 = 11.17 savarts, 499/486 = 11.46 savarts, and 250/243 = 12.33 savarts ;

the quarter-tone, 14 savarts, to 31/30 = 14.84 savarts, and 32/31 = 13.79 savarts ;

the minor half-tone, 25/24 = 17.73 savarts, to ratios between 28/27 = 51.8 savarts, and 24/23 = 18.48 savarts ;

the limma, 256/243 = 22.63 savarts, to 20/19 = 22.30 savarts, and to 135/128 = 23.12 savarts ;

the major half-tone, 16/15 = 28.03 savarts, to 2187/2048 = 28.52 savarts (apotome) ;

the large half-tone, 27/25 = 33.32 savarts, to 14/13 = 32.19 savarts, etc., etc. .

The limma (256/243) is, properly speaking, but the complement of the apotome (2187/2048) to the major tone (9/8). It is, therefore, a complementary interval in the ascending scale, but a direct interval in the descending one, as the ancient scale was. There is an interval of one limma between C (Sa) and B+ (Ni+) which is the 5th fifth of the cyclic series ; the same interval exists between the 2nd and the 7th fifth (D to C♯) (Re to Re ⊾+). This is because a difference of five fifths always produces a limma. In the ascending scale are found the limma 135/128 = 23.12 savarts, or the 48th fifth (23.48 savarts).

To study and realize all these different intervals, and to accustom the ear to them, it is necessary to have an instrument allowing of their accurate execution. The simplest is, of course, a stringed instrument of sufficient dimensions, such as the Indian Sitār, for example, with easily movable frets and with the exact place of the śrutis marked along the slide on which the frets move. To mark these places we should remember that the string-length ratios refer to the string shortened without pulling or pressing. If the finger presses the string on the fret, the tension is increased and, therefore, the place of the fret must be accordingly corrected. This rectification is easy to do by tuning two strings in unison at the correct pitch. One of the strings is then lightly pinched with light wood or metal tongs, without pulling or pressing it, leaving free the portion of string corresponding to the desired note. The fret is then adjusted until the second string, pressed upon the fret, comes into perfect unison with

the first string. A mark is then made on the wood so that the fret may be easily and exactly replaced whenever the same note is desired. This must be done for each note of the scale, and the whole length of the instrument becomes marked, so that, by changing the place of the frets, the correct tuning for each mode can be obtained.

Conclusions.

In short, according to traditional data, as well as to experimental facts, it appears that :

1) the division of the octave into fifty-three intervals is in conformity with the nature of sounds,

2) the intervals utilized in all music and at all times are only the major tone, the minor tone, the major half-tone (apotome), and the limma, together with the intervals resulting from their sum or difference (the minor half-tone, for example, is the difference of the minor tone and the major half-tone); these, by their different combinations, produce the scale of fifty-three sounds,

3) any other intervals would not bring out a distinct expression, and would also be less consonant ; their utilization is, therefore, without interest,

4) within one octave we cannot discern more than twenty-two groups of sounds having distinct expressions. The division of the octave into fifty-three intervals is only necessary to make these twenty-two different expressions coincide with perfect harmonic relations in the different modes,

5) all the twenty-two divisions cannot be utilized simultaneously in a mode, or in any melodic or harmonic combination ; at the most twelve, and at the least three notes are used, the normal number being seven.

In all the traditional modal systems, the intervals musically utilized are the same. The differences in the divisions of the octave

are due only to the fact that some methods take into account a greater number of intervals.

Thus, the notes of the pentatonic scale are five of the notes of the heptatonic scale, which can be identified with seven of the degrees of the twelve-note scale; which notes are themselves twelve of the notes of the Arabic division into seventeen sounds; which, in turn, are identical to seventeen of the twenty-two śrutis; which, again in turn, belong to the scale of fifty-three sounds. This scale can further be extended up to sixty sounds, beyond which we are no longer within the field of music.

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