

Diesen 24 Temperier-Bebündungen gesellen sich zu je 12 untemperierte der drei folgenden Schemata:

d	d	d
es	es	dis
e	e	e
f	f	f
fis	fis	fis
g	g	g
as	gis	gis
a	a	a

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Zwei Temperierungs-Schemata stehen drei untemperierte Schemata gegenüber, wobei es einstweilen offen zu lassen ist, ob es sich nach dem jeweiligen Instrument um eine eigentliche Bebündung oder um ein Applikatur-Schema handelt. Die Musik für Viola-da-gamba zeigt ebenso untemperiertes wie temperiertes Tonmaterial, d.h. also Bebündung dieser Art.

Da das Tonmaterial der Bachischen Instrumental-, d.h. Violin-, Viola-Stimmen, vom Quantzisch bebündeten Violoncello zu schweigen, einwandfreie Entsprechungen zu dem der Bund-Instrumente zeigt, sind auch bei diesen Instrumenten wie bei den Violen da gamba Verstimmungen anzunehmen, sei es in Verbindung mit Bündeln, sei es ohne sie zur Erreichung einer entsprechenden Applikatur, die Folgen für Intonation und Artikulation zwangsläufig mit sich bringt. Da erfahrungsgemäß heute selbst erstrangige Musiker bei bestimmten Bachischen Folgen beachtliche Intonations-Schwierigkeiten beim ersten Zusammenspiel haben, ist es unerklärlich, wie Bachs halbwüchsige Latein-Schüler und Liebhaber-Studenten ohne umständliche Vorbereitung den Kirchen-Musik-Dienst auch nur einigermaßen zufriedenstellend bewältigen konnten. Wenn eine Schulung und Übung dieser Instrumentalisten im Sinne der bei der Viola da gamba so selbstverständlichen Verstimmung angenommen werden kann, eine Übung, die gerade von Latein-Schülern und Studenten etwas durchaus Angemessenes verlangt, so kann man in der Verstimmung an sich die Möglichkeit sehen, wie diese Instrumentalisten auch schwierige Bachische Aufgaben-Stellungen einwandfrei bewältigten, wobei die Frage der Bebündung sogar offen gelassen werden kann.

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A "Pythagorean" Tone-System in China - Antedating the Early Greek Achievements by Several Centuries

Tradition ascribes to Pythagoras the construction of a tone-system subdividing the octave into twelve semitonic intervals derived from a circle of twelve perfect fifths. The Greek philosopher is also credited with the computation of the comma of 24 cents by which this circle fails to close after the twelfth step. Most recent authors, however, are inclined to believe that both these achievements were not completed until about 100 - 150 years after Pythagoras. We may thus date the tone-system from which all Western music theory departed, some time around 400 B.C.

It is usually taken for granted that the same system was known and used in China from time immemorial. For almost two hundred years learned men and less learned missionaries kept stressing the conviction that China had a "Pythagorean" tone-system already in the second, third, or even fourth (!) millennium B.C. They all based this opinion upon an ancient legendary tradition: in 2697 the Emperor Huang-ti sent his

minister Ling Lun to the Kun-Lun mountains in western China where the emissary learned to cut a set of twelve bamboo panpipes each of which was one third shorter than the preceding one. Here — it was argued — we had the principle of the 2 : 3 division for the perfect fifth, and hence the traditional twelve *lüs*, the twelve semitonic intervals of these panpipes, were the prototypes of "Pythagorean" intonation. This argument, unfortunately, is wrong. If we cut the lengths of two panpipes of equal diameter in the ratio 2 : 3, the result is not a perfect fifth but a somewhat smaller interval; the size of the error varies with the inner diameter and length of the pipes and accumulates with each successive step of the circle. What is valid for string divisions in the ratio 2 : 3, cannot be applied to sonant tubes whose acoustic and mathematical properties are complicated by several physical and intonation factors. Thus the legendary panpipe tradition, always cited as evidence for an extremely early existence of a "Pythagorean" system in China, is actually acoustic and physical counterevidence. It is gratifying, under the circumstances, that some of my studies have produced the first clear proof of the existence of a "Pythagorean" system in early China.

In 250 B.C. Lü Pu-Wei, a Chinese scholar and statesman, published a work in which he described two scientific achievements which are commonly connected with the Pythagorean school: the Pythagorean theorem depicting the triangle with the three squares, and a correct listing of the mathematical values for the twelve "Pythagorean" semitones. About 140 years later the great Chinese historian Ssu Ma T'sien reported in his work *Shih Chi* the precise semitone ratios and the formula for the Pythagorean comma, $(\frac{2}{3})^{12} \times 2^7$. Hence the system was known and mathematically defined in China at least from the third century B. C. This date has frequently lead to the speculation that Greek or Mediterranean knowledge must have arrived in the Far East some time around 300 B.C., presumably following Alexander's invasion of Sogdiana in 327 from where the information may have travelled to Sinkiang in western China. Other authors believed that the learned information must have come to eastern China *via* Tibet when Alexander's armies penetrated as far as the Hyphasis river. All these hypotheses as to routes and directions of information are based, of course, on the assumption that the pertinent mathematical and acoustic knowledge did not exist in China before 300 B.C.

The Royal Ontario Museum of Archaeology in Toronto owns a set of sonorous stones originating from the tombs of the Princes of Han in Lo-Yang, in the northern part of Honan province. According to current sinological opinion, the tombs were closed in the middle of the sixth century B.C. In 1928 an archaeological commission began excavations, and the finds acquired by the Toronto Museum were evaluated by William Charles White, the well-known Canadian sinologist, in a catalogue published in 1934. Traditionally, sets of lithophones from that period consisted of sixteen stones each, and since the specimens secured appear to come from at least six different sets, there must have been 96 stones in the tombs. The Museum acquired 18; between 70 and 80 specimens apparently were lost due to ignorance and carelessness during the excavations — a major catastrophe for Far Eastern musicology.

The author subjected the 18 Toronto lithophones to a thorough physical and acoustic investigation lasting many weeks. Since six stones were broken, only twelve could be used as conclusive evidence. Pitches were measured with the aid of a stroboscopic frequency meter whose measuring results are precise to within one cent. A series of complex acoustic experiments established methods for accurate estimates of the amount of correction to be applied against some individual stones whose surface showed slight damages. Thus it became possible to determine, within negligible tolerance, the pitches of three slightly damaged stones before the damage had occurred.

A tabulation of the measurements and reasoned corrections showed that, with one exception, all stones were tuned, within two cents or less deviation, in the ideal pattern of "Pythagorean" or of just intonation, mostly "Pythagorean". This is a truly amazing result if we consider that two cents represent roughly the threshold of tuning accuracy for highly trained musical ears, and that more than 2500 years have passed since these lithophones were made or buried. It follows that the Chinese knew and used both the "Pythagorean" and natural systems of intonation about 550 B.C. or earlier, especially for the major third which is represented in both intonations among our lithophones. Since the investigated stones belonged to at least six different sets it also follows that they were interchangeable between sets, and that each of the twelve *liis* actually represented an independent standard pitch within the semitonic scale system.

The Lo-Yang tombs were closed around 550 B.C.; therefore the stones should be dated "550 B. C. or earlier". Now it is certain that many of the funerary gifts found in the tombs were made earlier than the closing date. Whether or not the lithophones fall into this category is a matter of archaeological speculation; most sinologists are inclined to doubt it. However, among many richly ornamented and artistically perfected funerary gifts the lithophones are the most primitive objects so far as external appearance is concerned. This fact speaks in favor of an earlier date of manufacture, particularly in view of the many sonorous jades from that period which show elaborate and exquisite ornamentation. Furthermore, there are numerous facts of a strictly musicological nature — usually unknown to professional sinology and archaeology — which forcefully support an earlier date of manufacture. Most important among these facts is a comparison of tuning and intonation techniques, and their historical development in China, for sonorous substances such as bronze bells and lithophones in general. This type of evidence makes it highly probable that the lithophones were actually made in the ninth century B.C., possibly even earlier. Oriental archæo-musicology may therefore safely assume that the knowledge and skills of making idiophones for a "Pythagorean" system of intonation of amazing durability and precision were already in existence in China 400-500 years before the achievements of the Pythagorean school.

The above theories of a migration of Greek or Mediterranean knowledge to China would seem to be refuted by these findings. Either we are concerned here with an independent Chinese tone-system, or we must assume that these acoustic and mathematical achievements originated in West Asia and penetrated from there in both directions east and west. If the information came from West Asia, it arrived much earlier in China than in the Mediterranean territories. That the ancient Chinese also knew the syntonic comma, the difference between the natural and "Pythagorean" major thirds, as evidenced by the presence of both tunings in the Toronto set, makes these findings all the more significant for Far Eastern archæo-musicology and for our sketchy knowledge of ancient Oriental musical theory.

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Harmonic Rhythm as an Indicator of Rhythmic Function

A central problem in detailed musical analysis is to determine the relative intensity of the various parts of a piece. We can determine melodic intensity in terms of the melodic contour, the climaxes and depressions of the line. We can estimate harmonic intensity in terms of the relative complications of chord structure, of dissonance, of tension and